वार्षिक प्रतिवेदन
Annual Report
2023

भा.कृ.अनु.प.-केन्द्रीय आलू अनुसंधान संस्थान
शिमला- 171001, हिमाचल प्रदेश

ICAR-CENTRAL POTATO RESEARCH INSTITUTE
SHIMLA-171001, HIMACHAL PRADESH

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प्रस्तावना

आईसीएआर-केंद्रीय आलू अनुसंधान संस्थान (सीपीआरआई), शिमला की वार्षिक रिपोर्ट-2023 आप सभी के समक्ष प्रस्तुत करते हुए मुझे अत्यंत प्रसन्नता हो रही है। वर्ष 1949 में अपनी स्थापना के बाद से ही संस्थान ने ऐसी उपयुक्त किस्मों और प्रौद्योगिकियों का विकास किया है, जिसने समशीतोष्ण आलू की फसल को उपोष्णकटिबंधीय में परिवर्तित कर दिया, जिसके चलते इसका विस्तार पहाड़ी क्षेत्रों से लेकर विशाल सिंधु-गंगा के मैदानों में रबी की फसल के रूप में किया जा सका। परिणामस्वरूप, आज भारत आलू का दूसरा सबसे बड़ा उत्पादक राष्ट्र है, जो कुल वैश्विक उत्पादन में लगभग 15% का योगदान देता है। वर्ष 2022-23 के लिए DAC&FW के अंतिम अनुमान के अनुसार, भारत ने 2.33 मिलियन हेक्टेयर क्षेत्र से 60.14 मिलियन टन आलू का उत्पादन किया, जिसकी औसत उत्पादकता 25.81 टन/हेक्टेयर थी। यह वार्षिक रिपोर्ट वर्ष भर में संस्थान द्वारा किए गए अनुसंधान और विकास गतिविधियों की एक झलक प्रस्तुत करती है।

रिपोर्टाधीन अवधि के दौरान 41वीं अखिल भारतीय समन्वित आलू अनुसंधान परियोजना (एआईसीआरपी) (आलू) समूह की बैठक में आलू की दो आशाजनक किस्मों, कुफरी सुख्याति और कुफरी जामुनिया को जारी करने की सिफारिश की गई थी। नई आलू किस्मों कुफरी लोहित और कुफरी दक्ष को सीवीआरसी द्वारा अधिसूचित किया गया। बहु-स्थानिक परीक्षण के लिए भारतीय समन्वित आलू अनुसंधान परियोजना (एआईसीआरपी) में कुल 13 उन्नत प्रजनन आलू क्लोन परीक्षण के लिए लाए गए। आलू क्लोन, नामतः एमएस/8-1148 (विटामिन सी से भरपूर) और एसएम/92-338 (बैक्टीरियल विल्ट के लिए प्रतिरोधी), को राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो द्वारा आनुवंशिक स्टॉक के रूप में पंजीकृत किया गया। संस्थान आलू जर्मप्लाज्म भंडार को समृद्ध करने के लिए निरंतर प्रयास कर रहा है और वर्तमान में यह 30 देशों से प्राप्त 4700 से अधिक परिग्रहणों को संरक्षित करता है।

129.44 हेक्टेयर से कुल 27622.92 क्विंटल न्यूक्लियस और प्रजनक बीज का उत्पादन प्राप्त किया गया। इनमें से 101.83 हेक्टेयर से 21387.89 क्विंटल उत्पादन पारंपरिक और 27.61 हेक्टेयर से 6235.03 क्विंटल हाई-टेक बीज उत्पादन प्रणाली के माध्यम से हुआ। मैदानी इलाकों से विभिन्न सरकारी और निजी एजेंसियों को कुल 21807.89 क्विंटल प्रजनक बीज की आपूर्ति की गई। वर्ष के दौरान प्रजनक बीज के विक्रय से 10.6 करोड़ रुपए प्राप्त हुए। भारत में 40 विभिन्न बीज उत्पादक संगठनों को 31 किस्मों के मूल बीज सामग्री के कुल 334 वायरस-मुक्त स्व: पात्रे संवर्धन नलिका की आपूर्ति की गई, जिससे 16,70,000 रुपये का राजस्व प्राप्त हुआ। जैविक तनावों को नियंत्रित करने वाले जीनोमिक विनियामकों की पहचान करने के लिए जीनोम-व्यापी संबद्धता मानचित्रण अध्ययन किया गया।

जल और पोषक तत्व प्रबंधन हेतु कम लागत वाली तकनीक विकसित करने के लिए क्षेत्रीय केंद्र मोदीपुरम में तीन और ग्वालियर में एक प्रयोग किया गया। जालंधर में आलू की फसल के लिए उपभोग्य जल उपयोग पैटर्न का आकलन करने और जल कुशल तकनीकों की खोज करने के लिए कार्य किया गया। शिमला में, फास्फोरस संचय में जीनोटाइपिक परिवर्तनशीलता पर किए गए अध्ययनों से पत्ती फास्फोरस सांद्रता (0.20-0.47%) में एक बड़ी जीनोटाइपिक परिवर्तनशीलता का पता चला। जर्मप्लाज्म में इस परिवर्तनशीलता का उपयोग फास्फोरस कुशल किस्मों के प्रजनन के लिए किया जा सकता है। हिमालयी एसिड अल्फिसोल्स में आलू में एएम-फंगी और पीएसबी के सह-संक्रमण के माध्यम से फास्फोरस उपयोग दक्षता में सुधार करने के लिए शिमला में एक क्षेत्र अध्ययन संपन्न हुआ। मध्य प्रदेश में उर्वरक मात्रा की गणना के लिए एक वेब-आधारित निर्णय समर्थन प्रणाली भी विकसित की गई थी।

आलू वायरस ए (पीवीए) का तेजी से पता लगाने के लिए एक मजबूत वन-स्टेप रिवर्स ट्रांसक्रिप्शन रीकॉम्बिनेज पॉलीमरेज़ एम्प्लीफिकेशन (आरटी-आरपीए) जांच विकसित की गई थी। इंडो-ब्लाइटकास्ट मॉडल ने कृषि-पारिस्थितिकी में पिछेता झुलसा के दिखने का पहले से ही पूर्वानुमान लगा लिया था और तदनुसार इसके प्रबंधन के लिए कृषि-सलाह जारी की गई थी। वैलिफेनालेट 6%+ मैन्कोज़ेब 60% डब्ल्यूजी @ 0.5% का प्रयोग पिछेता झुलसा के विरुद्ध फेनामिडोन 10 + मैन्कोज़ेब 50% डब्ल्यूजी @ 0.3% और डाइमेथोमॉर्फ 50% डब्ल्यूपी @ 0.1% जितना ही प्रभावी पाया गया। आलू की काली रूसी के विरुद्ध इमिडाक्लोप्रिड 17.8 एसएल @ 0.04% + पेनफ्लूफेन 22.43% एफएस @ 0.1% के साथ कंद बीज का उपचार पेन्सीक्यूरोन 22.9% एससी और थिफ्लूजामाइड 24% एससी @ 0.5% के समान था। साधारण खुरंड रोग के विरुद्ध आलू जर्मप्लाज्म की स्व: पात्रे जांच के लिए एक नवीन ऊतक संवर्धन-आधारित विधि विकसित की गई।

डीएनए बारकोडिंग के माध्यम से आलू के पौधों को संक्रमित करने वाले थ्रिप्स टैबैसी की पहचान ने लक्षित प्रबंधन रणनीतियों के लिए बहुमूल्य जानकारी प्रदान की है। माइज़स पर्सिका को संक्रमित करने वाले एंटोमोपैथोजेनिक कवक की रोगज़नक़ी के अलगाव, पहचान और

मूल्यांकन पर अध्ययन ने कवक को एकेंथोमाइसेस डिप्टेरिजेनस के रूप में पहचाना, जो एम.पर्सिका के खिलाफ एक माइक्रोबियल नियंत्रण एजेंट के रूप में इसकी क्षमता को दर्शाता है। तीन साल के डेटा विश्लेषण से पता चला कि ट्रैप फसलों और गैर-मेज़बान फसलों के साथ बैसिलस सेरेस एसजीएल 6 को शामिल करने वाले उपचारों ने नेमाटोड प्रजनन कारकों को काफी कम कर दिया, जो पीसीएन प्रबंधन के लिए उनकी क्षमता को दर्शाता है।

सबसे अधिक इस्तेमाल किए जाने वाले अंकुर दमनक आइसोप्रोपाइल एन-(3-क्लोरोफेनिल) कार्बामेट (सीआईपीसी) के नवीन और पर्यावरण की दृष्टि से सुरक्षित विकल्प का पता लगाने के लिए, सात वाष्पशील तेलों के संयोजन को 16 किस्मों पर शुद्ध प्रयोग को 120 दिनों के लिए अंकुर नियंत्रण में अत्यधिक प्रभावी पाया गया। इस वर्ष तीन नए उत्पाद विकसित किए गए जिनमें आलू-काले चने की बूंदी, ग्लूटेन मुक्त आलू-कोदो कुकीज़ और पटैटो स्वर्ल शामिल हैं। आलू आधारित सिंबायोटिक्स विकास के मोर्चे पर, बैक्टीरिया के दस उपभेदों को भरोसेमंद पाया गया है। संभाग में विकसित कुल तीन प्रौद्योगिकियों को भाकृअनुप द्वारा प्रमाणित किया गया।

बिहार में 120 उत्पादकों (60 वैशाली और 60 नालंदा जिलों से) का यादृच्छिक रूप से साक्षात्कार करके आलू उत्पादन की लागत और आर्थिक लाभ का अनुमान लगाया गया। बिहार और उत्तर प्रदेश में उन्नत आलू किस्मों को अपनाने हेतु मूल्यांकन किया गया। गैरेट की रैंकिंग तकनीक का उपयोग करके बिहार और उत्तर प्रदेश में गुणवत्ता/प्रमाणित आलू के बीज अपनाने में आलू उत्पादकों के सामने आने वाली प्रमुख बाधा की पहचान की गई। आलू और उसके उत्पादों के भारतीय निर्यात के प्रदर्शन का अनुमान एपीडा और विश्व बैंक के आंकड़ों का उपयोग करके लगाया गया।

संस्थान ने मुख्यालय एवं इसके क्षेत्रीय केंद्रों पर 29 प्रशिक्षण कार्यक्रम, 4 प्रदर्शनियां, 3 किसान गोष्ठी, 3 जागरूकता शिविर, 5 क्षेत्र दिवस, राष्ट्रीय आलू दिवस और कई अन्य आउटरीच कार्यक्रम भी आयोजित किए। आईसीएआर-सीपीआरआई, शिमला और इसके क्षेत्रीय केंद्रों के विभिन्न विषय विशेषज्ञों वैज्ञानिकों ने दूरदर्शन और आकाशवाणी पर 14 लाइव फोन-इन कार्यक्रमों में भाग लिया। किसान कॉल सेंटर, मोदीपुरम स्टेशन और व्हाट्सएप सलाह के माध्यम से आलू उत्पादकों के 1000 से अधिक प्रश्नों का समाधान किया गया और 7000 से अधिक आगंतुकों को संस्थान की अनुसंधान और विस्तार गतिविधियों तथा प्रौद्योगिकियों से अवगत करवाया गया। मानव संसाधन विकास प्रकोष्ठ के तहत 9 वैज्ञानिकों, 7 तकनीकी अधिकारियों और 12 प्रशासनिक अधिकारियों को विभिन्न प्रशिक्षण कार्यक्रमों में भाग लेने के लिए भेजा गया और कई वैज्ञानिकों और अधिकारियों ने सेमिनार/ संगोष्ठी/ कार्यशालाओं/ सम्मेलनों आदि में भाग लिया।

इस अवधि के दौरान सात पेटेंट (पवन संचालित हवाई कीट जाल, आलू कंद में ग्लूकोज के आकलन के लिए डिपस्टिक, प्लांट होल्डिंग और लिफ्टिंग सिस्टम, एक क्षेत्र को जाल से ढकने के लिए मॉड्यूलर संरचना, गन्ना कली रोपण प्रणाली, तरल रसायन के छिड़काव के लिए प्रणाली और विधि, ट्रेपोजॉइडल ब्लेड वीडर) प्रदान किए गए। संस्थान के वैज्ञानिकों द्वारा 117 शोध प्रकाशन और 69 अन्य प्रकाशन प्रकाशित किए गए। वैज्ञानिकों को 21 प्रतिष्ठित सम्मान एवं पुरस्कारों से सम्मानित किया गया।

मैं, सचिव (डेयर) और महानिदेशक, **भाकृअनुप** डॉ. हिमांशु पाठक तथा डॉ. संजय कुमार सिंह, उप महानिदेशक (बागवानी विज्ञान) का अत्यंत आभारी हूँ, जिन्होंने आवश्यक दिशा-निर्देश, निरंतर मार्गदर्शन और अपने बहुमूल्य सुझाव प्रदान किए। मैं संस्थान की अनुसंधान एवं विकास गतिविधियों को दिशा देने के लिए विभिन्न समितियों (क्यूआरटी, आरएसी, आईआरसी, आदि) के अध्यक्ष और सदस्यों को भी धन्यवाद देता हूँ। मैं इस अवसर पर वैज्ञानिकों और अन्य कर्मचारियों की पूरी टीम को सभी अनुसंधान और विकास गतिविधियों को समय से कार्यान्वित करने के लिए बधाई देने के साथ ही निर्धारित समय के अंतर्गत इस व्यापक वार्षिक रिपोर्ट को प्रस्तुत करने के लिए संपादकीय टीम को विशेष धन्यवाद और बधाई देता हूँ।

(ब्रजेश सिंह)
निदेशक

PREFACE

It is my great pleasure to present the Annual Report 2023 of ICAR-Central Potato Research Institute (CPRI), Shimla. Since its inception in 1949, the institute developed suitable varieties and technologies that virtually transformed the temperate potato crop to sub-tropical one enabling its spread from hilly regions to the vast Indo-Gangetic plains as a rabi crop. As a result, India is now the second largest producer of potato contributing to ~15% of global production. As per the final estimate of DAC&FW for the year 2022-23, India produced 60.14 million tonnes of potatoes from 2.33 million ha area with average productivity of 25.81 t/ha. This Annual Report presents a glimpse of research and development activities carried out at the institute during the year.

During the reporting period, two promising potato varieties, namely *Kufri Sukhyati* and *Kufri Jamunia* were recommended for release in the 41stAICRP (Potato) group meeting. New Potato varieties Kufri Lohit and Kufri Daksh were notified by CVRC. A total of 13 advanced-stage hybrids have been introduced in AICRP for multi-location testing. Potato clones, namely MS/8-1148 (rich in vitamin C) and SM/92-338 (resistant to bacterial wilt), were registered as genetic stocks by NBPGR. The institute has been making continuous efforts to enrich potato germplasm repository and presently it conserves more than 4700 accessions obtained from 30 countries. A total of 92 in-vitro accessions were imported from 3 different countries, including 24 accessions from CIP, Lima, Peru, 56 accessions from the USA, seven from the Netherlands, and five cultures from Germany.

Total production of 27622.92 q nucleus and breeder seed was achieved from 129.44 ha. Of these, 21387.89 q production from 101.83 ha was through conventional and 6235.03 q from 27.61 ha through hi-tech seed production systems. A total of 21807.89 q of breeder seed was supplied to various government and private agencies from plains. Disposal of breeder seed generated 10.6 crores during the year. A total of 334 virus-free in vitro culture tubes of basic seed material of 31 varieties were supplied to 40 different seed-producing organizations in India, generating a revenue of Rs. 16,70,000/. The hybridization program produced 11,77,629 true potato seeds from 458 crosses involving superior parents for yield, quality, and resistance/tolerance to biotic and abiotic stresses. A genome-wide association mapping study was conducted to identify the genomic regulators controlling the biotic stresses.

Three experiments were conducted at regional station Modipuram and one at Gwalior for developing low-cost technology for water and nutrient management. At Jalandhar, work was carried out for assessment of consumptive water use pattern and exploring water efficient technologies for potato crop. At Shimla, studies on genotypic variability in P accumulation revealed a large genotypic variability in leaf P concentration (0.20- 0.47%). This variability in germplasm can be utilized for breeding P efficient varieties. A field study was concluded at Shimla to improve phosphorus use efficiency through co-inoculation of AM-fungi and PSB in potato in Himalayan acid Alfisols. A web-based decision support system was also developed for calculating fertilizer doses in Madhya Pradesh.

A robust one-step Reverse Transcription Recombinase Polymerase Amplification (RT-RPA) assay was developed for rapid detection of Potato virus A (PVA). Indo-Blightcast model predicted appearances of late blight well in advance across agro-ecologies and accordingly agro-advisories were issued for its management. The application of Valifenalate 6% + Mancozeb 60% WG @ 0.5% was found equally effective against late blight as Fenamidon10 + mancozeb50%WG @ 0.3% and Dimethomorph 50% WP @ 0.1%. Tuber seed treatment with Imidacloprid 17.8 SL @ 0.04% + Penflufen 22.43% FS @0.1% was on par with Pencycuron 22.9% SC and Thifluzamide 24% SC @ 0.5% against black scurf of potato. A novel tissue culture-based method was developed for *in-vitro* screening of potato germplasm against common scab disease.

The identification of *Thrips tabaci* infesting potato plants through DNA barcoding provided valuable insights for targeted management strategies. The study on the isolation, identification, and assessment of pathogenicity of entomopathogenic fungi infecting *Myzus persicae* identified the fungus as *Akanthomyces dipterigenus*, suggesting its potential as a microbial control agent against *M. persicae*. Three years of data analysis revealed that treatments incorporating *Bacillus cereus* SGL6 with trap crops and non-host crops significantly reduced nematode reproduction factors, showcasing their potential for PCN management.

To find out the novel and environmentally safe alternatives to the most commonly used sprout suppressant Isopropyl N-(3-chlorophenyl) carbamate (CIPC), a combination of seven volatile oils was found highly effective in sprout control for 120 days with single application on 16 varieties. This year three novel products were developed which included Potato-Black gram Boondi, Gluten free Potato-Kodo cookies and Potato swirls. On the front of Potato based Synbiotics development, ten strains of bacteria have been found promising. A total of three technologies developed in the division were certified by ICAR.

The cost and economic returns of potato production were estimated by randomly interviewing 120 growers (60 from Vaishali and 60 from Nalanda districts) in Bihar. The adoption of improved potato varieties was assessed in Bihar and Uttar Pradesh. The major constraint faced by potato growers in adopting quality/certified potato seeds in Bihar and Uttar Pradesh was identified using Garrett's Ranking Technique. The performance of Indian exports of potato and its products was estimated using data from APEDA and the World Bank.

The institute also conducted 29 training programs, 4 exhibitions, 3 *Kisan Goshti*, 3 awareness camps, 5 field days, National Potato Day, and many other outreach programmes at the headquarter and the regional stations. Expert scientists from different disciplines at ICAR-CPRI, Shimla and its regional stations participated in 14 live phone-in programs on *Doordarshan* and *Aakashwani*. More than 1000 queries from potato growers were attended at Kisan Call Centre, Modipuram station and by WhatsApp advisories, and more than 7000 visitors were apprised about the research and extension activities and technologies of the institute. Under the HRD Cell, 9 scientists, 7 technical officers, and 12 administrative officers were sent to participate in various training programs, and many scientists and officers attended seminars/ symposia/ workshops/ conferences etc.

Seven patents (wind operated aerial insect trap, dipstick for estimation of glucose in potato tubers, plant holding and lifting system, modular structure for covering an area with a net, a system of sugarcane bud planter, system and method for spraying liquid chemical, trapezoidal blade weeder) were granted during this period. The scientists of the institute published 117 research publications and 69 other publications. The scientists were conferred with 21 prestigious awards and recognitions.

I am extremely grateful to Dr. Himanshu Pathak, Secretary (DARE) & Director General, ICAR and Dr. Sanjay Kumar Singh, Deputy Director General (Horticultural Science), for providing necessary direction, constant guidance and valuable suggestions. I would also thank the Chairperson and members of different committees (QRT, RAC, IRC, etc.) for giving direction to the R&D activities of the institute. I take this opportunity to congratulate the entire team of scientists and other staff for carrying out all the research and development activities and bringing out the results in time. I extend my special thanks and congratulate the editorial team for bringing out this comprehensive annual report within the stipulated time.

(Brajesh Singh)
Director

CONTENT

भाकृअनुप
ICAR

ICAR-CPRI: AN INTRODUCTION

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

The Research and Development activities of the institute are carried out under the five divisions namely, Division of Crop Improvement & Seed Technology, Crop Production, Plant Protection, Crop Physiology, Biochemistry and Post Harvest Technology and Social Sciences. The institute headquarters is located in the heart of Shimla city, 4 kilometer from Shimla bus stand near Bemloe. It is located at an altitude of 2000 meters above mean sea level and has a wet temperate climate. It has six regional stations located across the country viz. Modipuram (UP), 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 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 56 scientists, 115 technical staffs and 58 administrative staff & 58 Skilled Support Staff working on potato crop.

THE MISSION

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

THE MANDATE

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

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 five Divisions namely; Crop Improvement & Seed Technology; Plant Protection; Crop Production, Crop Physiology, Biochemistry & Post Harvest Technology and Social Sciences under 11 well defined research programmes. In addition to regular research programmes, a total of 11 externally funded research projects sponsored by different agencies viz. ICAR, DST, DBT, PPV&FRA, CIP, IASRI, NASF, NEC and UPCAR are also under operation. Production of Breeders' seed is being done by the Institute under a Revolving Fund Scheme and National Seed Programme.

STAFF & FINANCE

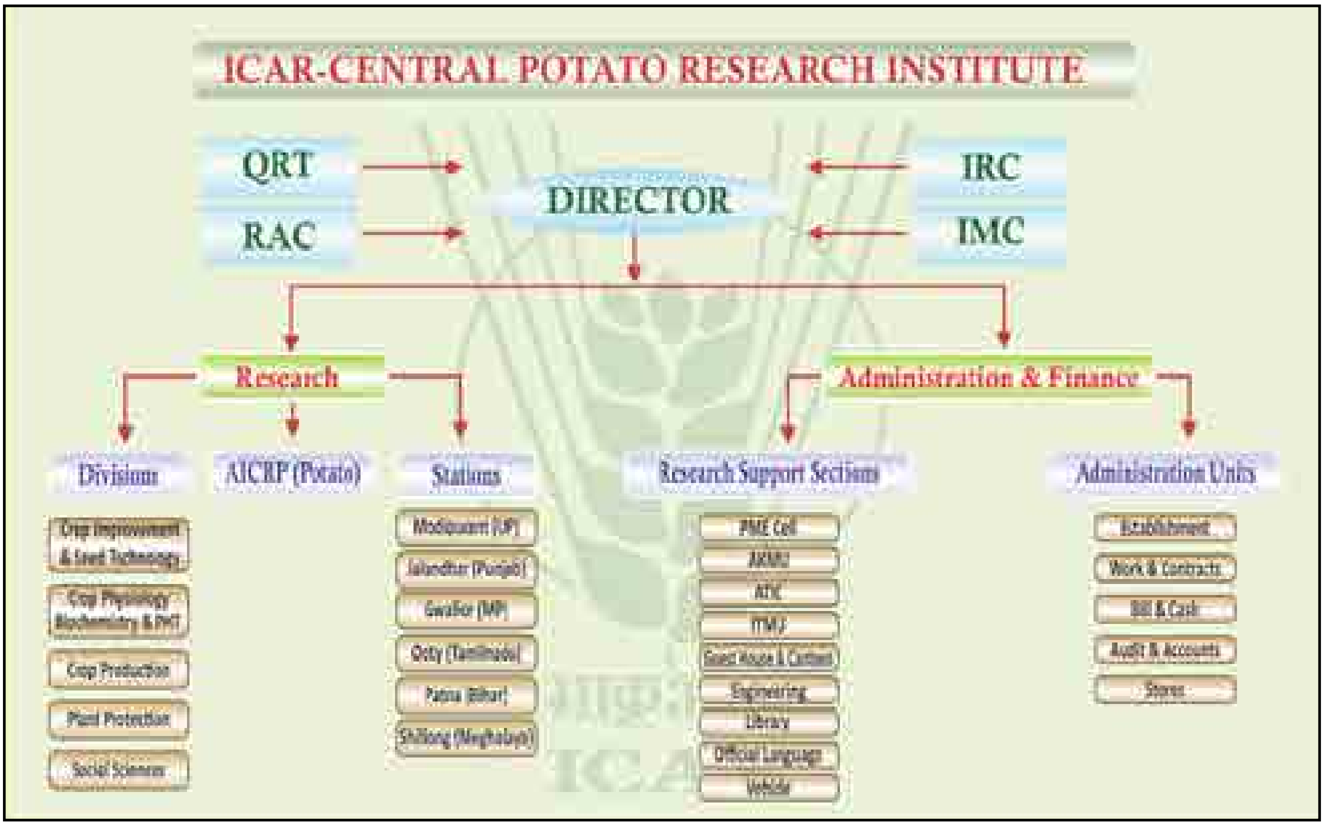
The institute has 437 sanctioned staff strength comprising of 87 scientific, 168 technical and 67 administrative staff excluding RMP. The staff position as on 31.12.2022 was 287 including 56 scientific, 115 technical, 58 administrative and 58 supporting staff. In 2023-24, total allocation was Rs. 83,93,07,000.00/- and total expenditure was 83,92,97,786.00/-. During the year, Dr. Brajesh Singh, Principal Scientist joined to the post of Director, ICAR-CPRI, Shimla on 21.01.2023 (AN), 6 principal scientists joined to the post of Head in various divisions and regional station, 1 new scientist joined the institute, 1 promoted from Senior Scientist to Principal Scientist, 1 Principal Scientist retired & 1 Principal Scientist expired. In technical category, 21 were promoted, 4 retired, 4 were transferred (inter) and 3 were transferred (intra). Under administrative category, 1 promoted, 3 retired, 1 expired, 1 transferred (intra), 1 transferred (inter), 2 transferred on selection basis, and 2 granted financial up-gradation under MACP Scheme.

FACILITIES

The institute has created state-of-the-art laboratories for conducting basic and strategic research in the field of biotechnology, genetics and plant breeding, plant protection, soil science and agronomy, plant physiology, biochemistry, and post-harvest technology. The ICAR-CPRI is the first institute, among plant science research institute of India, to introduce ELISA (1984) and ISEM (1987) for plant virus diagnosis. The virus diagnosis laboratory is now equipped with automated ELISA system, PCR and NASH facilities. Because of its unique record in the field of virus diagnosis, the Government of India has notified this laboratory as 'Accredited Test Laboratory' for testing and certification of tissue culture raised potato micro plants and minitubers.

The biotechnology laboratory of the institute, created in 1992, presently houses all the facilities for transgenic research, DNA fingerprinting, molecular breeding, micro propagation and cryo-conservation. A new laboratory has recently been created for conducting basic research on cell biology and somatic cell genetics. The 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 514.84 ha farm lands distributed over 15 units for conducting field experiments and undertaking breeders' seed production. Recently, Aeroponic facility was created at ICAR-CPRI, Shimla, ICAR-CPRI, RS, Modipuram, ICAR-CPRI, RS, Patna and ICAR-CPRI, RS, Shillong for soilless disease-free seed potato production. An Institute Technology Management Unit (ITMU) has been established at ICAR-CPRI, Shimla for commercialization of potato technologies developed by the institute., 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 REGIONAL STATIONS


ICAR-CPRI, RS, Modipuram


ICAR-CPRI, RS, Patna


ICAR-CPRI, RS, Jalandhar


ICAR-CPRI, RS, Gwalior


ICAR-CPRI, RS, Ooty


ICAR-CPRI, RS, Shillong

विशिष्ट सारांश

फसल सुधार एवं बीज प्रौद्योगिकी संभाग

आनुवंशिक संसाधन, विशेष रूप से आलू के संसाधन, सिर्फ़ एक संसाधन नहीं हैं, बल्कि टिकाऊ फसल उत्पादन के लिए एक रणनीति है। आलू सुधार कार्यक्रमों के दीर्घकालिक भविष्य के लिए आलू आनुवंशिक संसाधनों (पीजीआर) का संरक्षण महत्वपूर्ण है। इस वर्ष, हमने तीन अलग-अलग देशों से 92 स्व: पात्रे प्राप्तियां आयात की, जिनमें सीआईपी, लीमा, पेरू से 24 प्राप्तियां , यूएसए से 56 प्राप्तियां , नीदरलैंड से सात और जर्मनी से पांच संवर्धन शामिल हैं। हमने संगरोधित कीटों से मुक्त 70 प्राप्तियां को जननद्रव्य रिपोजिट्री में शामिल किया, जिससे हमारे संग्रह में वृद्धि हुई।

वर्तमान में, 30 देशों से प्राप्त, खेती और जंगली आलू प्रजातियों की 4700 से अधिक प्राप्तियां संस्थान में संरक्षित हैं। शोधकर्ताओं द्वारा उपयोग के लिए आसानी से पुनर्प्राप्त करने योग्य रूप में उक्त संग्रह का मूल्यांकन, लक्षण वर्णन और प्रलेखिकरण किया जाता है। इन्हें खेत जीन बैंकों, स्व: पात्रे रिपोजिटरी और वास्तविक बीजों के रूप में संरक्षित किया जा रहा है। गुणवत्ता बनाए रखते हुए, गुणों का प्रसंस्करण करते हुए साथ ही विभिन्न ताप प्रदीप्तिकाल के प्रति अनुकूलनशीलता के साथ संकलन का मूल्यांकन महत्वपूर्ण जैविक और अजैविक दबावों के लिए किया गया और आशाजनक प्राप्तियों की पहचान की गई। सृजित जानकारी को इलेक्ट्रॉनिक डेटाबेस में शामिल किया गया है। तीन श्रेष्ठ आनुवंशिक स्टॉक का पंजीकरण भा.कृ.अनु.प.- राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो , नई दिल्ली में करवाया गया है।

संकरण कार्यक्रम के अंतर्गत 458 संकर के द्वारा 11,77,629 वास्तविक आलू के बीज तैयार किए, जिनमें उपज, गुणवत्ता और जैविक तथा अजैविक दबावों के प्रति प्रतिरोध/सहिष्णुता के लिए बेहतर जनक शामिल थे। कुल मिलाकर 284 संकर के 5,69,447 वास्तविक आलू के बीजों से 2,29,218 पौधे प्राप्त किए गए और कटाई के समय 34,873 आशाजनक क्लोन चुने गए। प्रारंभिक क्लोनल पीढ़ियों में 22,523 क्लोनों का मूल्यांकन किया गया और कटाई के समय 3,952 आशाजनक क्लोन चुने गए। उन्नत-चरण संकर परीक्षणों में 34 परीक्षणों में उपज, गुणवत्ता और जैविक तथा अजैविक दबावों के प्रति प्रतिरोध/सहिष्णुता के लिए 487 उन्नत क्लोनों का मूल्यांकन किया गया और कटाई के समय 169 आशाजनक उन्नत क्लोन बनाए रखे गए।

कंद की उपज, पोषण और प्रसंस्करण विशेषताओं के आधार पर, मानव स्वास्थ्य के लिए आवश्यक उच्च पोषण और खनिज मूल्यों को ध्यान में रखते हुए क्लोनों का चयन किया गया। पिछले कई वर्षों से लगातार अच्छे प्रदर्शन के आधार पर, 13 उन्नत संकर, नामत: जे/15-36, जे/15-91 (प्रारम्भिक बल्किंग), पीएस/16-2 (बैंगनी गूदा युक्त), पीएस/17-12 (रक्तवर्णी), एमएस/16-1157 (उत्कृष्ट गुणवत्ता बनाए रखना), एमएसपी/17-07, एमएस/18-1272 (पोषण की दृष्टि से बेहतर), एमपी/17-330, एमपी/17-824 (प्रसंस्करण उपयोग), एचटी/17-257 (ताप सहनशील), एन/14-85, एन/15-53, एनयूई/15-23 (नाइट्रोजन उपयोग कुशल), को बहु-स्थानीय परीक्षण के लिए अखिल भारतीय समन्वित आलू अनुसंधान परियोजना में लाया गया।

उन्नत आलू क्लोन, नामतः एमएस/8-1148 (विटामिन सी युक्त) और एसएम/92-338 (शाकाणु मुरझान रोग के लिए प्रतिरोधी) को राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो द्वारा आनुवंशिक स्टॉक के रूप में पंजीकृत किया गया था। आलू जीनोम के सभी 12 गुणसूत्रों में फैले 99 एसएनपी (KASP assay) परीक्षणों के माध्यम से विभिन्न स्व-पीढ़ियों में द्विगुणित क्लोनों के समयुग्मता विश्लेषण अंतःप्रजनन (आईबीएस) के आधार पर दिखाया कि डायहैप्लोइड सहित संस्थापक द्विगुणित क्लोनों में समयुग्मता, 20.1-78.3% थी, जिसका औसत 56.7% था। S0, S1, S2 और S3 पीढ़ियों में समयुग्मता की सीमा क्रमशः 45.6-80.9, 51.2-82.8, 59.5-85.4 और 69.3-87.6% थी। सभी पीढ़ियों में क्लोनों के लिए प्राप्त समयुग्मता मान अपेक्षित मान से कम थे।

18-20 अक्टूबर, 2023 तक हरियाणा के हिसार स्थित हिसार कृषि विश्वविद्यालय में आयोजित 41वीं अखिल भारतीय समन्वित आलू अनुसंधान परियोजना (एआईसीआरपी) (आलू) समूह की बैठक में आलू की दो नई किस्मों, कुफरी सुख्याति और कुफरी जामुनिया को जारी करने की सिफारिश की गई थी। कुफरी सुख्याति एक शीघ्र स्थूलता वाली किस्म है और उत्तर भारतीय मैदानों में खेती के लिए उपयुक्त है। कुफरी जामुनिया, बैंगनी गूदे वाली एक जैव-फोर्टिफाइड आलू की किस्म है, जो उत्तर भारतीय मैदानों में उगाने के लिए उपयुक्त है। नई आलू किस्मों, कुफरी लोहित और कुफरी दक्ष को सीवीआरसी द्वारा अधिसूचित किया गया था। कुफरी लोहित, लाल छिलके वाली, अधिक उपज देने वाली किस्म है जो उत्तर भारतीय मैदानों में उगाने के लिए उपयुक्त है। कुफरी दक्ष एक जल-उपयोग

वाली कुशल किस्म है जिसकी खेती मध्य मैदानों (गुजरात, मध्य प्रदेश और छत्तीसगढ़) और पूर्वी मैदानों (उड़ीसा और उत्तर प्रदेश) में की जा सकती है।

ट्रांसक्रिप्टोम अनुक्रमण दृष्टिकोण का उपयोग करके आलू में शाकाणु मुरझान रोग प्रतिरोध लक्षणों को नियंत्रित करने वाले प्रमुख जीन और नियामक तत्वों की पहचान करने के प्रयास शुरू किए गए हैं। दो आलू जीनोटाइप यथा एसएम/92-338 और कुफरी लीमा को नियंत्रित परिस्थितियों के अंतर्गत बढ़वार कक्षों में शाकाणु मुरझान रोग के लिए जांचा गया और ट्रांसक्रिप्टोम अनुक्रमण के लिए पत्ती के नमूने लिये गए। डेटा विश्लेषण कार्य प्रगति पर है। आलू के सभी सहलग्नता समूहों को कवर करने वाले कुल 360 जीनोमिक-एसएसआर मार्करों का मूल्यांकन आलू के जर्मप्लाज्म और किस्मों के लक्षण वर्णन के लिए एसएसआर मार्करों का एक मुख्य सेट विकसित करने के लिए किस्मों, जर्मप्लाज्म, सोमैटिक हाइब्रिड और जंगली प्रजातियों से युक्त 12 आलू जीनोटाइप के प्रतिनिधि सेट में उनकी बहुरूपी क्षमता के लिए किया गया था। अब तक, 179 एसएसआर चिह्नक बहुरूपी हैं।

जीनोम-वाइड एसोसिएशन मैपिंग अध्ययन ने पिछेता झुलसा के लिए 7 एसएनपी एसोसिएशन और जी. पैलिडा के लिए 9 की पहचान की, जबकि 11 एसएनपी को जी. रोस्टोचेंसिस प्रतिरोध से जुड़ा पाया गया। जी. पैलिडा (0.04-0.14) और जी. रोस्टोचेंसिस (0.14-0.21) के प्रतिरोध के लिए जीनोमिक चयन संभावना सटीकता अनुमान कम से मध्यम थे, जबकि पिछेता झुलसा के प्रति प्रतिरोध ने 0.42-0.51 की सटीकता की उच्च संभावना दिखाई। यह अध्ययन आलू में इन जैविक दबाव लक्षणों की जटिल आनुवंशिक प्रकृति और प्रतिरोध प्रजनन के लिए संभावित एसएनपी चिह्नकों के बारे में जानकारी प्रदान करता है।

129.44 हेक्टेयर क्षेत्र से कुल 27622.92 क्विंटल न्यूक्लियस और प्रजनक बीज का उत्पादन किया गया। इसमें से 101.83 हेक्टेयर से 21387.89 क्विंटल उत्पादन पारंपरिक तरीके से और 27.61 हेक्टेयर से 6235.03 क्विंटल हाई-टेक बीज उत्पादन प्रणाली के माध्यम से हुआ। पारंपरिक प्रणाली से न्यूक्लियस और प्रजनक बीज का प्रतिशत 77.42 और हाई-टेक प्रणाली के माध्यम से 22.58 प्रतिशत था। 2023 के दौरान, मैदानी इलाकों की विभिन्न सरकारी और निजी एजेंसियों को कुल 21807.89 क्विंटल ब्रीडर बीज की आपूर्ति की गई। कुल 22 किस्मों को रोपित किया गया और विभिन्न आलू विषाणुओं के विरुद्ध एलिसा/पीसीआर के साथ उनका परीक्षण किया गया। पीसीआर/एलिसा के माध्यम से परीक्षणों की एक श्रृंखला आयोजित करने के बाद, सभी स्वस्थ किस्मों को स्थानांतरित कर दिया गया और माइक्रोप्लांट गुणन और आपूर्ति श्रृंखला में स्व: पात्रे संवर्धनों के रूप में शामिल किया गया। इसके अलावा, 31 किस्मों की मूल बीज सामग्री के 334 वायरस-मुक्त स्व: पात्रे संवर्धन ट्यूब, 40 विभिन्न बीज-उत्पादक संगठनों को आपूर्ति किए गए। स्व: पात्रे ट्यूबों की बिक्री से 16,70,000 रुपये का राजस्व उत्पन्न हुआ और पंजीकरण शुल्क के रूप में 1,00,000 रुपये प्राप्त हुए। प्रजनक बीज के निपटान से कुल 10.6 करोड़ रुपये का राजस्व उत्पन्न हुआ है। उच्च तकनीक बीज सामग्री में सफलतापूर्वक वृद्धि करने के लिए बीज अनुसंधान में विभिन्न कृषि तकनीकों को अपनाया गया है। कुफरी बहार के लिए, पारंपरिक कंदों से GA के साथ और उसके रहित मेरि-क्लोन विकसित किए गए हैं। इन पौधों से प्राप्त कंद, कुफरी बहार की मूल किस्म से मिलते जुलते थे। माइक्रो-क्लोनल प्रसार, एरोपोनिक्स और फील्ड लेवल के लिए बैसिलस सेरेस (कुफरी स्ट्रेन, एसजीएल-6) के उपयोग की खोज की गई है।

फसल उत्पादन संभाग

'आलू की बेहतर उत्पादकता और स्थिरता के लिए पोषक तत्व और जल प्रबंधन' कार्यक्रम के तहत वर्ष 2023 के दौरान चार प्रमुख शोध गतिविधियों के अंतर्गत कार्य किया गया।

कम लागत वाली तकनीक विकसित करने के लिए मोदीपुरम में तीन और ग्वालियर में एक प्रयोग किया गया। मोदीपुरम में, आलू की किस्म कुफरी बहार ने ड्रिप सिंचाई के तहत सबसे अच्छा प्रदर्शन किया और विभिन्न खाद पद्धतियों के तहत उच्चतम कंद उपज (29.1 टन प्रति हेक्टेयर) प्राप्त की। हरी खाद वाली फसल से पहले एनपीके का 75% प्रयोग करने से 100% एनपीके के बराबर उपज उत्पन्न हुई, जिससे एनपीके की 25% मात्रा की बचत हुई। फसल की महत्वपूर्ण अवस्था पर सिंचाई के साथ-साथ 15 टन प्रति हेक्टेयर की दर से एफवाईएम के प्रयोग से दो सिंचाई यानी 28% पानी की बचत हो सकी, नई जारी की गई जल दबाव प्रतिरोधी आलू की किस्म कुफरी थार-3 के लिए सिंचाई और मैक्रो-पोषक तत्वों की आवश्यकताओं को अनुकूलित किया गया और 20 मिमी सीपीई पर सिंचाई करने से अन्य उपचारों की तुलना में काफी अधिक कंद उपज (22.3 टन प्रति हेक्टेयर) और संख्या (531 000 हेक्टेयर) प्राप्त हुई। उर्वरता के स्तर के मामले में, एनपीके की 100% अनुशंसित मात्रा ने अधिकतम उपज (21.4 टन प्रति हेक्टेयर) उत्पन्न की। परिणामों से पता चला कि स्प्रिंकलर सिंचाई में सबसे अधिक कुल कंद उपज (29 टन प्रति हेक्टेयर) ग्वालियर में दर्ज की गई और पोषक तत्वों के स्तरों में, सेसबानिया-आलू (75% आरडीएफ एनपीके + एफवाईएम15 टन

प्रति हेक्टेयर) में सबसे अधिक कुल कंद उपज (33 टन प्रति हेक्टेयर) देखी गई।

जालंधर में, आलू की फसल के लिए उपभोग्य जल उपयोग पैटर्न का आकलन और जल कुशल प्रौद्योगिकियों की खोज हेतु कार्य किया गया था। आलू की किस्म कुफरी ज्योति में, 100% ईटीआरईएफ पर जल अनुप्रयोगों के साथ काटा गया बायोमास काफी अधिक था, जबकि 150% ईटीआरईएफ पर सिंचाई के साथ कुल और साथ ही विपणन योग्य पैदावार उच्चतम (39.4 और 36.8 टी हेक्टेयर-1) रही। हालांकि, इसने 18% की दर से टूटे हुए कंदों (> 1 इंच लंबाई) का अधिकतम प्रतिशत भी दर्ज किया। आलू की खेती में फास्फोरस (पी) उपयोग दक्षता में सुधार करने के प्रयास जारी हैं। जालंधर में, 20 टन चावल की भूसी (आरएचए) के साथ 75% अनुशंसित फास्फोरस के प्रयोग से कुफरी पुखराज के कंद उपज में उल्लेखनीय वृद्धि (41.4 टन प्रति हैक्टर) हुई, जबकि केवल 75% अनुशंसित फास्फोरस की मात्रा से यह वृद्धि (37.6 टन प्रति हैक्टर) हुई। क्लोन जे/15-91, जे/14-242 और सीपी-4444 ने कंद उपज के आधार पर बेहतर प्रदर्शन किया और इन्हें अग्रिम मूल्यांकन के लिए चुना गया।.

शिमला में फास्फोरस संचयन में जीनोटाइपिक परिवर्तनशीलता पर किए गए अध्ययनों से पता चला कि पत्तियों में फास्फोरस की सांद्रता (0.20-0.47%) में बड़ी जीनोटाइपिक परिवर्तनशीलता है। जनन द्रव्य में इस परिवर्तनशीलता का उपयोग फास्फोरस कुशल किस्मों के प्रजनन के लिए किया जा सकता है। हिमालयी एसिड अल्फिसोल्स में आलू में एएम-कवक और पीएसबी के सह-संरोपण के माध्यम से फास्फोरस उपयोग दक्षता में सुधार करने के लिए शिमला में एक क्षेत्र अध्ययन संपन्न किया गया। यह देखा गया कि कम मिट्टी में फास्फोरस के प्रयोग पर, उच्च मिट्टी में फास्फोरस के प्रयोग की तुलना में पीएसबी + एएमएफ या पर्ण-फाइबर की प्रतिक्रिया बेहतर (10.4-16.5%) थी। शिलांग में, एक प्रारंभिक अध्ययन में, अकेले अनुशंसित फास्फोरस P के 20 और 40% की तुलना में SSP (अनुशंसित मात्रा का 20 और 40%) + पीएसबी PSB (पूसा माइक्रोफॉस) + एएमएफ (पूसा माइकोराइजा) + दो पत्तियों पर फास्फोरस P के संयुक्त प्रयोग से वर्षा आधारित परिस्थितियों में कुफरी गिरधारी की उपज में उल्लेखनीय वृद्धि हुई।

पहाड़ी क्षेत्रों में कम पीएच मृदा प्रबंधन के लिए स्पेंट मशरूम सब्सट्रेट (एसएमएस) का उपयोग किया गया। शिलांग में, छह महीने पुराने प्राकृतिक रूप से अपक्षयित एसएमएस में आलू की कुल और विपणन योग्य कंद उपज 20 टन प्रति हेक्टेयर + आरडीएफ पर लागू होने पर एफवाईएम की तुलना में 15 टन प्रति हेक्टेयर + आरडीएफ पर लागू होने पर काफी अधिक थी। ऊटी में, आलू की किस्म कुफरी स्वर्णा में कुल (33.8 टन प्रति हैक्टर) तथा विपणन योग्य (30.1 टन प्रति हैक्टर) कंद उपज दर्ज की गई, तथा उर्वरक की अनुशंसित मात्रा तथा समृद्ध मशरूम सब्सट्रेट का प्रयोग अनुशंसित पोषक तत्व प्रबंधन पद्धतियों के साथ तुलनीय रहा। इस अवधि के दौरान, मध्य प्रदेश के लिए उर्वरक मात्रा की गणना के लिए एक वेब-आधारित निर्णय समर्थन प्रणाली भी विकसित की गई थी।

पौध संरक्षण संभाग

रबी 2023 के दौरान सभी आलू उत्पादक क्षेत्रों में पिछेता झुलसा के लक्षण बहुत पहले दिखाई दिए, लेकिन इसने कुछ विशेष इलाकों में ही उपज को प्रभावित किया। आलू के खेतों में फाइटोफ्थोरा इन्फेस्टांस के स्व-उपजाऊ (होमोथैलिक) पृथक्कों की उपस्थिति देखी पी. इन्फेस्टांस के पृथक्कों ने साइमोक्सानिल के प्रति असंवेदनशीलता दर्शाई है, जो यह दर्शाता है कि रोगाणु साइमोक्सानिल आधारित कवकनाशी के प्रति प्रतिरोध विकसित कर रहा है, जो सभी आलू हितधारकों के लिए चिंता का कारण है। पृथकों को अभी भी मेटालैक्सिल के प्रति प्रतिरोधी और मध्यम प्रतिरोधी पाया गया, जबकि डाइमेथोमोर्फ और फेनामिडोन के प्रति संवेदनशील पाया गया। स्ट्रेप्टोमाइसीज पृथकों के आणविक लक्षण-निर्धारण से स्ट्रेप्टोमाइसीज की लगभग एक दर्जन विविध प्रजातियां प्राप्त हुईं। आलू वायरस ए (पीवीए) का तेजी से पता लगाने के लिए एक मजबूत एकल-चरण रिवर्स ट्रांसक्रिप्शन रिकॉम्बिनेज पॉलीमरेज़ एम्प्लीफिकेशन (आरटी-आरपीए) परख विकसित की गई है। इंडो-ब्लाइटकास्ट मॉडल ने कृषि-पारिस्थितिकी में पिछेता झुलसा रोग के प्रकट होने का पूर्वानुमान काफी पहले ही लगा दिया था और तदनुसार इसके प्रबंधन के लिए कृषि-सलाह जारी की गई थी।

महामारी विज्ञान संबंधी अध्ययनों से पता चला है कि स्व-उपजाऊ आइसोलेट्स A1 और A2 युग्मन प्रकारों के साथ समान रूप से प्रतिस्पर्धी हैं, इस प्रकार पिछेता झुलसा प्रबंधन के लिए एक गंभीर खतरा पैदा करते हैं। वैलिफेनालेट 6% + मैन्कोजेब 60% डब्ल्यूजी @ 0.5% का प्रयोग, फेनामिडोन 10 + मैन्कोजेब 50% डब्ल्यूजी @ 0.3% और डायमेथोमॉर्फ 50% डब्ल्यूपी @ 0.1% के समान ही पिछेता झुलसा के विरुद्ध प्रभावी पाया गया। आलू की काली रूसी के विरुद्ध इमिडाक्लोप्रिड 17.8 एसएल @ 0.04% + पेनफ्लूफेन 22.43% एफएस @ 0.1% के साथ कंद बीज का उपचार पेन्सीक्यूरोन 22.9% एससी और थिफ्लूजामाइड 24% एससी @ 0.5% के समान था। साधारण खुरंड का विकास मृदा पीएच (4.0 से 9.0) की व्यापक श्रेणी के अंतर्गत हो सकता है;

हालांकि, मृदा पीएच में वृद्धि के साथ साधारण खुरंड की गंभीरता में क्रमिक वृद्धि भी देखी गई। साधारण खुरंड के विकास में मिट्टी की नमी की कोई महत्वपूर्ण भूमिका नहीं देखी गई। ClO2 (0.3%) को सबसे अधिक प्रभावी पाया गया तथा इसने एस. स्कैबीई की वृद्धि को लगभग पूरी तरह से बाधित कर दिया, इसके बाद NaOCl का स्थान रहा, जबकि बोरिक एसिड सबसे कम प्रभावी रहा।

साधारण खुरंड रोग के विरुद्ध आलू जर्मप्लाज्म की स्व: पात्रे जांच के लिए एक नवीन ऊतक संवर्धन-आधारित विधि विकसित की गई। यह विधि त्वरित, सरल और प्रयोगशाला में व्यवहार्य है तथा सूक्ष्म-कंदों पर लक्षण, संरोपण के 7-10 दिनों के भीतर विकसित हो जाते हैं। इस विधि द्वारा साधारण खुरंड रोग के विरुद्ध किस्मों (27) की जांच से पता चला कि परीक्षण की गई किसी भी किस्म में इस रोग के प्रति प्रतिरोधिता नहीं है। आलू की किस्म एसएम/92-338 में कटाई तक कोई भी मुरझाने का लक्षण नहीं दिखा। एसएम/11-93, पीएपी 2-4 और कुफरी ज्योति में शाकाणु मुरझान रोग का प्रकोप क्रमशः 20.0, 20.0 और 100.0% था। एस.एम./92-338, एस.एम./03-23 और पी.ए.पी. 2-4 में भूरा गलन का प्रकोप क्रमशः 2.0, 20.0 और 20.0% था, जबकि कुफरी ज्योति में यह 100.0% था। पर्यावरणीय उत्सर्जन के लिए पिछेता झुलसा प्रतिरोधी जीई आलू KJ66 के जैव सुरक्षा मूल्यांकन पर किए गए अध्ययनों से पता चला है कि KJ66 में पिछेता झुलसा प्रतिरोध का स्तर उच्च है। कीटों और रोगों के प्रकोप के आंकड़ों से पता चलता है कि जीई आलू KJ66 की संवेदनशीलता का स्तर अन्य सभी परीक्षित पारंपरिक गैर-ट्रांसजेनिक समकक्षों और जांचों के समान था और इसमें कीटों और रोगों का कोई बढ़ा हुआ प्रकोप नहीं दिखा।

आलू के जीव विज्ञान, महामारी विज्ञान और कीटों के प्रबंधन पर परियोजना ने कीट प्रबंधन के विभिन्न पहलुओं पर महत्वपूर्ण निष्कर्ष सामने रखे। एफिड उड़ान गतिविधि में उल्लेखनीय उतार-चढ़ाव देखा गया, जिससे सतर्क कीट प्रबंधन रणनीतियों के महत्व पर बल दिया गया। इसके अतिरिक्त, कीटों के प्रकोप पर विभिन्न रोपण तिथियों के प्रभाव ने संक्रमण के स्तर में स्पष्ट भिन्नता को उजागर किया, विशेष रूप से एफिड्स और लीफहॉपर के संबंध में, जिससे आलू की खेती में रणनीतिक रोपण प्रथाओं और निरंतर निगरानी के महत्व को रेखांकित किया गया। इसके अलावा, डीएनए बारकोडिंग के माध्यम से आलू के पौधों को संक्रमित करने वाले थ्रिप्स टैक्सा की पहचान ने लक्षित प्रबंधन रणनीतियों के लिए बहुमूल्य अंतर्दृष्टि प्रदान की। प्रारंभिक और मुख्य आलू फसलों में एफिड और कोक्सीनेलिड बीटल की आबादी में उतार-चढ़ाव देखा गया, तथा सहसंबंध विश्लेषण से इन कीटों के बीच रोचक संबंध का पता चला। इसके अलावा, आलू की फसलों पर एफिड्स, व्हाइटफ्लाई और लीफहॉपर की सह-उपस्थिति और सहसंबंध पर किए गए अध्ययन से इन कीटों के बीच कमजोर और सांख्यिकीय रूप से महत्वहीन संबंध सामने आए।

आलू की विभिन्न किस्मों पर एफिड और सफेद मक्खी के प्रकोप के मूल्यांकन से पता चला कि हालांकि किस्म के चयन से कीटों की आबादी पर कोई खास प्रभाव नहीं पड़ा, लेकिन विभिन्न किस्मों के बीच औसत संख्या में भिन्नताएं थीं। इसके अतिरिक्त, टुटा एब्सोल्यूटा ने बेमिसिया टैबैसी द्वारा क्षतिग्रस्त आलू के पौधों के प्रति महत्वपूर्ण आकर्षण प्रदर्शित किया, तथा गैस क्रोमैटोग्राफी-मास स्पेक्ट्रोमेट्री विश्लेषण से संक्रमित और असंक्रमित आलू के पौधों के बीच वाष्पशील संरचना में उल्लेखनीय परिवर्तन का पता चला। एकीकृत कीट प्रबंधन (आईपीएम) पद्धतियों से प्रबंधित आलू की फसलों पर कीटों के प्रकोप और रोगों के आगमन का आकलन करने के लिए किए गए अध्ययन की तुलना में गैर-आईपीएम क्षेत्रों में किए गए अध्ययन से पता चला कि आईपीएम और गैर-आईपीएम क्षेत्रों के बीच एफिड और व्हाइटफ्लाई की आबादी में कोई महत्वपूर्ण अंतर नहीं है। हालांकि, आईपीएम उपचारित फसलों में आलू के शीर्षस्थ पत्ती कुंचन और गंभीर चित्ती के लिए कम रोगग्रस्त पौधे देखे गए, जिससे आईपीएम पद्धतियों के साथ कीट और रोग प्रबंधन में संभावित प्रभावशीलता का संकेत मिलता है। इसके अलावा, सफेद इल्ली के विरुद्ध कीटनाशकों के मूल्यांकन से पता चला कि विभिन्न उपचारों के कारण कंदों को होने वाले नुकसान और वजन में कमी में महत्वपूर्ण भिन्नताएं हैं, जिसमें क्लोथियानिडिन 50WDG ने पहाड़ी इलाकों में आलू की खेती में सफेद इल्ली से होने वाले नुकसान के प्रबंधन की क्षमता दिखाई है। अंत में, माइज़स पर्सिका को संक्रमित करने वाले एन्टोमोपैथोजेनिक कवक के पृथक्करण, पहचान और रोगजनकता के आकलन पर किए गए अध्ययन में कवक की पहचान एकेंथोमाइसेस डिप्टेरिजेनस के रूप में की गई, जिससे यह पता चला कि माइज़स पर्सिका के विरुद्ध सूक्ष्मजीवी नियंत्रण एजेंट के रूप में इसकी क्षमता है। इसके अतिरिक्त, एम. पर्सिका में नियोनिकोटिनोइड्स के प्रति प्रतिरोध के तंत्र की जांच से दो प्रमुख तंत्रों का पता चला, जिससे कीट प्रबंधन रणनीतियों के लिए बहुमूल्य अंतर्दृष्टि प्राप्त हुई।

आलू के नेमाटोड कीटों के जीव विज्ञान, पारिस्थितिकी और प्रबंधन पर परियोजना से आलू सिस्ट नेमाटोड (पीसीएन) के खिलाफ प्रभावी प्रबंधन रणनीतियों के लिए महत्वपूर्ण अंतर्दृष्टि प्राप्त हुई है। तीन साल के डेटा विश्लेषण से पता चला कि बेसिलस सेरेस SGL6 को ट्रैप फसलों और गैर-होस्ट फसलों के साथ शामिल करने वाले उपचारों ने नेमाटोड प्रजनन कारकों को काफी हद तक कम कर दिया, जिससे PCN प्रबंधन के लिए उनकी क्षमता का प्रदर्शन हुआ।

इसी तरह, परती या गैर-होस्ट फसलों के बाद ब्लीचिंग पाउडर के प्रयोग से सिस्ट आबादी में उल्लेखनीय कमी देखी गई। इसके अलावा, विभिन्न फसल प्रणालियों पर किए गए अध्ययन ने PCN आबादी को कम करने में विशिष्ट फसल चक्रों की प्रभावकारिता पर प्रकाश डाला, जिसमें ओट-सरसों-सरसों-जाल जैसे संयोजनों ने आशाजनक परिणाम दिखाए। इसके अतिरिक्त, PCN के लिए नए हैचिंग कारकों के रूप में मोटे अनाजों और अनाज की जड़ रिसाव की खोज संभावित वैकल्पिक नियंत्रण विधियों में मूल्यवान अंतर्दृष्टि प्रदान करती है।

फसल कार्यिकी, जैव रसायन विज्ञान एवं और फसलोत्तर प्रौद्योगिकी संभाग

सबसे अधिक इस्तेमाल किए जाने वाले अंकुर दमनक आइसोप्रोपाइल एन-(3-क्लोरोफेनिल) कार्बामेट (सीआईपीसी) के नवीन और पर्यावरण की दृष्टि से सुरक्षित विकल्प का पता लगाने के लिए, सात वाष्पशील तेलों के संयोजन को 16 किस्मों पर शुद्ध प्रयोग को 120 दिनों के लिए अंकुर नियंत्रण में अत्यधिक प्रभावी पाया गया। कुफरी चंद्रमुखी किस्म पर एक अन्य प्रारंभिक परीक्षण में, आठ वाष्पशील तेलों के संयोजन के शुद्ध प्रयोग को 300 दिनों के लिए अंकुर नियंत्रण में प्रभावी पाया गया।

आलू में एस्कॉर्बिक एसिड और कैरोटीनॉयड मात्रा पर खाना पकाने के तरीकों के प्रभाव का अध्ययन किया गया और यह पाया गया कि उबालने की तुलना में माइक्रोवेव में खाना पकाने से इन यौगिकों की अवधारण अधिक होती है। इस प्रयोग में अध्ययन की गई सात किस्मों में से कुफरी सूर्या में एस्कॉर्बिक एसिड और कैरोटीनॉयड की मात्रा अधिकतम पाई गई।

इस वर्ष तीन नए उत्पाद विकसित किए गए जिनमें आलू-काले चने की बूंदी, ग्लूटेन मुक्त आलू-कोदो कुकीज और पटेटो स्वर्ल्स शामिल हैं। आलू आधारित बूंदी का स्वाद और कुरकुरी बनावट अद्वितीय है। आलू-कोदो कुकीज आहार रेशा (~ 6.7%), कैल्शियम (~ 39 मिलीग्राम / 100 ग्राम) और पोटेशियम (~ 270 मिलीग्राम / 100 ग्राम) से भरपूर हैं। इस तकनीक में उन्हें आटे में परिवर्तित करके कटाई के बाद के नुकसान के प्रतिशत को कम करने की क्षमता है, जिसका उपयोग कम उपयोग किए जाने वाले मोटे अनाजों के लाभों के साथ-साथ बेकरी उत्पादों के उत्पादन के लिए किया जा सकता है। आलू-कोदो कुकीज का अनूठा निर्माण उन्हें सीलिएक और गेहूं की एलर्जी वाले लोगों के लिए भी उपयुक्त बनाता है। यह तकनीक किसी भी आकृति, आकार और किस्म के आलू पर लागू होती है, चाहे वे ताजे हों या शीत भण्डारित। आलू आधारित सहजीवी विकास के मोर्चे पर जीवाणुओं की दस प्रजातियां आशाजनक पाई गई हैं।। संभाग में विकसित कुल तीन तकनीकों को भाकृअनुप द्वारा प्रमाणित किया गया।

सामाजिक विज्ञान विभाग

120 उत्पादकों का यादृच्छिक साक्षात्कार करके आलू उत्पादन की उत्पादन लागत और आर्थिक लाभ का अनुमान लगाने से पता चला कि कुल लागत रु. 1,48,611/- थी। सकल और शुद्ध आय क्रमशः ₹224343/- और ₹75732/- थी, जिसमें बी:सी अनुपात 1.51 था। बिहार में 120 किसानों और उत्तर प्रदेश में 140 किसानों के सर्वेक्षणों से प्राप्त आंकड़ों से पता चला कि कुफरी पुखराज ने बिहार में आलू के क्षेत्रफल में लगभग 57% का योगदान दिया, उसके बाद के. सिंधुरी (~11%) और के. ज्योति (~10%) का स्थान रहा। उत्तर प्रदेश में आलू के क्षेत्रफल के 43% के साथ, कुफरी बहार सबसे लोकप्रिय किस्म पाई गई, उसके बाद के. चिप्सोना-1 (19%), के. मोहन (6.27%) और के. ख्याति (6.15%) का स्थान है। गैरेट की रैंकिंग तकनीक के अनुसार, बिहार में आलू उत्पादकों द्वारा गुणवत्ता/प्रमाणित आलू के बीज अपनाने में सामने आने वाली मुख्य बाधा आवश्यक किस्मों की अनुपलब्धता (स्कोर=63.83, रैंक I) थी, उसके बाद उच्च बीज लागत (स्कोर=60.32, रैंक II) और कोल्ड स्टोरेज की कमी (स्कोर=50.37, रैंक III) थी। उत्तर प्रदेश में, पहली महत्वपूर्ण बाधा आवश्यक किस्मों के बीजों की कमी (स्कोर=69.47, रैंक I) थी, उसके बाद बीजों की उच्च लागत (स्कोर=65.17, रैंक II) और उन्नत किस्मों के बारे में जानकारी का अभाव (स्कोर=51.44, रैंक III) था।

भारतीय आलू निर्यात के प्रदर्शन का विश्लेषण करने के लिए APEDA और विश्व बैंक के डेटा का उपयोग किया गया। TE 2022-23 के दौरान, ताजे आलू, बीज आलू और आलू उत्पादों की कुल निर्यात की मात्रा 5.59 लाख टन थी और कुल निर्यात मूल्य ₹14.56 बिलियन था। 2003-03 से 2022-24 के दौरान कुल निर्यात मात्रा का कंपाउंड एनुअल ग्रोथ रेट 14.1% है। आलू उत्पादों की निर्यात मात्रा TE 2005-06 के दौरान 7295.00 टन से बढ़कर TE 2022-23 में 1.56 लाख टन हो गई, जिसमें निर्यात मात्रा का कंपाउंड एनुअल ग्रोथ रेट 15.4% था। TE 2022-23 के दौरान आलू उत्पादों का निर्यात कुल निर्यात मात्रा का 28.01% और कुल निर्यात मूल्य का 54.82% है।

संस्थान ने देश भर के अधिकारियों, किसानों और अन्य आलू हितधारकों के लिए मुख्यालय और क्षेत्रीय केंद्रों पर 29 प्रशिक्षण कार्यक्रम आयोजित किए। संस्थान ने 4 प्रदर्शनियाँ, 3 किसान गोष्ठी, 3 जागरूकता शिविर, 5 क्षेत्र दिवस, राष्ट्रीय आलू दिवस

और कई अन्य आउटरीच कार्यक्रम भी आयोजित किए। भाकृअनुप-के.आ.अनु.सं. , शिमला और इसके क्षेत्रीय केंद्रों के विभिन्न विषय विशेषज्ञ वैज्ञानिकों ने दूरदर्शन और आकाशवाणी पर 14 लाइव फोन-इन कार्यक्रमों में भाग लिया। किसान कॉल सेंटर, मोदीपुरम केंद्र और के.आ.अनु.सं. के व्हाट्सएप आलू सलाहकार समूह के माध्यम से आलू उत्पादकों के 1000 से अधिक प्रश्नों का उत्तर दिया गया। 7000 से अधिक आगंतुकों को संस्थान की अनुसंधान और विस्तार गतिविधियों और प्रौद्योगिकियों से अवगत कराया गया। मानव संसाधन विकास प्रकोष्ठ के तहत, 9 वैज्ञानिकों, 7 तकनीकी अधिकारियों और 12 प्रशासनिक अधिकारियों को विभिन्न प्रशिक्षण कार्यक्रमों में प्रतिभागिता के लिए भेजा गया।

EXECUTIVE SUMMARY

DIVISION OF CROP IMPROVEMENT & SEED TECHNOLOGY

Genetic resources, particularly those of the potato, are not just a resource but a strategic one for sustainable crop production. The conservation of potato genetic resources (PGRs) is critical for the long-term future of potato improvement programs. This year, we imported 92 in-vitro accessions from 3 different countries, including 24 accessions from CIP, Lima, Peru, 56 accessions from the USA, seven from the Netherlands, and five cultures from Germany. We introduced 70 accessions free from quarantined pests to the germplasm repository, further enhancing our collection.

Presently, more than 4700 accessions of cultivated and wild potato species, obtained from 30 countries, are conserved at the institute. The collection is evaluated, characterized, and documented in an easily retrievable form for use by the researchers. These are being conserved in field gene banks, in vitro repositories, and as true seeds. Many accessions were evaluated for various biotic and abiotic stresses, keeping quality, processing attributes, quality attributes, and adaptability to various thermos-photoperiods, and promising accessions were identified. Generated information has been maintained in electronic databases. Three elite genetic stocks were registered with the ICAR-NBPGR, New Delhi.

The hybridization program produced 11,77,629 true potato seeds from 458 crosses involving superior parents for yield, quality, and resistance/tolerance to biotic and abiotic stresses. In all, 2,29,218 seedlings were recovered from 5,69,447 true potato seeds of 284 crosses, and at harvest, 34,873 promising clones were selected. In initial clonal generations, 22,523 clones were evaluated, and 3,952 promising clones were selected at harvest. In advanced-stage hybrids trials, 487 advanced clones were assessed in 34 trials for yield, quality, and resistance/tolerance to biotic and abiotic stresses, and at harvest, 169 promising advanced clones were retained. Based on tuber yield, nutritional and processing attributes, selections were made aiming for high nutritional and mineral values in clones essential for human health. Based on consistently good performance over the years, 13 advanced-stage hybrids, namely J/15-36, J/15-91 (early bulking), PS/16-2 (purple fleshed), PS/17-12 (red skin), MS/16-1157 (excellent keeping quality), MSP/17-07, MS/18-1272 (nutritionally superior), MP/17-330, MP/17-824 (processing use), HT/17-257 (heat tolerant), N/14-85, N/15-53, NUE/15- 23 (Nitrogen use efficient), have been introduced in AICRP for multi-location testing. Advanced potato clones, namely MS/8-1148 (rich in vitamin C) and SM/92-338 (resistant to bacterial wilt) were registered as genetic stocks by NBPGR. The homozygosity analysis of diploid clones in different selfing generations through 99 SNP KASP assays spread across all the 12 chromosomes in the potato genome based on inbreeding by state (IBS) showed that the homozygosity in the founder diploid clones, including dihaploids varied from 20.1-78.3% with an average of 56.7%. The range of homozygosity in S_0, S_1, S_2 and S_3 generations was 45.6-80.9, 51.2-82.8, 59.5-85.4 and 69.3-87.6%, respectively. The realized homozygosity values were lower than the expected value for clones in all the generations.

Two new potato varieties, namely Kufri Sukhyati and Kufri Jamunia, were recommended for release in the 41st AICRP (Potato) group meeting held at HAU, Hisar, Haryana, from 18-20 October 2023. Kufri Sukhyati is an early bulking variety and is suitable for cultivation in the north Indian plains. Kufri Jamunia is a biofortified potato variety with purple flesh, suitable for growing in the north Indian plains. New Potato varieties, Kufri Lohit and Kufri Daksh were notified by CVRC. Kufri Lohit is a red-skinned, high-yielding variety suitable for growing in north Indian plains. Kufri Daksh is an efficient water-use variety that can be cultivated in the central plains (Gujarat, Madhya Pradesh, and Chhattisgarh) and eastern plains (Orissa and Uttar Pradesh).

Efforts have been initiated to identify key genes and regulatory elements governing bacterial wilt resistance traits in potatoes using a transcriptome sequencing approach. Two potato genotypes viz. SM/92-338 and Kufri Lima were screened for bacterial wilt disease in the growth chambers under controlled conditions, and leaf samples were procured for transcriptome sequencing. The data analysis work is in progress. A total of 360 genomic-SSR markers covering all the linkage groups of potatoes were evaluated for their polymorphic potential in a representative set of 12 potato genotypes, comprising of varieties, germplasm, somatic hybrids, and wild species to develop a core set of SSR markers for potato germplasm and varieties characterization. So far, 179 SSR markers are polymorphic.

A genome-wide association mapping study identified 7 SNP associations for late blight, and 9 for *G. pallida,* while 11 SNPs were detected to be associated with *G. rostochiensis* resistance. The genomic selection prediction accuracy estimates were low to moderate for resistance to *G. pallida* (0.04-0.14) and *G. rostochiensis* (0.14-0.21), while late blight resistance showed a high prediction accuracy of 0.42-0.51. This study provides information on the complex genetic nature of these biotic stress traits in potatoes and putative SNP markers for resistance breeding.

A total of 27622.92 qtls nucleus and breeder seed production was achieved from 129.44 ha area. Of this, 21387.89 qtls production from 101.83 ha was through conventional and 6235.03 qtls from 27.61 ha through hi-tech seed production systems. The percentage of nucleus and breeder seed from the conventional system was 77.42 and 22.58 through the hi-tech system. During 2023, a total of 21807.89 qtls of breeder seed was supplied to various government and private agencies from plains. A total of 22 varieties were planted and tested with ELISA/PCR against different potato viruses. After conducting a series of tests through PCR/ELISA, all healthy varieties were shifted and included as in vitro cultures in the microplants multiplication and supply chain. Besides, 334 virus-free in vitro culture tubes of basic seed material of 31 varieties were supplied to 40 different seed-producing organizations. A revenue of Rs. 16,70,000/- was generated from the sale of in vitro tubes and Rs.1,00,000 was received as a registration fee. Total revenue of Rs. 10.6 crores have been generated by the disposal of breeder seed. Various agro techniques have been deployed in seed research to multiply hi-tech seed material successfully. For Kufri Bahar, meri-clones from the conventional tubers have been developed with and without GA. The tubers harvested from these plants resembled the original variety K. Bahar. The use of *Bacillus cereus* (Kufri strain, SGL-6) has been explored for micro-clonal propagation, aeroponics, and field level.

DIVISION OF CROP PRODUCTION

Work under four major research activities was carried out during 2023 under the programme 'Nutrient and Water Management for Improved Productivity and Sustainability of Potato'.

Three experiments were conducted at Modipuram and one at Gwalior for developing low-cost technology. At Modipuram, potato cv. Kufri Bahar performed best under drip irrigation highest tuber yield (29.1 t ha^{-1}) under different manurial practices. Application of 75 % of NPK+ preceding green manure crop produced yield equivalent to 100% NPK thereby saving 25% NPK dose Irrigations at critical stages of crop along with application of FYM @ 15 t ha^{-1} could save two irrigations i.e. 28% of water in another trial in potato cv. Kufri Pukhraj. Irrigation and macro-nutrient requirements were optimized for newly released water stress tolerant potato variety Kufri Thar- 3 and irrigations given at 20 mm CPE produced significantly higher tuber yield (22.3 t ha^{-1}) and numbers (531 000 ha^{-1}) as compared to other treatments. In case of fertility levels, 100% recommended dose of NPK produced maximum yield (21.4 t ha^{-1}). At Gwalior, results revealed that highest total tuber yield (29 t ha^{-1}) was recorded in sprinkler irrigation and among nutrient levels, highest total tuber yield (33 t ha^{-1}) was observed in Sesbania-potato (75% RDF NPK+ FYM15 t ha^{-1}).

At Jalandhar, work was carried out for assessment of consumptive water use pattern and exploring water efficient technologies for potato crop. In potato cv. Kufri Jyoti, harvested biomass was significantly higher with water applications at 100% ETref, while total as well as marketable yields were highest (39.4 and 36.8 t ha^{-1}) with irrigation at 150% ETref. However, this also recorded maximum percentage of cracked tubers (>1-inch length) to the tune of 18%. Attempts are continuing in improving phosphorus (P) use efficiency in potato cultivation. At Jalandhar, application of 20t rice husk ash (RHA) along with 75% of recommended P significantly increased the tuber yield (41.4 t ha^{-1}) of Kufri Pukhraj compared to 75% of recommended dose of P alone (37.6 t/ha). In order to develop P efficient varieties, nineteen germplasm number and seven varieties were evaluated under two levels of phosphorus for P use efficiency. Clone J/15-91, J/14-242 and CP- 4444 performed better on tuber yield basis and these were selected for further evaluation. At Shimla studies on genotypic variability in P accumulation revealed a large genotypic variability in leaf P concentration (0.20- 0.47%). This variability in germplasm can be utilized for breeding P efficient varieties. A field study was concluded at Shimla to improve phosphorus use efficiency through co-inoculation of AM-fungi and PSB in potato in Himalayan acid Alfisols. It was observed that at lower soil applied P, the response of PSB + AMF or foliar-P was better (10.4–16.5%) over their application at the higher soil applied P. At Shimla, 15 potential PSBs were isolated from various sources were found effective to solubilize phosphate from rock phosphate. These isolates will further be tested in pot and field conditions to develop a commercial formulation. At Shillong, in a preliminary study, combined use of P applied as SSP (20 and 40% of the recommended dose) + PSB (Pusa microphos) + AMF (Pusa mycorrhiza) + two foliar P applications as compared to 20 and 40% of the recommended P alone increased the yield of Kufri Girdhari yield significantly under rainfed conditions.

Spent mushroom substrate (SMS) was utilized for low pH soil management in hill regions. At Shillong, total and marketable tuber yield of potato was significantly higher in six month old naturally weathered SMS when applied @ 20 t ha^{-1} + RDF than FYM applied @ 15 t ha^{-1} + RDF. At Ooty, potato cv. Kufri Swarna recorded total (33.8 t ha^{-1}) as well as marketable (30.1 t ha^{-1}) tuber yield with application of recommended dose of fertilizer and enriched spent mushroom substrate remaining comparable to recommended nutrient management practices. During this period, a web-based decision support system was also developed for calculating fertilizer doses for Madhya Pradesh.

DIVISION OF PLANT PROTECTION

Late blight appeared much early during *rabi* 2023 in all the potato growing areas but impacted the yield in certain pockets only. The occurrence of self-fertile (Homothallic) isolates of *Phytophthora infestans* were observed in potato fields. Isolates of *P. infestans* had shown insensitivity towards cymoxanil indicating that the pathogen is acquiring resistance towards cymoxanil based fungicide which is cause of concern to all potato stakeholders. Isolates were still observed resistant and intermediate resistant to metalaxyl while sensitive to dimethomorph and fenamidone. Molecular characterization of *Streptomyces* isolates yielded about a dozen diverse species of *Streptomyces*. A robust one-step Reverse Transcription Recombinase Polymerase Amplification (RT-RPA) assay has been developed for rapid detection of Potato virus A (PVA). Indo-Blightcast model predicted appearances of late blight well in advance across agro-ecologies and accordingly agro-advisories were issued for its management. Epidemiological studies revealed that self-fertile isolates are equally competitive with A1 and A2 mating types thus imposing a serious threat to late blight management. The application of Valifenalate 6% + Mancozeb 60% WG @ 0.5% was found equally effective against late blight as Fenamidon10 + mancozeb50%WG

@ 0.3% and Dimethomorph 50% WP @ 0.1%. Tuber seed treatment with Imidacloprid 17.8 SL @ 0.04% + Penflufen 22.43% FS @0.1% was on par with Pencycuron 22.9% SC and Thifluzamide 24% SC @ 0.5% against black scurf of potato. Development of common scab could occur under wide range of soil pH (4.0 to 9.0); however, a gradual increase in common scab severity was also observed with an increase in soil pH. No significant role of soil moisture was observed in the development of common scab. ClO_2 (0.3%) was observed most effective and almost completely inhibited the growth of *S. scabiei*, followed by NaOCl, whereas boric acid was least effective. A novel tissue culture-based method was developed for *in-vitro* screening of potato germplasm against common scab disease. The method is quick, simple and feasible in lab and the symptoms on micro-tubers develop within 7-10 days of inoculation. Screening of varieties (27) against common scab by this method revealed that none of the tested varieties has resistance to this disease. The potato line SM/92-338 did not show any wilt symptoms till harvesting. The bacterial wilt incidence in SM/11-93, PAP 2-4 and Kufri Jyoti was 20.0, 20.0 and 100.0%, respectively. The brown rot incidence in SM/92-338, SM/ 03-23 and PAP 2-4 was 2.0, 20.0 and 20.0%, respectively, compared to 100.0% in Kufri Jyoti. Studies on biosafety evaluation of Late Blight resistant GE potato KJ66 for environmental release revealed high level of late blight resistance in KJ66. The data on pests and disease incidence suggest that susceptibility level of GE potato KJ66 was similar to all other tested conventional non-transgenic counterparts and checks and did not show any enhanced incidence of pests and diseases.

The project on the biology, epidemiology, and management of insect pests of potato unveiled significant findings across various aspects of pest management. Notable fluctuations in aphid flight activity were observed, emphasizing the importance of vigilant pest management strategies. Additionally, the influence of different planting dates on insect pest incidence highlighted distinct variations in infestation levels, particularly concerning aphids and leafhoppers, underlining the significance of strategic planting practices and continuous monitoring in potato cultivation. Furthermore, the identification of *Thrips tabaci* infesting potato plants through DNA barcoding provided valuable insights for targeted management strategies. Fluctuations in aphid and Coccinellid beetle populations in early and main potato crops were observed, with correlation analysis revealing intriguing relationships between these pests. Moreover, the study on co-occurrence and correlation of aphids, whiteflies, and leafhoppers on potato crops revealed weak and statistically insignificant relationships between these pests. Evaluation of aphid and whitefly incidence on different potato varieties indicated that while the choice of variety did not significantly impact pest populations, there were variations in mean counts among varieties. Additionally, *Tuta absoluta* showed significant attraction to potato plants damaged by *Bemisia tabaci*, with Gas Chromatography-Mass Spectrometry analysis revealing notable alterations in volatile composition between infested and uninfested potato plants. The study on assessing insect pest incidence and disease occurrence on potato crops managed with Integrated Pest Management (IPM) practices compared to non-IPM fields indicated no significant difference in aphid and whitefly populations between IPM and non-IPM plots. However, IPM-treated crops exhibited fewer diseased plants for Potato Apical Leaf Curl and Severe Mosaic, suggesting potential effectiveness in pest and disease management with IPM practices. Furthermore, evaluation of insecticides against white grub revealed significant variations in tuber damage and weight loss among treatments, with Clothianidin 50WDG showing potential for managing white grub damage in potato cultivation in hilly terrain. Lastly, the study on the isolation, identification, and assessment of pathogenicity of entomopathogenic fungi infecting *Myzus persicae* identified the fungus as *Akanthomyces dipterigenus*, suggesting its potential as a microbial control agent against *M. persicae*. Additionally, investigation into mechanisms of resistance to neonicotinoids in *M. persicae* unveiled two key mechanisms, providing valuable insights for pest management strategies.

The project on the biology, ecology, and management of nematode pests of potato yielded significant insights into effective management strategies against potato cyst nematodes (PCNs). Three years of data analysis revealed that treatments incorporating *Bacillus cereus* SGL6 with trap crops and non-host crops significantly reduced nematode reproduction factors, showcasing their potential for PCN management. Similarly, treatments involving bleaching powder application followed by fallow or non-host crops demonstrated notable reductions in cyst populations. Furthermore, the study on different cropping systems highlighted the efficacy of specific crop rotations in reducing PCN populations, with combinations like Oat-Mustard-Mustard-Trap showing promising results. Additionally, the discovery of millet and cereal root leachates as new hatching factors for PCNs provides valuable insights into potential alternative control methods.

DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY

To find out the novel and environmentally safe alternatives to the most commonly used sprout suppressant Isopropyl N-(3-chlorophenyl) carbamate (CIPC), a combination of seven volatile oils was found highly effective in sprout control for 120 days with single application on 16 varieties. In another preliminary trial with variety Kufri Chandramukhi, a combination of eight volatile oils was found effective in sprout control for 300 days with single application.

Effect of cooking methods was studied on the ascorbic acid and carotenoid content in potatoes and it was found that microwave cooking results in higher retention of these compounds as compared to boiling. Among the seven varieties studied in this experiment, Kufri Surya was found to have maximum values of ascorbic acid and carotenoids.

This year three novel products were developed which included Potato-Black gram Boondi, Gluten free Potato-Kodo cookies and Potato swirls. Potato based Boondi has unique taste and crunchy texture. Potato-Kodo cookies are rich in dietary fiber (~6.7%), calcium (~39 mg/100g), and potassium (~270 mg/100g). This technology has the potential to reduce the percentage of post-harvest losses by converting them into flour, which can be utilized for the production of bakery products along with the benefits of underutilized millets. The unique formulation of Potato-Kodo cookies makes them fit for celiac and wheat allergic population also. The technology is applicable to potatoes of any shape, size, and variety, whether fresh or cold-stored. On the front of Potato based Synbiotics development, ten strains of bacteria have been found promising. A total of three technologies developed in the division were certified by ICAR.

DIVISION OF SOCIAL SCIENCES

The estimation of the production cost and economic returns of potato production by randomly interviewing 120 growers revealed that the total cost was ₹1,48,611/-. The gross and net incomes were ₹224343/- and ₹75732/-, respectively, with a B:C ratio of 1.51. Data from surveys of 120 farmers in Bihar and 140 farmers in Uttar Pradesh showed that Kufri Pukhraj contributed about 57% of the potato area in Bihar, followed by K. Sindhuri (~11%) and K. Jyoti (~10%). With 43% of the potato area in Uttar Pradesh, Kufri Bahar is the most popular variety, followed by K. Chipsona-1 (19%), K. Mohan (6.27%), and K. Khyati (6.15%). According to Garrett's Ranking Technique, the major constraint faced by potato growers in adopting quality/certified potato seeds in Bihar was non-availability of required varieties (score=63.83, Rank I), followed by high seed cost (score=60.32, rank II) and lack of cold storage (score=50.37, rank III). In Uttar Pradesh, the first important constraint was lack of seeds of required varieties (score=69.47, rank I), followed by high cost of seeds (score=65.17, rank II) and lack of information regarding improved varieties (score=51.44, rank III).

Data from APEDA and the World Bank was used to analyse performance of Indian potato exports. During, TE 2022-23, the total export volume of fresh potatoes, seed potatoes and potato products was 5.59 lakh tons and total export value was ₹14.56 billion. The CAGR of total export volume during 2003-03 to 2022-24 is 14.1%. The export volume of potato products rose from 7295.00 tons during TE 2005–06 to 1.56 lakh tons in TE 2022–23, with the CAGR of export volume of 15.4%. The exports of potato products comprise 28.01% of total export volume and 54.82% of total export value during TE 2022–23.

The institute conducted 29 training programmes at the headquarter and the regional stations for the officials, farmers and other potato stakeholders in the country. The institute also organized 4 exhibitions, 3 *Kisan Goshti*, 3 awareness camps, 5 field days, National potato day and many other outreach programmes. Expert scientists from different disciplines of ICAR-CPRI, Shimla and its regional stations participated in 14 live phone-in programmes on *doordarshan* and *aakashwani*. More than 1000 queries of potato growers were attended at Kisan Call Centre, Modipuram station and through CPRI's WhatsApp potato advisory group. More than 7000 visitors were apprised about the research and extension activities and technologies of the institute. Under HRD Cell, 9 scientists, 7 technical officers and 12 administrative officers were sent to participate in various training programmes.

RESEARCH PROGRAMMES

All PIs and Co-PIs

Sl. No.	Research Programmes & Institute Code No.	Programme Leader and Associates
1.	**Management of potato genetic resources HORTCPRISIL202000300142**	**PI: Dr. Vinod Kumar. Associates: Drs.** Salej Sood, Ajay Kumar Thakur, Dalamu, Vikas Mangal, Ashwani Kr. Sharma, Raj Kumar, Ratna Preeti Kaur, SK Luthra, Babita Chaudhary, Pooja Mankar, Sarla Yadav, Divya K Lekshmanan, Arvind Kumar Jaiswal, Sanjay Rawal, Bandana, Anuj Bhatnagar, Sanjeev Sharma, Ravinder Kumar, Clarissa Challam, Janani P., Priyank Hanuman Mhatre, Aarti Bairwa, Kailash Naga, Rahul Tiwari, Jagdev Sharma, Som Dutt, Brajesh Singh, Vinay Sagar
2	**Breeding trait specific varieties for productivity, quality and resistance to biotic and abiotic stresses HORTCPRISIL202000400143**	**PI: Dr. SK Luthra. Associates: Drs**. Babita Chaudhary, Dalamu, Vinod Kumar, Brajesh Singh, Jagdev Sharma, Bandana, Arvind Kumar Jaiswal, Mehi Lal, Sanjay Rawal, Milan Kumar Lal, Pooja Mankar, Yvonne Angel Lyngdoh, Raj Kumar, Ratna Preeti Kaur, Sarla Yadav, VK Gupta, Salej Sood, Arvind K Jaiswal, Vikas Mangal, Aarti Bairwa, Ravinder Kumar, Kailash C Naga, Ashwani Kr. Sharma, Tanuja Buckseth, Ajay Kumar Thakur, Devendra Kumar, Som Dutt, Sugani Devi, Anuj Bhatnagar, Manoj Kumar, Prince Kumar
3	**Genetic enhancement of potato through molecular and genomic tools. HORTCPRISIL202000500144**	**PI: Dr. Ajay K Thakur. Associates: Drs.** Som Dutt, Salej Sood, Milan Kumar Lal, Dharmendra Kumar, Sanjeev Sharma, Aarti Bairwa, Jagdev Sharma, Tanuja Buckseth, Vinod Kumar, SK Luthra, Devendra Kumar, Ratna Preeti Kaur, Ashwani K. Sharma, Dalamu, Priyank Mhatre, Clarissa Challam, Vikas Mangal
4	**Vulnerability and resilience to climate change for sustainable potato production HORTCPRISIL202100100150**	**PI: Dr. Anil Sharma. Associates: Drs**. Jagdev Sharma, Sanjay Rawal, SP Singh, Anuj Bhatnagar, Anil Kr. Choudhary, Subhash Katare, Mehi Lal, Sunayan Saha, Prince Kumar, Brajesh Nare, Subhash S.,
5	**Nutrient and water management for improved productivity and sustainability of potato HORTCPRISIL202000200141**	**PI: Dr. Sanjay Rawal, Associates: Drs.** SP Singh, Prince Kumar, Sunayan Saha, RK Singh, Sunayan Saha, Jagdev Sharma, Anil Sharma, Manoj Kumar Nanda, Brajesh Nare, Anil K Choudhary, Janani P., Divya K Lekshmanan, Dharmendra Kumar, Priyank Mhatre, Ajay Thakur, Sarala Yadav, Dalamu,
6.	**Technology development and refinement for potato and potato based cropping system HORTCPRISIL202000100140**	**PI: Dr. Sanjay Rawal. Associates: Drs.** Pooja Mankar, Sanjeev Sharma, SK Luthra, VK Gupta, Devendra Kumar, Mehi Lal, Subhash S., SP Singh, Subhash Katare, Murlidhar Sadawarti, Anil Sharma, Anil K Choudhary, RK Singh, Janani P, Dharmendra Kumar, Kailash C Naga, Yogesh Gautam, Clarissa Challam, N. Sailo, Anuj Bhatnagar, Vinay Sagar, Brajesh Nare, Sukhwinder Singh, Sugani Devi, Som Dutt, Ratna Preeti Kaur, Prince Kumar,

Sl. No.	Research Programmes & Institute Code No.	Programme Leader and Associates
7	**Biology, ecology and management of insects and nematodes pests of potato. HORTCPRISIL202000700146**	**PI: Dr. Anuj Bhatnagar Associates: Drs.** Subhash Katare, Kailash Naga, Subhash S., Aarti Bairwa, Priyank Mhatre, Ravinder Kumar, Sanjeev Sharma, Kamala Jayanthi, Jagdev Sharma, N Sailo, Rahul Tiwari, Chandan Maharana, Ashwani Kr. Sharma, Tanuja Buckseth, Dalamu,
8	**Re-defining epidemiological parameters and management approaches for potato pathogens HORTCPRISIL202000600145**	**PI: Dr. Sanjeev Sharma. Associates: Drs.** Vinay Sagar, Mehi Lal, Rahul Tiwari, Jagdev Sharma, Priyank Mhatre, Ravinder Kumar, Kailash Naga, Subhash S, Murlidhar Sadawarti, Subhash Katare,
9	**Post-harvest management and nutritional enhancement of potatoes HORTCPRISIL202000800147**	**PI: Dr. Dinesh Kumar. Associates: Drs.** Brajesh Singh, Som Dutt, Milan Kumar Lal, Dharmendra Kumar, Devendra Kumar, Bandana, Arvind K Jaiswal, N Sailo, SK Luthra, Ratna Preeti Kaur, Vinay Sagar, Rahul Tiwari, Jagdev Sharma, Sanjay Rawal, Pynbianglang Kharumnuid, Sukhwinder Singh, Brajesh Nare,
10	**Transfer of potato technologies to stakeholders and assessment of their impacts HORTCPRISIL202000900148**	**PI: Dr. Alok Kumar. Associates: Drs.** Pynbianglang Kharumnuid, Ravinder Kumar, Yogesh Gautam, RK Singh, Milan Kumar Lal, Rahul Tiwari
11	**Development and production of nucleus and breeder seed of notified potato varieties through conventional and hi-tech systems. HORTCPRISIL202001000149**	**PI: Dr. Vinod Kumar. Associates: Drs.**, Tanuja Buckseth, Ashwani Kr. Sharma, Manoj Kumar, Devendra Kumar, Vinay Singh, Subhash S., Anil Sharma, Ratna Preeti Kaur, Dhruv Kumar, Raj Kumar, Ratna Preeti Kaur, Sugani Devi, Subhash Katare, Murlidhar Sadawarti, SP Singh, RK Singh, N Sailo, Clarissa Challam, Priank Mhatre, Sukhwinder Singh, Anil K Choudhary, Jagdev Sharma, Dhruv Kumar, Sunayan Saha, Prince Kumar,

DIVISION OF CROP IMPROVEMENT & SEED TECHNOLOGY

PROGRAMME: MANAGEMENT OF POTATO GENETIC RESOURCES

Genetic resources are strategic for sustainable crop production. Conserving potato genetic resources (PGRs) is critical for the long-term future of potato improvement programs. This program aims to conserve and provide diverse genetic material to potato researchers. The collection is evaluated, characterized, and documented in an easily retrievable form for use by the researchers.

Collection

92 in-vitro accessions were imported from 3 different countries, including 24 accessions from CIP, Lima, Peru, 56 accessions from the USA, 7 from the Netherlands, and 5 cultures from Germany. During the year, 70 accessions free from quarantined pests were introduced to the germplasm repository. Presently, more than 4700 accessions of cultivated and wild potato species, obtained from 30 countries, are conserved at the institute.

Table 1. Potato germplasm holding at CPRI, Shimla

Material	No. of accessions				No. of donor countries
	Tuber	In vitro	True seed	Total	
a) Tuberosum (Cultivars / parental lines) **Indian**					
Cultivars bred at CPRI	68	65		**68**	
Advanced hybrids	86	50	-	**96**	
Indigenous varieties	117	107	-	**117**	
Indigenous samples	97	44		**97**	
Exotic	1945	2850	-	**3050**	30
b) Andigena	701	77	-	**762**	5
c)Wild/ semi-cultivated sps.	119 (40 species)	130 (29 species)	294 (70 species)	**540 (125 species)**	5
Total germplasm				**4730**	

Conservation

Field conservation:

One thousand five hundred and thirty-nine Tuberosum accessions, 701 Andigena accessions and 63 indigenous samples were maintained in fields at Jalandhar. In field conditions at Kufri, 1490 cultivated potato germplasm was conserved. This includes CPRI-bred varieties (62 Nos.), Indigenous varieties (117 nos), and CP No. (*Solanum tuberosum ssp. tuberosum*) (1311 Nos.). Besides this, 259 Tuberosum accessions were maintained at Modipuram. In wild species, 305 clones of 133 accessions representing 38 Solanum species were multiplied for maintenance breeding, whereas 294 accessions of 70 species were maintained in TPS form. In total, 540 accessions (in tuber / TPS/ *in vitro* form) of 125 species were conserved at CPRI, Shimla.

In vitro conservation:

Nearly 3000 Tuberosum accessions and 130 accessions of 29 wild species were maintained in *in-vitro* form. Minitubers of 57 accessions from the *in vitro* repository were produced and added to the germplasm collection maintained under field conditions at Modipuram. During this year, one variety, namely Kufri Lohit, and one advanced hybrid MP/13-1093, were made free from all viruses using meristem tip culture.

Evaluation

Adaptability

Temperate long days (Kufri):

Twenty-eight cultivated germplasm and controls, Kufri Jyoti, Kufri Girdhari, and Kufri Himalini, were evaluated for adaptability based on tuber yield per plant. SVAM-21, SVAM-26, SVAM-32, SVAM-37, Kanpuria Safed, Rangpuria, and JG-1 performed well at the Kufri condition with a higher average yield per plant over the best control Kufri Girdhari (103 gms).

Sub-tropic short days:

Jalandhar

Ninety-seven (97) Tuberosum accessions were evaluated under spring planting conditions. The yield of germplasm accessions ranged from 20 to 310 g/plant, while the best control variety was Kufri Jyoti (310 g/plant). The other control, Kufri Pukhraj, yielded 300 g/plant. Only one accession (CP 4459) out yielded the better control (310 g/plant).

Modipuram

Under early planting, 50 Tuberosum genotypes were evaluated under heat stress conditions in a replicated trial at 75 DAP. The total tuber yield (g/plant) ranged from 25.53 to 267.27g/plant. The highest total tuber yield was recorded in K Lima (267g) followed by K Arun (255g), K Ganga (241g), K Mohan (214g), K Garima (212g), K Lalit (208g), K Lalima (174g) K Sinduri (155g), K Pukhraj (152g) and K Neelkanth (149g).

Under normal planting, 37 Tuberosum genotypes were evaluated in a replicated trial at 95 DAP. The total tuber yield (g/plant) ranged from 160.00 to 495 g/plant and high total tuber yield was recorded in CP3294 (495g) followed by CP3413 (479g), CP3469 (455g), CP3266 (452g), CP3464 (451g), CP3326 (426g), CP3421 (386g), CP3437and CP3438 (379g), CP3361 (378g), CP3414 (374g), CP1651 (372g), CP3259 (363g), CP2094 (363g), CP3360 (362g), CP3337 (361g) and CP3415 (360g).

Reaction to late blight

Twenty-eight cultivated germplasm and controls, Kufri Jyoti, Kufri Girdhari, and Kufri Himalini, were evaluated for foliar blight resistance under epiphytotic conditions at Kufri. Based on late blight incidence recorded four times at intervals of seven days between two subsequent readings, nine accessions viz., SVAM-15, SVAM-17, SVAM-22, SVAM-23, SVAM-26, SVAM-38, Rangpuria, Kanpuria Safed & Desi aloo were highly resistant (AUDPC < 250); whereas one accession (JG-1) was resistant (AUDPC 251-350).

29 germplasm were evaluated for late blight resistance under lab conditions, i.e., for tuber resistance by tuber slice method and foliar resistance by detached leaf method. All the genotypes were susceptible in the tuber slice method based on reaction. In the Detached leaf assay, three accessions (Desi Alu, Rangpuria, and Jalandhar) were highly resistant, whereas three accessions, namely Beeta, Dehati Alu, and DRR blue, were resistant. Nine accessions Viz., Aruconia, Australian white, Bhoora Alu, Deshla Lal, Kacha Bhutia, JG-1, JG-2, K-22, and NJ-47 were moderately resistant. The remaining were susceptible.

Viruses

Forty-one germplasm accessions were screened for resistance through DAS-ELISA against PVX and PVY. Eleven accessions, namely AGR/56, Australian White, Desi Alu, Dehati Alu, DRR Blue, Edony, Garlentic, NJ-47, NJ-62, NJ-78, and Panamera had combined resistance to PVX and PVY, while 16 and 24 accessions showed resistance to PVX and PVY, respectively.

Dry Rot

For dry rot screening, the uniform size of healthy tubers was surface sterilized and wound with a cork borer up to 3 mm in depth. The mycelial plug was removed from the pure culture of *Fusarium sambucinum* and inoculated on the tuber wounds. Healthy, non-inoculated tubers were kept in control. After 21 days of incubation at 18°C and 85- 90% relative humidity, the lesion index and volume of tuber rot were calculated using the formula and scale previously used by Trabelsi et al. (2015).

The lesion diameter, height, and volume were reported in the range of 11.66 (J/A288) – 32.33 mm (J/A702), 4.66 (J/A457) – 21 mm (Kufri

Badshah), and 783.54 (J/A288) – 16184.61 mm^3 (Kufri Badshah), respectively. None of the 50 accessions evaluated showed a diameter <11 mm diameter, meaning no accessions can be considered tolerant to dry rot pathogen based on this year's study. Figure 1 shows the lesion diameter of potato tubers after 21 days of pathogen inoculation. Figure 2 shows how much the data values of lesion diameter, lesion height, and lesion volume vary or spread out with the help of box plots.

A) Kufri Jyoti

B) Kufri Jyoti

C) CP 1335

D) CP 1367

Fig 1: Potato tubers after 21 days of pathogen *(F. sambucinum)* inoculation

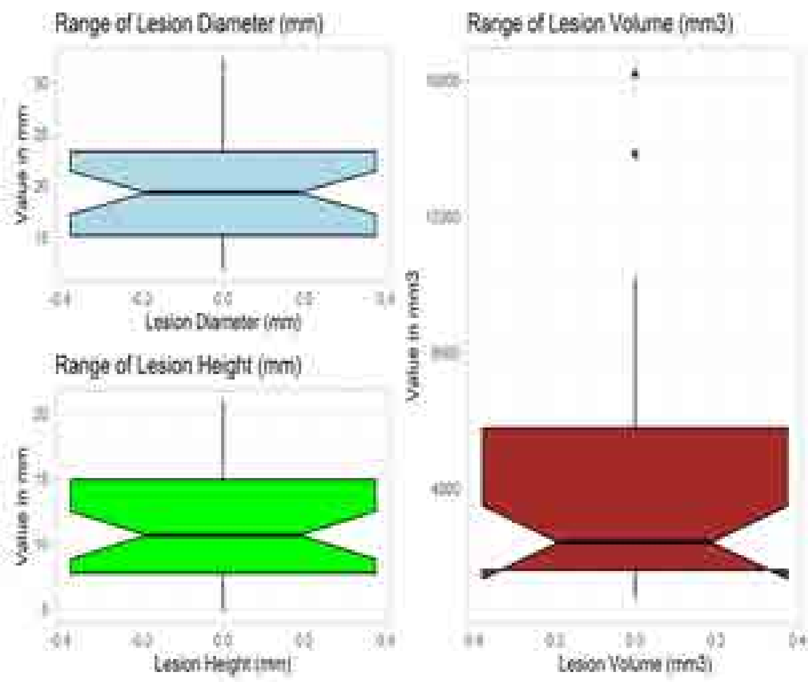


Fig 2: Box plots showing lesion diameter (mm), lesion height (mm) and lesion volume (mm^3)

Leaf-hopper and mites

Of 184 accessions, 42 had hopper burn below 20%, whereas no mite damage was observed in any accessions.

Cyst nematodes

Seventy germplasm accessions with controls SM/11-120 and K. Jyoti were screened for potato cyst nematode (*Globodera rostochiensis* and *G. pallida*) resistance through root ball technique under glasshouse condition at Kufri. Based on cyst count at 55 days after planting, 16 accessions, namely CP2275, CP4353, CP4418, CP4741, CP4742, CP4743, CP4744, CP4746, CP4768, CP4769, CP4777, CP4792, CP4793, JG-1, Jeevan Jyoti and Garlentic were highly resistant to both the species. In contrast, five accessions (SVAM-3, SVAM-20, RSR/BR-10, Thangal, and Jalpai) were moderately resistant. The remaining accessions fall in the category of either susceptible or highly susceptible.

At Ooty, out of 246 accessions, 9 accessions (CP 1137, CP 1674, CP 1932, CP 1988, CP 2285, CP 2418, CP 3183, CP 3201, and CP3881) were resistant to both the species of PCN (*G. rostochiensis* & *G. pallida*). In contrast, twenty-one accessions were resistant to *G. rostochiensis.*

Keeping quality

Seventy-five accessions, along with three control varieties, namely Kufri Dewa, Kufri Ashoka, and Kufri Pukhraj, were evaluated for their keeping quality at ambient (15-39°C, 44-75% Relative humidity) storage conditions. Periodical observations on weight loss, sprouting, and spoilage in tubers were recorded at 60 and 90 days of storage. Firmness was recorded on a scale of 1-5, with a score of 5 assigned to the firmest as freshly harvested/cold-stored potatoes. Accessions were rated in different categories based on storage performance, viz., weight loss, rotting, total loss, and physical appearance of tubers after 90 DOS. Out of the 75 accessions, only 8 accessions (CP Nos. 1709, 3432, 3620, 3624, 3681, 3686, 3687, and 3851) were found as good keeper (total storage losses between 10-15%), 18 as average keeper (total storage losses between 15-20 %) and remaining 49 accessions as a poor keeper (total storage losses > 20%).

Chipping and Physico-chemical constituents

At Jalandhar, 76 Tuberosum accessions were evaluated for processing quality parameters, viz. chip color, dry matter, and reducing sugar and sucrose contents. Based on-chip color (acceptable score up to 3 on a 1-10 scale of increasing dark color), dry matter (>21%), and reducing sugar (<100 mg/100g fresh tuber wt.), only one accession (CP 3917) was found suitable for chipping.

Seventy-five accessions were also evaluated for vitamin C content which varied widely between 20.25 to 41.99 (mg/100 g fr. Wt.) with minimum and maximum values registered by CP 3387 and CP 3495, respectively. Ten top most accessions for vitamin C content (mg/100g fr. wt.) were: CP 3495 (41.99), CP 3371 (41.24), CP 3415 (41.24), CP 3413 (41.22), CP 3505 (41.22), CP 3365 (40.49), CP 3468 (40.49), CP 3511 (39.74), CP 3435 (38.99) and CP 3507 (38.99).

Micro-nutrient Content

Sixty-two accessions were evaluated for iron and zinc content. Iron content varied from 22.83 (JG-27) to 31.43 mg/kg (NJ-130), whereas the range for Zn content was from 16.78 (Rangpuria) to 24.78 mg/kg (NJ-130) on a dry weight basis. The topmost five accessions for Zn content (mg/kg) were: NJ-130 (24.78), Memphis (24.36), Sathoo (23.55), Aruconia (23.45) and JG-1 (23.25) and for Fe content (mg/kg) were: NJ-130 (31.43), NJ-75 (31.25), Lal mitti-1 (31.05), Evora (30.45) and NJ-23 (30.24).

Water use efficiency

Germplasm accessions are evaluated at 3 moisture regimes, i.e., 0.20-0.25, 0.40-0.45, and 0.60-0.65 bars/atm soil moisture tension at 15 cm soil depth for higher yield and water use efficiency. Out of 20 accessions, eight accessions, namely CP 3770, CP 3780, CP 3797, CP 3850, CP 3853, CP 4030, CP 4140, and CP 4388, were found promising in the 3rd year evaluation; in another lot, 20 accessions were evaluated and 4 accessions namely CP Nos. 4393, 4473, 4535, and 4536 gave significantly higher yields as produced by var. Kufri Pukhraj, in the 2nd year of testing, seems promising for higher water use efficiency.

Foliage maturity

Of 165 Tuberosum accessions screened for foliage maturity at Patna, 35 CP Nos. 3984, 3985, 4030, 4254, 4394, 4399, 4397, 4631, 4633, 4639, 4640, 4652, 4659, 4658, 4659, 4665, 4669, 4677, 4678, 4680, 4681, 4683, 4686, 4688, 4735, 4739, 4740, 4746, 4747, 4750, 4751, 4754, 4762, BADAMI and OEFENDER were found early maturing having > 75% foliage maturity at 90 DAP.

Wild Species

Screening against late blight resistance

Thirty-five clones of 22 accessions belonging to 9 species were screened for late blight resistance using leaf disc assay in the lab. Out of 35 clones, 5 clones were highly resistant [*S. ambosinum* (1767-0), *S. demissum* (1840-18), *S. spegazini* (2267-03), *S. acaule* (2839-09), *S. berthaulti* (2847-01)], 16 were resistant, 7 were moderately resistant and 7 were found susceptible.

Screening against white-fly resistance

Twenty-one wild potato germplasms were evaluated for their resistance to the whitefly, *Bemisia tabaci*, with SM/11-120 as the control. A choice assay method was employed for the screening process. Approximately one thousand newly emerged adult whiteflies were introduced into a cage containing randomly positioned wild potato germplasms. After two days, the number of settled adults on each plant was determined by gently inspecting the leaves during the early morning hours. The findings revealed that none of the screened wild germplasms exhibited a lower preference for whiteflies than the control, SM/11-120.

Diversity analyses of germplasm using SSR markers

Genetic diversity evaluation in a germplasm panel (SVAM collection) comprising 37 potato germplasm accessions procured from North-Eastern India has been carried out using genomic-SSR markers. Leaf material of these accessions was procured from the Kufri farm, and pooled leaf samples for each genotype were used for genomic-DNA extraction using the modified CTAB method (Doyle and Doyle, 1990). A set of 126 selected SSR markers covering all potato chromosomes was used for genotyping potato germplasm, out of which 102 (80.95%) SSRs resulted in polymorphic amplicons. In contrast, 24 (19.04%) SSRs produced monomorphic amplicons. A total of 298 alleles were produced by 102 SSR markers, and the allele number varied from 2-6, with 2.92 as the average number of alleles per SSR marker.

The allelic binary matrix was analyzed in NTSYSpc software and a dendrogram based on Jacquard's similarity coefficient was constructed, depicting the genetic relationships among various potato genotypes (Fig.3). At a similarity coefficient value of 0.67, the UPGMA-dendrogram divided all the 37 potato germplasm accessions into four main groups viz., I, II, II and IV. Group I comprised 9 potato genotypes, further divided into two subgroups, IA and IB, consisting of 5 and 4 potato genotypes, respectively. Group II had 16 potato germplasm accessions, further divided into subgroups IIA, IIB, and IIC; each having 3, 11, and 2 genotypes, respectively. Eleven potato genotypes clustered into group III, where subgroup IIIA comprised 2 accessions, while IIIB had 9 potato lines. Potato germplasm accession, SVAM-13, was found to be the most unique and genetically diverse genotype, which did not show clustering with any other potato germplasm line and formed a separate group, i.e., group IV.

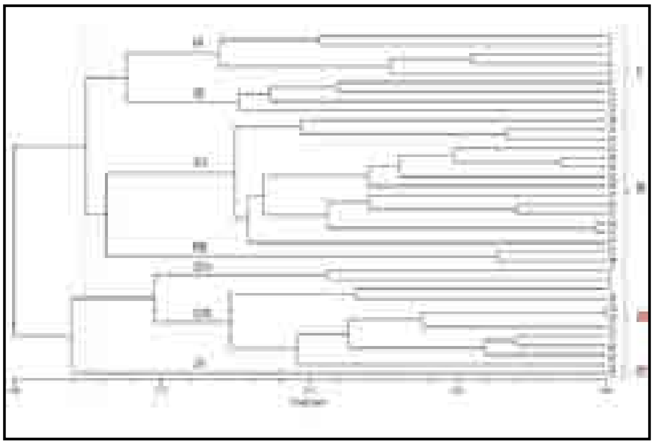


Fig. 3: Dendrogram based on Jacquard's similarity coefficient

Germplasm registered with the NBPGR, New Delhi

Three elite potato clones were registered with the ICAR-NBPGR, New Delhi. These are critical genetic materials for somatic hybridization and parental lines for different breeding programs.

S. No.	Elite Germplasm	INGR No.	Details of Special Achievements
1	NUE/15-23	22188	High nitrogen use efficiency traits such as NUE, Agronomic NUE (AgNUE), Nitrogen Uptake Efficiency (NUpE), and Nitrogen Utilization Efficiency (NUtE). High tuber yield under low nitrogen fertilizer input under field conditions.
2	SM/92-338	23063	Highly resistant to bacterial wilt
3	MS/8-1148	23120	Cultivated clone (*Solanum tuberosum*; 2n=4x; 48). High vitamin C content (77.7 mg/100g FTW).

Documentation

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

PROGRAMME: GENETIC ENHANCEMENT OF POTATO THROUGH MOLECULAR AND GENOMIC TOOLS

PI: Ajay Kumar Thakur, **Co-PIs**: Som Dutt, Salej Sood, Milan K. Lal, Dharmendra Kumar, Sanjeev Sharma, Aarti Bairwa, Jagdev Sharma, Tanuja Buckseth, Vinod Kumar, Satish K. Luthra, Devendra Kumar, Ratna P. Kaur, Ashwini K. Sharma, Dalamu, Priyank Mahatre, Clarissa Challam, Vikas Mangal

Transcriptome sequencing for bacterial wilt resistance in potato

Potato is third most important staple food crop in world after rice and wheat in terms of human consumption. It is being cultivated on 2.2-million-hectare acreage with ~54 million tonnes production in India. However, the overall production and productivity of potato is hampered significantly by various biotic and abiotic stresses. Among biotic stresses, bacterial wilt (brown rot) caused by soil bacterium - *Ralstonia solanacearum* is the second most devastating disease of potato globally including India. At present, almost all released varieties of potato in India are susceptible to bacterial wilt. The reason was lack of bacterial wilt resistant genotype in parental background. Recently, at ICAR-CPRI, Shimla, one potato hybrid, SM/92-338 had been identified, which exhibit resistance to bacterial wilt disease. However, information regarding potato gene expression profiles and their role in responding to *R. solanacearum* is lacking. Thus, it is of paramount importance to investigate the molecular mechanisms of potato response to this pathogen and identify differentially expressed genes and their regulatory elements responsible for imparting resistance against bacterial wilt using transcriptome analysis.

In the year 2023-24, efforts have been initiated to identify key genes and regulatory elements governing bacterial wilt resistance trait in potato using transcriptome sequencing approach. Two potato genotypes viz. SM/92-338 (resistance to BW) and Kufri Lima (highly susceptible to BW) were raised and established in pots under glasshouse conditions using *in vitro* developed potato plantlets. At a time point of 30 days after transplanting, roots of plants of both the genotypes were injured manually and inoculation of *R. solanacearum (potato race)* was done for proper infection. The plants in pots were immediately moved to growth chamber maintained at 28°C temperature under a 16 hrs/8hrs light and dark period regime along with the check untreated plants of both the genotypes. The symptoms of bacterial wilt were observed critically and first symptom appeared on 13th day after infection and Kufri Lima plants started wilting, whereas no wilting symptoms appeared on SM/92-338 (resistance to BW) plants (Fig. 1). Leaf samples were procured from both the genotypes in three technical replicates, prior to infection and at 13th day, at the time of symptoms appearance. The leaf material was immediately frozen in liquid nitrogen and then stored at -80°C for RNA extraction and sequencing work. Further, transcriptome sequencing and data analysis work is in progress.

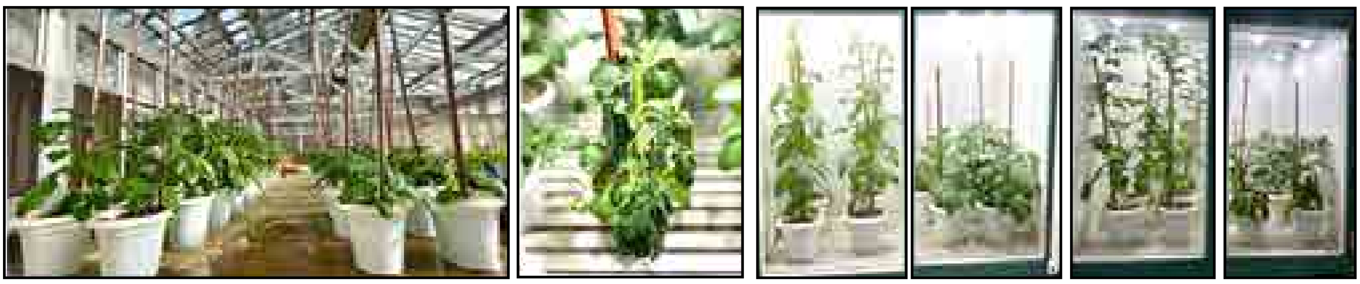


Fig. 1 Screening of potato genotypes for bacterial wilt resistance: a) Establishment of *in vitro* raised plants of potato genotypes- SM/92/338 (left) and Kufri Lima (right) under glasshouse conditions; b) Potato genotypes at 0 day of inoculation in growth chamber maintained at 28 °C temperature; c) & d) Appearance of bacterial wilt symptoms in Kufri Lima plants (right)

Development of a core set of SSR markers for characterization of potato germplasm and varieties

A total of 360 genomic-SSR markers covering all the linkage groups of potato had been evaluated for their polymorphic potential in a representative set of 12 potato genotypes, comprising of varieties, germplasm, somatic hybrids and wild species to develop a core set of SSR markers for potato germplasm and varieties characterization. So far, 179 SSR markers were found to be polymorphic.

Development of potato genotype for higher NUE

One potato hybrid identified/ developed for improved nitrogen use efficiency trait namely 'NUE/15-23', was accepted for AICRP testing. Subsequently, seed/tuber material of this new hybrid has been multiplied at ICAR-CPRI RS, Modipuram for further testing.

Genome-wide association mapping and genomic prediction for late blight and potato cyst nematode resistance

Potatoes are an important source of food for millions of people worldwide. Biotic stresses, notably late blight and potato cyst nematodes (PCN) pose a major threat to potato production worldwide, and knowledge of genes controlling these traits is limited. A genome-wide association mapping study was conducted to identify the genomic regulators controlling these biotic stresses, and the genomic prediction accuracy was worked out using the GBLUP model of genomic selection (GS) in a panel of diverse potato accessions. The phenotype data on resistance to late blight and two PCN species (*Globodera pallida* and *G. rostochiensis*) were recorded for three and two consecutive years, respectively. For the phenotype data, the number of accessions varied yearly for late blight and PCN resistance evaluation. Late blight observations were recorded at weekly intervals after the first appearance of late blight on the susceptible check variety, Kufri Jyoti and continued till the susceptible control variety observed 100% disease incidence. Disease severity was evaluated as the percentage of foliage area of plants infected in the plot. Data were collected on each accession, and disease severity was recorded at weekly intervals. The area under the disease progress curve (AUDPC) was calculated as per the standard formula. Late blight AUDPC values varied from 0 to 2520, 0 to 1265 and 0 to 1192 in three different years (Fig. 2). The susceptible control variety Kufri Jyoti recorded an AUDPC value of 2060 (2018), 707.5 (2019) and 810 (2020), while the resistant variety Kufri Girdhari did not observe any disease incidence and recorded zero AUDPC value across the years. The moderately resistant variety Kufri Himalini observed an AUDPC of 840 (2018), 572.5 (2019) and 315 (2020) during three different years. The year-wise AUDPC values of three years i.e. 2018, 2019 and 2020 were used for GWAS and GP analyses.

Likewise, for PCN resistance screening, 3 well-sprouted tubers of each accession were raised in pots using PCN infested soils during the summer (June-September) under controlled conditions in a glass house at Kufri, Shimla, Himachal Pradesh, India. Indian potato varieties *viz.*, Kufri Jyoti and Kufri Himalini were used as susceptible controls. Phenotypic screening was done using the root-ball technique. The tubers were planted in pots (10 cm diameter) containing about 500 g soil in glass house. The soil used for planting contained a mixed population of both PCN species, *i.e.*, *Globodera pallida* and *G. rostochiensis* (200-250 cysts per 100 g soil), which provides 8000-10000 eggs and juveniles per test tuber. The root ball was examined for the presence of PCN females from the 55th day after planting until the 65th day. The two species were distinguished by the colour of developing females (White – *G. pallida*; Yellow- *G. rostochiensis*). Based on the number of females developed per root ball, the accessions were categorised into 0 = Immune (Grade 0), 1 to 5 = Highly resistant (Grade 1), 6 to 20 = Moderately resistant (Grade 2), 21 to 50 = Susceptible (Grade 3), and >50 = Highly susceptible (Grade 4). The planting was staggered (one week gap), accommodating 75 accessions at a time for proper maintenance and observations in the glass house. We observed highly resistant to highly susceptible accessions in the population for both species in both evaluation years. The susceptible controls viz., Kufri Jyoti and Kufri Himalini observed highly susceptible reaction (Grade - 4) to both the species of the PCN during both the evaluation years. The number of accessions under each category are shown in Fig. 3. The accessions under the highly resistant and resistant categories were less in number than susceptible and highly susceptible accessions. The correlation between PCN scores of two different years was 0.76 and 0.79 for *G. rostochiensis* and *G. pallida*, respectively. The evaluation was carried out for two years, *i.e.*, 2020 and 2021 and the grades for each species individually were used for GWAS and GS analysis. W

The genotype data was generated on 288 accessions using high-throughput DNA sequencing, performed on the Illumina HiSeq 2500 platform with a read length of 144 bp at each end. Initial fastq files were processed for read quality (Q>20) using a custom Perl script for trimming low-quality bases. The trimmed sequence data were aligned to the reference potato genome (http://solanaceae.plantbiology.msu.edu/dm_v6_1_download.shtml) using Bowtie2 to obtain the SAM file. The SAM file was further converted into a BAM file for faster manipulation. The GATK (Genome Analysis Toolkit) was used for variant calling using the criterion described earlier. Finally, 222 accessions with high quality genotype data were considered for further analysis. The five genotype classes were assigned (AAAA, AAAB, AABB, ABBB, or BBBB) using the HaplotypeCaller function. These SNP data of 222 accessions were used for genetic diversity, GWAS and genomic prediction analysis. Initially, a set of 1,0,24,680 SNPs were detected, which were reduced to 1,20,622 high-confidence SNPs following missing data filters (site coverage ≥90%) and minor allele frequency (mafMAF ≥ 0.05). The SNPs were evenly distributed with an average density of 1.5 SNPs/10kb region and were proportional to the chromosome size for all the 12 chromosomes (Table 1). The minimum number of SNPs were present on the smallest chromosome, i.e., Chr. 11 (6,538), while the highest was on the largest chromosome, i.e., Chr. 1 (13,610) (Table 1).

A total of 7 SNP associations for late blight resistance, 9 and 11 for *G. pallida* and *G. rostochiensis*, respectively, were detected by additive and simplex dominance models of GWAS (Table 2). The associated SNPs were distributed across the chromosomes, but most of the associations were found on chromosomes 5, 10 and 11, which have been earlier reported as the hotspots of disease-resistance genes. For late blight resistance, we found major QTLs on chromosome 11, while PCN resistance QTLs were observed on chromosomes 3 and 10 (Table 2). The major genes for late blight resistance were functionally related to response regulators, proteins of unknown function, plant U-box and ENTH/VHS/GAT family protein. Similarly, the putative functions of candidate genes for PCN resistance (*G. pallida and G. rostochiensis*) had been found associated with intergenic region, hypothetical protein and response regulator.

The GS prediction accuracy estimates were low to moderate for resistance to *G. pallida* (0.04-0.14) and *G. rostochiensis* (0.14-0.21), while late blight resistance showed a high prediction accuracy of 0.42-0.51. The genomic prediction accuracy results with complete vs five times reduced marker data set showed almost similar results except for *G. pallida* and *G. rostochiensis* in 2021. In both cases, the prediction accuracy was perfect for late blight resistance across the years, while PCN resistance for the two species had low prediction accuracy. This study provides information on the complex genetic nature of these biotic stress traits in potatoes and putative SNP markers for resistance breeding.

Table 1 Distribution of filtered SNPs and SNP density across chromosomes

Chromosome	Length (in bp)	Number of SNPs detected	SNP Density/10Kb
Chr01	8,86,63,952	13610	1.5
Chr02	4,86,14,681	7524	1.5
Chr03	6,22,90,286	11952	2.0
Chr04	7,22,08,621	11988	1.6
Chr05	5,20,70,158	7594	1.5
Chr06	5,95,32,096	11945	2.0
Chr07	5,67,60,843	8038	1.4
Chr08	5,69,38,457	8724	1.5
Chr09	6,15,40,751	12752	2.1
Chr10	5,97,56,223	12611	2.1
Chr11	4,54,75,667	6538	1.4
Chr12	6,11,65,649	7346	1.2

Table 2 SNP markers significantly associated with the late blight and potato cyst nematode resistance phenotype in different years using complete and reduced marker data set

Trait	Model	Marker	Chr	Position	Ref allele	Alt allele	Threshold	Score	Effect	R^2	P value
Full marker set											
AUDPC18	additive	chr11_5176739	Chr11	5176739	T	G	6.12	8.19	-365.24	0.156	0
AUDPC18	1-dom-alt	chr08_1111466	Chr08	1111466	T	G	6.1	6.21	454.94	0.123	0
AUDPC18	1-dom-alt	chr11_5176739	Chr11	5176739	T	G	6.12	8.19	-365.24	0.156	0
AUDPC19	1-dom-alt	chr11_45392300	chr11	45392300	A	T	6.1	6.33	-741.63	0.171	0
GP20	additive	chr03_30051088	chr03	30051088	A	G	6.12	7.35	0.69	0.157	0
GP21	1-dom-alt	chr01_79870255	chr01	79870255	C	T	6.1	6.38	-1.72	0.078	0
GP21	1-dom-ref	chr05_39730271	chr05	39730271	C	T	6.1	6.37	-2.65	0.04	0.012
GP21	1-dom-ref	chr10_29357976	chr10	29357976	C	T	6.1	7.6	-1.95	0.058	0.003
GR20	1-dom-alt	chr01_48615182	chr01	48615182	C	T	6.11	6.69	-1.51	0.066	0
GR20	additive	chr03_27049362	chr03	27049362	A	G	6.12	7	0.91	0.115	0
GR20	1-dom-ref	chr05_52055419	chr05	52055419	A	G	6.11	6.21	1.30	0.045	0.003
GR20	additive	chr12_53396900	chr12	53396900	A	G	6.12	6.86	-0.80	0.048	0.003
GR20	additive	chr12_619482	Chr12	619482	A	G	5.55	6.41	-0.42	0.083	0
GR21	1-dom-alt	chr04_43994066	chr04	43994066	A	G	6.1	6.26	1.72	0.095	0
GR21	1-dom-alt	chr10_11705153	chr10	11705153	C	T	6.1	6.23	2.59	0.217	0
Reduced marker set											
AUDPC18	additive	chr03_2054715	Chr03	2054715	G	T	5.55	5.58	-298.04	0.105	0
AUDPC19	additive	chr04_5755401	Chr04	5755401	C	T	5.54	5.55	-125.50	0.127	0
AUDPC19	1-dom-ref	chr05_13326227	Chr05	13326227	A	G	5.53	6.06	-263.30	0.099	0
AUDPC20	additive	chr11_44083171	Chr11	44083171	A	G	5.55	5.6	50.96	0.107	0
GP20	additive	chr01_62889722	Chr01	62889722	C	T	5.55	5.83	-0.40	0.128	0
GP20	1-dom-ref	chr10_29996650	Chr10	29996650	A	G	5.54	5.73	-1.52	0.121	0
GP21	1-dom-alt	chr10_45333027	Chr10	45333027	A	G	5.53	7.44	2.84	0.024	0.053
GP21	1-dom-ref	chr10_29358030	Chr10	29358030	A	G	5.53	6.33	-1.88	0.065	0.001
GP21	1-dom-alt	chr11_43021827	Chr11	43021827	C	T	5.53	5.84	-1.27	0.065	0.001
GR20	1-dom-alt	chr01_14013398	Chr01	14013398	A	G	5.54	5.6	-1.42	0.109	0
GR20	additive	chr02_43988105	Chr02	43988105	A	T	5.55	5.69	0.69	0.115	0
GR20	1-dom-alt	chr05_47262811	Chr05	47262811	C	T	5.54	5.83	-1.66	0.065	0
GR20	additive	chr12_619482	Chr12	619482	A	G	5.55	6.41	-0.42	0.083	0
GR21	additive	chr10_29388315	Chr10	29388315	A	G	5.55	5.64	-0.66	0.088	0
GR21	1-dom-alt	chr03_23982469	Chr03	23982469	A	G	5.53	6.81	-2.07	0.129	0

Chr-Chromosome; Ref-Reference; Alt-Alternate; 1-dom-alt -dominant alternate; 1-dom-ref -dominant reference; AUDPC18-Late Blight 2018; AUDPC19- Late Blight 2019; AUDPC20- Late Blight 2020; GP20- *Globodera pallida* 2020; GP21- *Globodera pallida* 21; GR20- *Globodera rostochiensis* 20; GR21- *Globodera rostochiensis* 21

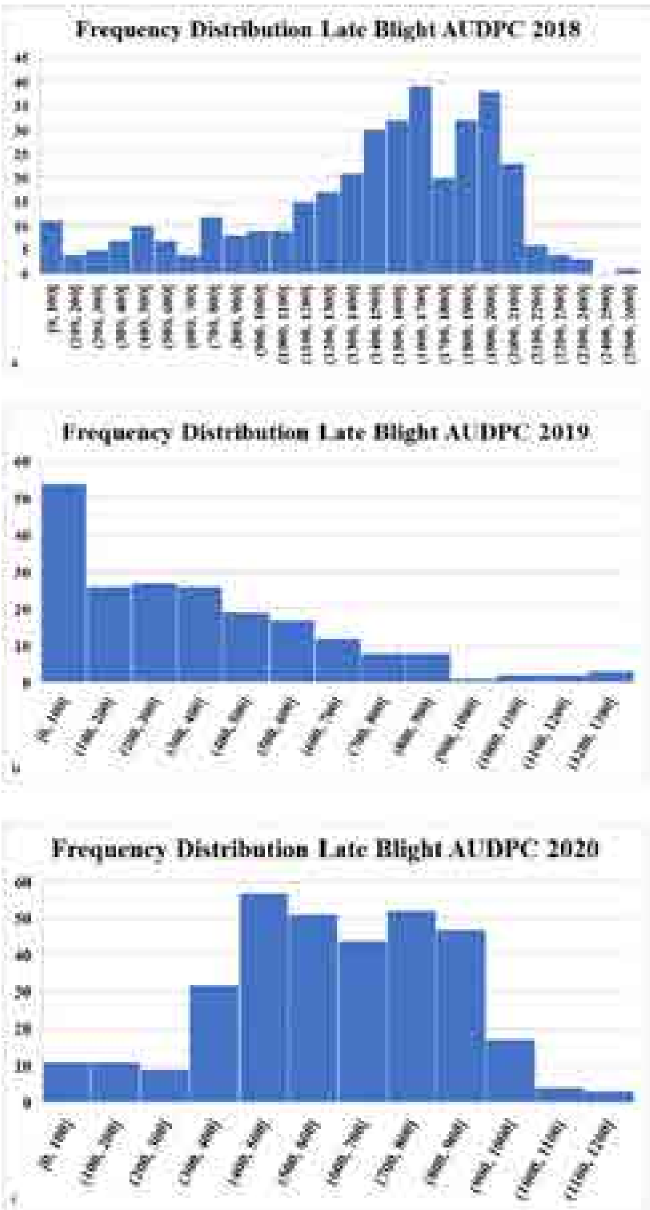


Fig. 2: Frequency distribution of potato accessions for late blight resistance (a) Late blight AUDPC 2018 (b) Late blight AUDPC 2019 (c) Late blight AUDPC 2020

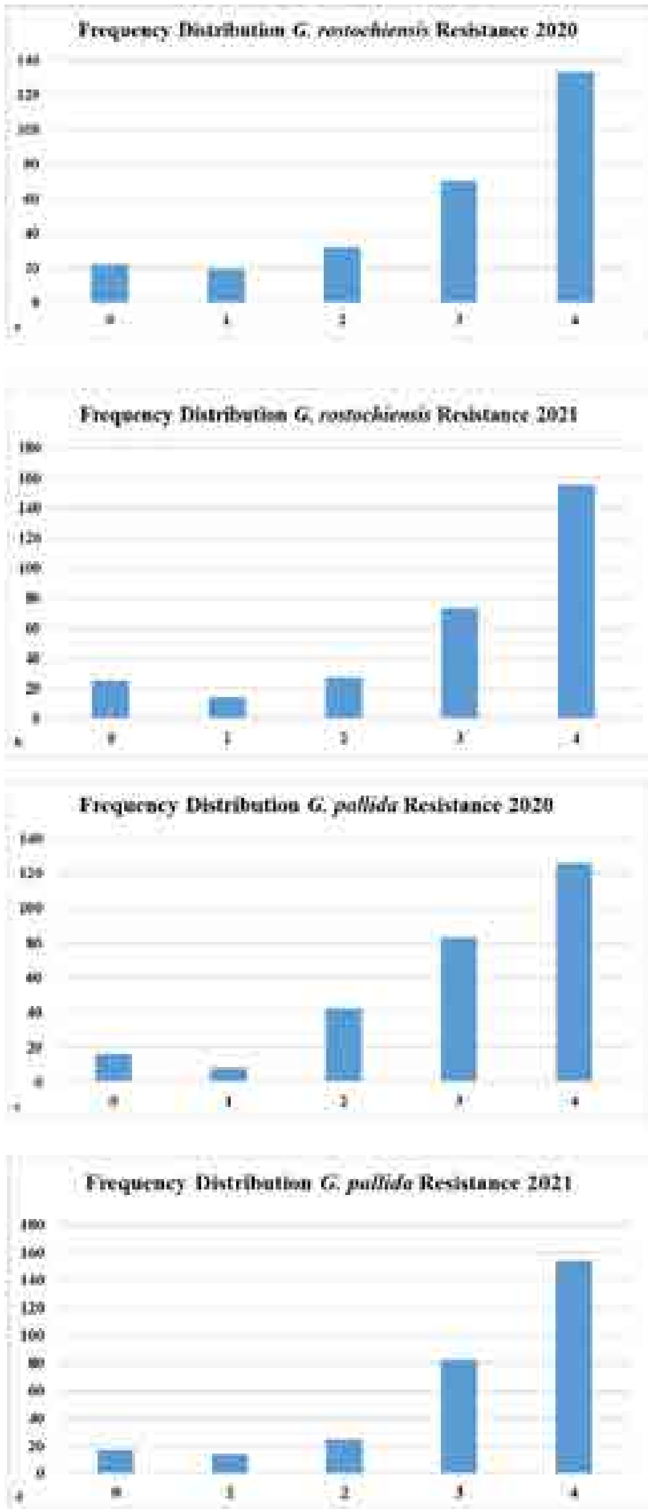


Fig. 3: Frequency distribution of potato accessions for potato cyst nematode resistance (a) Resistance to *G. rostochiensis* in 2020 (b) Resistance to *G. rostochiensis* in 2021 (c) Resistance to *G. palida* in 2020 (d) Resistance to *G. palida* in 2021

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

Project 1. Breeding nutritionally superior potatoes varieties

Project leader: Dr SK Luthra, **Component workers:** Drs Babita Chaudhary, Dalamu, Vinod Kumar, Brajesh Singh, Jagdev Sharma, VK Dua, Bandana, Arvind Kumar Jaiswal, Sanjay Rawal, Mehi Lal, Milan Kumar Lal, Pooja Mankar and Yvonne Angel Lyngdoh.

Hybridization: A total of 4,22,754 TPS were generated at Modipuram from 86 crosses involving diverse parental lines.

Seedling stage: In the seedling stage 1218 clones of 51 crosses were selected from 30,140 seedlings obtained from 98132 TPS of 51 crosses.

Initial clonal stages (F_1C_1, F_1C_2 and F_1C_3 stage)**:** In F_1C_1 stage, 1093 clones of 34 families were evaluated at 90 days and at harvest 115 promising clones were selected from 25 families. In F_1C_2 stage, 104 clones of 25 families were evaluated at 90 days and at harvest 40 promising clones (19 families) were retained. In F_1C_3 stage, 85 clones belonging to 16 families were evaluated at 90 days and at harvest 25 (12 families) promising clones were selected

Advanced stage trials: In all, 38 advanced clones were evaluated in five yield trials at 75/90 days at Modipuram and 16 promising advanced clones were selected. In the preliminary yield trial, 33 advanced clones were evaluated in 4 replicated trials along with controls at 75 and 90 DAP and at harvest 13 promising advanced clones namely MS/17-198, MS/18-101, MS/18-1272, MS/19-571, MS/19-602, MSP/19-190 (red skin), MSA/16-126 and MSP/17-07 (nutritionally superior clones), MS/19-400 and MS/19-664, MS/19-175, MS/19-253 and MS/19-268 were retained. In the confirmatory/final yield trial, five advanced clones were evaluated along with controls at 75 and 90 DAP and harvest, three advanced clones MS/16-1157, MS/18-393 and MS/18-465 were retained.

Chip colour score at Modipuram: Processing attributes investigated in 58 advanced clones/varieties revealed chip colour range from 1.5 (MP/19-020) to 8.0 (K. Ganga) and mean values 5.0 on the visual score. Among advanced clones, MP/19-020 (1.5), MS/17-198 (2, purple chips), MP/19-790 (2.3), K Frysona, Lady Rosetta, MP/19-256, MP/19-672 and MSV/20-12 (3) recorded acceptable chip colour scores).

Nutritional profiling at Shimla: In all 58 genotypes were assessed for nutritional components.

Ascorbic acid content* (mg/100 g FW)*: It ranged from 15 (MSA/16-126) to 67 (MS/19-602) with mean values of 30 mg/100 g FW. The genotypes with high ascorbic acid content were MS/19-602 (67), MSP/20-415 (65), MSP/20-1048 (58), MSP/20-445 (55), MSP/20-1163 (52), MSP/20-307 (45), MS/17-198 (45), MSP/20-554 (44), MSP/20-1100 (41) and MS/19-253 (40 mg/100 g FW).

Carotenoids (ug/100g FW): Carotenoids in flesh ranged from 4 (MSV/20-24) to 290 (K Lohit) with mean values of 86 ug/100g FW. The genotypes with high Carotenoids were K Lohit (290), MSP/20-554 (277), MSP/19-190 (202), K Lalima (198), MS/19-400 (185), MS/19-268 (159), MSP/20-415, MSV/20-12(158 ug/100g FW).

Amylose content (%): It ranged from 25 % (MSH/19-241) to 39% (MP/19-790) with mean values of 34%. The genotypes with high amylose content were MP/19-790 (39), MSP/20-1100 (38), MS/16-1157 (38), MP/19-256 (38), MSP/20-1163, MSP/20-121, MP/19-174 (37) and K Manik (36%).

Anthocyanins (mg/100 g FW): Anthocyanins in flesh ranged from 0 to (MP/19-209) to 75 (MSP/20-1048) with mean values of 7 mg/100 g FW. Anthocyanins on a whole tuber basis ranged from 1 (MSP/20-758) to 263 (MSP/20-415) with mean values of 46 mg/100 g FW. The genotypes with high total anthocyanins were MSP/20-415 (263), MSP/20-1048 (248), MSP/20-307 (211), MS/19-571 (197), MSP/20-666 (180), MS/17-198 (130), MSP/20-554 (116), MSV/20-15 (100 mg/100 g FW).

Zinc content (ppm): Zinc content (flesh) on a dry weight basis ranged from 15 (MS/17-198) to 29 ppm (MSP/20-129, MS/16-1157) followed by MSP/20-307, MP/19-672, MSP/20-445 (28), MSP/20-415, MSP/20-1100 (27), MSP/20-666, MSH/19-241 and MP/19-174 (26 ppm); whereas, zinc content on whole tuber basis ranged from 18 (MS/17-198) to 32 ppm (MSP/20-129, MS/16-1157) followed by MSP/20-307, MP/19-672 (30), MSP/20-445, MP/19-174, MSP/20-415, MSH/19-241 and MSP/20-1163 (29).

Iron content(ppm): Iron content (flesh) on a dry weight basis ranged from 28 (MSP/20-878) to 43 ppm (MSV/20-24) followed by MSH/19-241 (42), MP/19-174 (40), MSV/20-15, MP/19-020, MS/16-1157, MP/19-790 and MSP/20-445 (38ppm); whereas iron content on whole tuber basin ranged from 36 (K. Chip-3) to 50 ppm (MSH/19-241, MSV/20-24) followed by MSP/20-445, MP/19-672 (47), MSV/20-15, MSP/20-415, MSA/16-126 and MP/19-174 (45ppm).

Glycemic index (GI): The glycemic index (GI) of food or food product is the ability of food to enhance the blood sugar level after consumption which is measured in the range of 0-100. The GI is defined as the increment in the blood sugar area concerning test food (glucose) and expressed as a percentage response to an equivalent amount of carbohydrate taken as reference food taken by the same subject. High GI (GI >70, glucose scale) and low GI (GI <55, glucose scale). The screening of 62 varieties and 47 advanced clones based on in vitro glycemic response revealed that all varieties were in the range of high GI category (more than 70). Interventions are required to bring down GI in the Indian cultivars under moderate (56-69) or low category (less than 55).

Development of Potato Idli (Premix): Idli is a popular and traditional South Indian cuisine that has spread throughout India and abroad. Idli is famous for its light and fluffy texture and is frequently eaten with sambar and coconut chutney. Looking at the present market trend, we can see that the food processing sectors are concentrating on the inclusion of functional ingredients, adding vitamins, minerals, and other bioactive substances. ICAR-CPRI recently developed nutrient-rich (Anthocyanins)

Fig.1 Potato based anthocyanin rich Idli from Kufri Jamunia

potato variety Kufri Jamunia. ICAR-CPRI has conducted trials to develop idli premix from purple fleshed variety Kufri Jamunia. This one-of-a-kind Idli premix comprises anthocyanin-rich potato flour (75%), black gram flour, salt, and chemical leaveners. This idli premix can be cooked like conventional idlis by adding curd and water. Furthermore, due to the presence of anthocyanins, these idlis (**Fig. 1**) can change colour according on the pH (Red with the addition of lemon juice, blue in alkaline pH) and have a shelf-life of 9 months at room temperature.

Sharing of breeding material: About 1,62,270 TPS of promising crosses were sent to CPRI regional stations Patna and Shillong, AICRP center, Bhubaneshwar, Deesa, Dholi, Raipur for seedling raising and further selection as per institute breeding protocol for promotion of region-specific breeding. Eighty (80) promising advanced clones/parental lines were sent to Kufri for hybridization and late blight screening.

Introduction of advanced clones in AICRP: Introduced advanced clones MS/16-1157, MSP/17-07, MS/18-1272 (**Fig. 2,3,4**) in AICRP for multi-location testing.

MS/16-1157 (K Sangam x CP4406): The advanced clone produced a 6% high total tuber yield of 44 t/ha as compared to 41 t/ha of K.

Bahar at 90 days. It produces attractive 10-11 tubers/plant having white-cream ovoid tubers (**Fig. 2**) with shallow eyes and white flesh. MS/16-1157 possesses high tuber dry matter (20%) as compared to 18% in K. Bahar at 90 days. It possesses excellent keeping quality by virtue of low total weight losses and long tuber dormancy period, floury/mealy texture, higher vitamin C (31 (mg/100g FW), Amylose (33%), zinc (27 ppm) and iron (33 ppm) in flesh. It is slightly resistant to late blight (AUDPC:880) as compared to K. Bahar (AUDPC:1285).

Fig. 2: Morphological characters of MS/16-1157: Leaf, Inflorescence, tubes and sprout

MSP/17-07 (CP4042 x K. Chipsona-3): The advanced clones produced attractive 10-12 tubers/plant having yellow oblong tubers (**Fig.3**) with shallow eyes and yellow flesh. MSP/17-07 (44 t/ha) produced a 6% high total tuber yield as compared to Kufri Bahar (41 t/ha) at 90 days. MSP/17-07 possesses 17% tuber dry matter (90 days), excellent good keeping quality with medium tuber dormancy, floury texture, high total carotenoids (140 ug/100g FW), Vitamin C (33 mg/100g FW), amylose (35%), zinc (27 ppm) and iron (34 ppm) in flesh. It is slightly resistant to late blight (AUDPC:573) as compared to K. Bahar (AUDPC:1285), however, through detached leaf and tuber slice screening it was found moderately resistant to late blight.

Fig. 3: Morphological characters of MSP17-07: Leaf, Inflorescence, tubes and sprout

MS/18-1272 (SM/92-338 x CP4521): The advanced clones produced attractive 10-12 tubers/plant having dark red ovoid tubers (**Fig. 4**) with shallow eyes and yellow flesh. **MS/18-1272** (43 t/ha) produced a 5% high total tuber yield as compared to K. Manik (41) at 90 days. MS/17-848 possesses 20% tuber dry matter (90 days), medium tuber dormancy, excellent keeping quality, floury texture, high amylose (33%), and at par iron (34 ppm) with Kufri Manik. It is susceptible to late blight. It is slightly resistant to late blight (AUDPC:643) as compared to K. Bahar (AUDPC:1040).

Fig. 4: Morphological characters of MS/18-1272: Leaf, Inflorescence, tubes and sprout

Registration of elite germplasm: Biofortified potato genetic stocks MS/8-1148 (INGR23120, Parents: Kufri Surya x CP3125) was registered by NBPGR. Advanced potato clone MS/8-1148 produces light yellow, ovoid tubers with shallow eyes and yellow flesh colour (**Fig.5**). It possesses high ascorbic acid content (77.7 mg/100 FTW) in addition to desirable tuber traits, high tuber yield (48 t/ha), medium tuber dormancy (6-8 weeks), good keeping quality, tuber dry matter (17%), moderate level of late blight resistance. and desirable organoleptic attributes. It has a mealy texture, very good flavour with very good taste and free from discolouration after cooking. Thus, MS/8-1148 could serve a nutritionally superior clone for feeding the mal-nourished populations and can simultaneously be used as an elite parent in future breeding progrmmes.

Fig.5: Biofortified potato genetic stocks MS/8-1148 (INGR23120 registered by NBPGR

Notification of new red skin variety: An improved red coloured advanced potato variety MS/11-664 (K. Kanchan x K. Khyati) has been notified by the CVRC meeting during May 2023. The new variety is medium maturing (75-90 days) with yield potential of 35-38 t/ha and possesses a moderate level of late blight resistance, excellent keeping and culinary quality. It possesses 17-18% tuber dry matter, very good taste and a mealy texture. It has an edge over prevailing red skin varieties like K. Manik, K. Lalit and K. Lalima for tuber yield quality attributes. It produces attractive red

Fig. 6: Red skinned potato variety Kufri Lohit

ovoid uniform tubers with shallow eyes and cream flesh colour (**Fig. 6**). The new variety is suitable for growing in north Indian plains (Eastern and Central).

Release of new potato variety: Specialty advanced potato clone MSP/16-307 named as variety Kufri Jamunia (MS/8-1148 x CP4242) has been recommended in the 41st AICRP (Potato) group meeting held at HAU, Hisar, Haryana during 18-20 October, 2023. The new variety is medium maturing (75-90 days) with a yield potential of 32-35 t/ha and possesses a moderate level of late blight resistance, excellent keeping and culinary quality. It produces attractive purple oblong tubers, with shallow eyes and purple flesh colour (Fig. 7). It possesses 18-19% tuber dry matter, very good taste and a mealy texture. High anthocyanins (32), ascorbic acid 52 mg/100g FW), carotenoids (163 ug/100g fresh weight) & flavouring compounds 5 (AMP+GMP) ug/g than controls. Kufri Jamunia also possessed at par zinc (23 ppm) and iron (32 ppm) content on a dry weight basis with Kufri Manik. It is easy to cook, texture mealy, flavour mild, free from after-cooking discoloration. It is suitable for table potatoes and the preparation of speciality products like dalia, suji, ice cream, and biscuits. The new variety is suitable for growing in north Indian plains.

Fig. 7: Purples fleshed biofortified potato variety Kufri Jamunia

Late blight screening at Kufri: Among sixty genotypes screened for late blight resistance undertaken under natural epiphytotic field conditions and based on late blight data recorded thrice and AUDPC calculation, genotypes MSV/20-27 and MSH/19-241were highly resistant (AUDPC<250), MS/18-101, MSV/20-12 & MSA/16-126 were moderately resistant (AUDPC 351-650) and remaining accessions were either susceptible or highly susceptible.

Evaluation for late blight resistance at Modipuram: Among eighty three potato genotypes evaluated for late blight resistance under field and lab conditions. All advanced clones/accessions showed less Area Under Disease Progress Curve (AUDPC) than control highly susceptible variety K. Bahar (1685). Among all genotypes CP4643 (0), CP4688 (2), CP4668 (5), CP4681 (6), K. Karan (6), K. Girdhari (7), CP4680 (10), CP4682 (11), CP4659 (23), CP4638 (24), CP4665 (26), CP4666 (48), MSV/20-27 (49), MSH/19-241 (55), CP4658 (67), CP4678 (73), MSA/16-333 (83), MSV/20-17 (89), MS/19-602 (119), MSA/16-126 (121) compared to standard cv. K. Bahar (1685) under field conditions. These advanced clones also showed less rAUDPC. However, rAUDPC ranged from 0.0 to 0.73. Under laboratory condition, by detach leaf method 10 clones (CP4643, CP4688, CP4681, CP4682, CP4680, CP4668, CP4658, CP4665, K. Karan and CP4666) were highly resistant; 8 were resistant (CP4659, MSV/20-27, CP4638, MSV/20-17, CP4678, MSH/19-241, MS/19-640, MS/19-370); 23 were moderately resistant and remaining 42 were susceptible. Under laboratory condition, by tuber slice method, 40 clones (MSA/16-126, K. Surya, K. Girdhari, MSH/19-180, MSA/16-333, K. Fryom, K. Karan, MSV/20-17, MS/18-101, MSV/20-15, K.Chip-3, K. Sangam, K. Neelkanth, MS/19-370, K. Chip-1, MS/19-571, CP4643, CP4681, MS/13-527, MSA/16-140, CP4638, K.Himalaini , CP4688, MS/19-664, MS/19-640, MS/14-505, MS/18-463, MS/17-621, MS/19-400, MS/14-1381, MSH/14-243, Atlantic, K.Lalit, CP4678, MSV/20-12, MS/17-198, MSV/20-24, MS/18-465, MSP/17-07, CP4687) showed moderately resistant and remaining 43 genotypes were susceptible.

Screening of advanced clones for hollow heart: Among the eighty three evaluated for hollow heart and nine advanced clones and one variety; CP4682 (80%), MS/19-640 (30%), CP4638 (30%), MSA/16-333, CP4680, Atlantic (20%), CP4653, CP4666, CP4687, C 4688 (10%) showed hollow heart like symptoms.

Screening of advanced clones for black scurf and common scab: Among the eighty three evaluated for two times for black scurf, the disease incidence of black scurf ranged 0.0-12.5%. Genotypes namely MS/15-286 (12.5%), MSP/16-272 (12.0%), MS/14-342 (11.0%), MS/16-1157(11.0%), CP4650 (6.25%), CP 4682, MSP/17-07 (2.0%), MS/17-621 (2.5%), Atlantic (12.0%), Lady Rosetta (9.0%), K. Ganga (3.75%), K. Girdhari (2.5%), K Bahar (2.5%), K. Fryom (2.25%), K. Mohan & K. Sangam (1.25%) recorded different level of black scurf incidence. Similarly, the incidence of common scab was also recorded and it ranged from 0 to 7.5%. The genotypes namely MS/19-135 (7.5%), MS/18-465 (6.25%), MS/13-391(5.0%), MS/18-101, MS/18-290, MS/19-370 (4.25%), MS/18-193 (4.0%), MSH/14-243 (3.5%), MS/19-400 (3.25%) and K. Chipsona-3 (2.5%) showed different level of common scab incidence was recorded.

Optimizing agro-technology: Kufri Thar-2 indicated that nutrient levels of 160 kg N, 40 kg P_2O_5, and 100 kg K_2O/ha were sufficient for achieving the highest mean marketable (27.7-29.1 t/ha) and total tuber yields (31.0- 32.2 t/ha) when irrigated thrice (50 mm) during the crop period. The mean tuber dry matter content ranged between 20.5- 20.9%. Advanced baby potato clone MSP/15-60 responded up to 180 kg N, 40 kg P_2O_5, and 100 K_2O kg per ha with mean baby potato grade yield (25- 40 mm) of 15.0- 18.5 t/ha, while mean large and total tuber yields were 4.4-6.2 t/ha and 26.5- 33.6 t/ha, respectively and with the tuber dry matter range of 16.8- 17.9%

Project 2. Breeding early bulking agile potato varieties suitable for intensive cropping systems

Project leader: Dr Raj Kumar, **Component's workers**: Dr Ratna Preeti Kaur.

Hybridization: A total of 70998 seeds of 71 crosses were obtained.

Seedling stage: 13933 promising clones were selected from 43008 seedlings raised by sowing 79529 true potato seeds of 60 crosses.

Initial clonal stages: In the initial clonal stages (F_1C_1, F_1C_2 and F_1C_3), 940 promising clones were selected from the 7472 clones evaluated.

Advanced stage trials: In all, 62 advanced clone were evaluated in 5 yield trials at 65/75 days at Jalandhar and 16 promising advanced clones were selected. In preliminary yield trials (three) at 60 and 75 days, 8 clones namely J/17-141, J/17-155, J/17-210, J/17-212, J/17-216, J/17-96, J/17-104 and J/17-125 were selected of the 41 advanced clones evaluated. In confirmatory yield trial, 8 advanced clones J/16-4, J/16-78, J/16-84, J/16-134, J/16-196, J/15-36, J/15-74 and J/15-91 were selected from the 21 advanced clones evaluated.

Introduction of hybrids in AICRP: Based on consistently good performance over years, two advanced clones namely J/15-36 and J/15-91 (Fig. 8) were introduced in the All India Coordinated Research Project on Potato (AICRP Potato).

J/15-36 (J/92-164 x MS/82-797): Based on yield average over years, J/15-36 gave 10.3 % and 14.6% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. It produces white ovoid tubers with medium eyes and pale yellow flesh colour. It possesses 17 % tuber dry matter and good keeping quality.

Fig. 8: Tubers of advanced clone's J/14-242 and J/14-245

J/15-91 (J/92-167 x K Pukhraj): Based on yield average over years, J/15-91 gave 21.9 % and 24.3% higher yield over control Kufri Khyati at 60 and 75 days harvests, respectively. It produces white ovoid tubers with shallow eyes and pale yellow flesh colour. It possesses 16% tuber dry matter and good keeping quality.

Project 3. Breeding improved red skinned varieties for eastern plains

Project leader: Dr Sarala Yadav

Hybridization: A total of 65,498 seeds of 62 crosses were obtained.

Seedling stage: In the seedling stage 1,618 promising clones were selected from 46,846 seedlings raised by sowing 65, 498 true potato seeds of 62 crosses.

Initial clonal stages: In the initial clonal stages (F_1C_1, F_1C_2 and F_1C_3), 222 promising clones were selected from the 894 clones evaluated at 75 days.

Advanced stage trials: In all, 30 advanced clones were evaluated in 2 yield trials at 75/90 days at Patna and 15 promising advanced clones were selected. In the preliminary yield trial, 8 clones namely PS/18-02, PS/18-04, PS/18-21, PS/18-28, PS/18-44, PS/18-48, PS/18-53, PS/18-60 were selected of the 17 advanced clones evaluated at 60 and 75 days. In the confirmatory yield trial, 7 advanced clones namely PS/16-02, PS/16-34 (purple) PS/17-09, PS/17-11, PS/17-12, PS/17-15, PS/17-20 (red) were selected from the 13 advanced clones evaluated.

Introduction in AICRP: Advanced clones namely PS/16-2 (purple fleshed), PS/17-12 (red skin), (**Fig. 9**) have been introduced in AICRP for multi-location testing.

PS/16-2 (K. Arun x CP2419): The advanced clone with 26 and 31 t/ha total tuber yield showed a yield increase over K. Neelkanth by 7 and 13% at 75 and 90 days respectively. It produces purple ovoid tubers with shallow eyes, purple flesh and mealy texture. It possesses 20% tuber dry matter, very good keeping quality and a moderate level of late blight resistance to late blight. It possessed high Vitamin C (49 mg/100 gram fresh weight) and anthocyanins (29 mg/100 gram fresh weight as compared to K. Neelkanth (29 and 0.88).

PS/17-12 (K. Arun x PS6/82-2): The advanced clone with 29 and 34 t/ha total tuber yield showed a yield increase over K. Manik by 17 and 27% at 75 and 90 days respectively. It produces red ovoid tubers with shallow eyes and yellow flesh colour. It possesses 18% tuber dry matter, good keeping quality and a moderate level of late blight resistance to late blight. It possessed high iron (46 ppm), carotenoids (37) and anthocyanins (4 mg/100 gram fresh weight as compared to K. Manik (45,0.91 and 29)

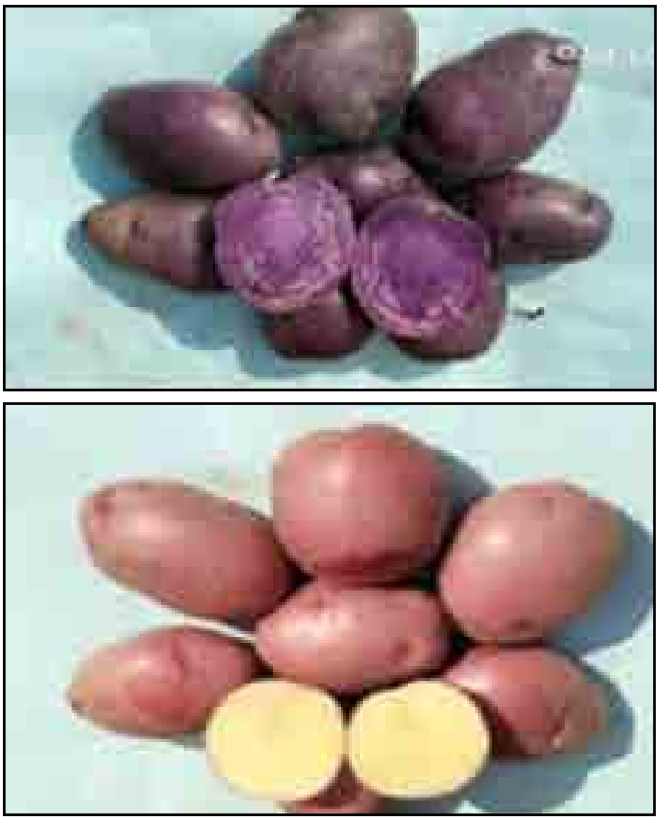


Fig. 9: Tubers of PS/16-2 and PS/17-12

Project 4. Breeding for processing varieties

Project leader: Dr VK Gupta, **Component workers:** Drs. Salej Sood, Vinay Bhardwaj, Bandana, Arvind Jaiswal, Sanjay Rawal and Mehi Lal

Hybridization: A total of 283833 TPS of 73 crosses were produced at Modipuram and Kufri.

Seedling stage: A total of 941 clones were selected from 32570 seedlings (31 crosses) obtained from 111542 TPS (38 crosses) sown in a nursery bed for seedling raising.

Initial clonal generations: Three hundred ninety two promising clones were selected from the 1796 clones evaluated in initial clonal generation based on superior tuber characters and chip colour, dry matter.

Preliminary yield trial: Nineteen genotypes having superior performance were selected from the 21 genotypes evaluated in a replicated yield trial.

Advanced clonal trial at Modipuram: Based on the 75, 90 and 110 days performance two advanced clones namely MP/17-330 and MP/17-824 having superior or at par yield (total and processing), dry matter, acceptable chip colour and synchrony as compared to control varieties were selected from 11 clones.

Evaluation trial in early planting season at Modipuram: Twenty-eight advanced clones and 6 control varieties were evaluated in early season planting and based on performance at 90 days, and MP/19-344, MP/19-387, MP/19-360, MP/18-745, MP/18-534 were found to be superior concerning yield as well as acceptable quality traits.

CPRI–ITC-Potato Trial–South, East and Northern India (Rabi): Multi-location field trials were conducted across three locations, Viz., Karnataka (19 genotypes at Chikaballapur), West Bengal (18 genotypes at Bankura) and Telangana (19 genotypes at Zaheerabad). Based on yield and quality, the following genotypes were shortlisted. Genotype MP/15-750, MP/12-126, MP/15-698 and MP/15-651 (Karnataka ITC Rabi), MP/15-651, MP/18-746 (Telangana ITC Rabi), MP/15-698, MP/12-126, MP/15-651, MP/16-315 (WB, ITC, Rabi). In addition, 19 advanced clones and varieties were evaluated in the northern region (Meerut) and based on yield and quality traits. three genotypes namely MP/9-28, MP/16-178 and MP/13-662 were found to have superior quality traits and yield.

CPRI–ITC-Potato Trial-South India (Kharif): Multi-location field experiments were conducted with processing genotypes at Chikmagalur, Karnataka (19 genotypes); Hasanur Erode, Tamilnadu (13 genotypes) and Thalavadi, Tamilnadu (16). Based on field performance, yield potential and quality, potential clones were identified at Thalavadi (MP/12-126, MP/15-651, MP/18-746 and MP/18-285), Hasanur (MP/12-126, MP/15-651 and MP/18-285) and Chikamagalur (MP/18-746 and MP/18-285).

Evaluation trial on new French fry genotypes in Gujarat: The evaluation trial of five advanced clones in Gujarat with French fries industry revealed the identification of promising clones namely MP/11-30, K Sangam, MP15-651 and K Frysona (Simplot, JRS India Foods), MP/15-651, K FryoM and K Sangam (McCain's Food) and K FryoM, MP/15-651and Kufri Sangam (Hyfun Food) showed the good potential of having high total tuber yield, processable grade and quality parameters.

Storage behaviour of advanced clones under ambient conditions at Modipuram: Thirty-six advanced clones were evaluated for storage behaviour and lesser total weight loss (%) was noted in MP/17-109 (9%), MP/17-340, MP/17-740 (10%), MP/16-226, MP/17-257 (11%), MP/16-178 and MP/18-786 (12%) than control varieties viz., Kufri Sangam (9%) LR (10%), Kufri FryoM, ATL (11%), Kufri Chipsona-5 and Kufri Chipsona-1 (12%) after 75 days of storage.

Tuber yield and processing quality at Jalandhar: Seventeen advanced clones/varieties were evaluated for yield and processing quality at 90 DAP and higher processing and total tuber yield was recorded in MP/16-178 followed by MP/17-709 and MP/16-315. Higher fry grade yield was recorded in MP/17-709 followed by MP/15-207 and MP/13-662. Whereas for Chip grade tubers highest yield was recorded in MP/16-178 followed by MP/16-173, MP/16-315 and MP/17-709. The dry matter content ranged from 18 to 23% and higher dry matter was found in MP/16-178 followed by MP/16-315, ATL and MP/17-745. Chip colour score of 9 clones (MP/16-178, ATL, MP/14-129, MP/17-709, MP/16-173, MP/16-315, MP/13-662, LR, MP/16-226) was within the acceptable range (Score up to 3 on the scale of 10). After curing 9 clones (MP/16-178, ATL, MP/14-129,

MP/17-709, MP/16-173, MP/16-315, MP/13-662, LR, MP/16-226) were found suitable for processing into chips and fries.

Changes in processing attributes during storage (180 days) at 12°C with CIPC: At the end of storage highest dry matter was found in MP/16-315 (23.57%) followed by ATL and MP/16-178. The mean chip colour score of 6 advanced clones/varieties viz., MP/14-129, K Chipsona-1, K Chipsona-3, ATL, MP/16-178 and MP/16-173 was within the acceptable range. Among all hybrids lowest chip colour score was found in MP/14-129 and MP/16-173. Among 17 advanced clones, 6 genotypes namely MP/14-129, K Chipsona-1, MP/13-662, ATL, MP/16-178 and MP/16-173 were found suitable for processing into chips and fries.

Optimizing crop geometry and depth of planting for dual-purpose potato variety Kufri Sangam: The crop geometry trial consisted of 16 treatment combinations of row-to-row spacing (60, 67.5, 75 & 82.5 cm) and plant-to-plant spacing (20, 25, 30 & 35 cm) in three replications in factorial RBD design. Tubers were graded as small (<30 mm), marketable (30-55 mm) and export grade (>55 mm), and net tuber yield was calculated by subtracting the used seed of 50g (mean weight). Optimum mean marketable (17.7 t/ha), export grade (12.0 t/ha), total (33.9 t/ha) and net tuber yield (31.2 t/ha) were recorded in 75 x 25 cm crop geometry, which was superior to several comparable treatments. Tuber dry matter content was not markedly influenced due to different treatment combinations, which ranged between 18.68- 20.36%. The depth of planting study had 4 treatments (5, 10, 15 & 20 cm) and 5 replications in RBD design. Maximum and significantly better mean marketable (8.1 t/ha), export grade (13.7 t/ha) and total (26.0 t/ha) tuber yield was recorded with 10 cm depth of planting. Green tuber weight (1.63 t/ha) was reduced by 23.8 % in this treatment in comparison to the treatment of 5 cm (2.14 t/ha). Tuber dry matter content was not markedly influenced due to different treatment combinations, which ranged between 18.85- 20.11%.

Evaluation for late blight resistance at Shimla: **S**ix advanced clones namely MP/17-257, MP/16-226, MP/13-662, MP/17-340, MP/16-178 and MP/17-216 along with eight control varieties were evaluated Kufri for late blight resistance and advanced clones viz., MP/13-662 and MP/16-226 recorded the lowest AUDPC value of 303 and 642, respectively, while the control varieties Lady Rosetta (1689) and Atlantic (1576) recorded the highest AUDPC.

Screening of Advanced clones for Late blight: Seven advanced clones along with control varieties were evaluated for late blight resistance under field and lab conditions during at Modipuram and all advanced clones showed less Area Under the Disease Progress Curve (AUDPC) than controls and highly susceptible varieties like K. Bahar (1685) & Lady Rosetta (1898). Among clones, less AUDPC was recorded in MP/17-216 (386), MP/15-207(453), MP/16-334 (516), MP/17-340 (596) as compared to standard cv. K. Bahar (1685). These advanced clones also showed less rAUDPC. The lowest rAUDPC was recorded in MP/17-216 (0.14) as against Lady Rosetta (0.70). Under laboratory conditions, by detach leaf method MP/15-207, MP/16-334, MP/17-109, MP/17-216 were moderately resistant and remaining susceptible. Under laboratory conditions, by tuber slice method, MP/15-207, MP/16-226, MP/16-334, MP/17-109, MP/17-216, MP/17-330, MP/17-340 were moderately resistant.

Screening of Advanced clones for dry rot of potato: Four advanced clones along with control varieties were evaluated for dry rot using the cork borer method in the lab. Results revealed that the penetration rate ranged from 5.0-15.0 mm. The less penetration rate was measured in MP/16-334 (6.7 mm), MP/16-226 (7.3 mm) and MP/15-207 (7.3 mm) than Kufri Chipsona-1 (11.3 mm) K. Chipsona-3 (15.0 mm) and K. FryoM (12.0 mm)

Screening of Advanced clones for Hollow heart, Black scurf and Common Scab: Four clones along with control varieties evaluated for hollow heart and MP/17-257 (40.0%) and Atlantic (20.0%) revealed the highest incidence of hollow heart-like symptoms. In three advanced clones along with four varieties; MP/17-330 (3.75%), MP/16-226 (1.75%), MP/17-340 (1.00%), Atlantic (12.0%), Lady Rosetta (9.0%), K. FryoM (2.25%), K. Sangam (1.25%) recorded variable level of black scurf incidence. In two advanced clones and one variety; MP/16-226 (2.00%), MP/17-109 (1.5%) and K. Chipsona-3 (2.5%) variable levels of common scab incidence was recorded.

Introduction in AICRP: Based on consistence superior performance advanced clones Namely MP/17-330 and MP/17-824 (Fig.10) has been introduced into AICRP for multi-location trials.

MP/17-330 (K Chipsona-1 X MP/6-595): MP/17-330 produced 9 % higher mean processing (31 t/ha) and at par total tuber yields (40 t/ha) with controls. It produces attractive white cream, round tubers with shallow eyes and cream flesh. It possesses 22% dry matter and an acceptable fry colour score. MP/17-330 also has field resistance to late blight (1109 AUDPC) than lady Rosetta (1898) and in ATL (1370). It is suitable for processing into chips,

MP/17-824 (VK-1 x MP/9-73): MP/17-824 produced 19 % higher mean processing tuber yield (36 t/ha) than control Lady Rosetta and Atlantic. However, it has only a 6% higher yield than Lady Rosetta and is at par with Kufri Chipsona-1 for total tuber yield. It produces white cream ovoid tubers with shallow eyes and cream flesh. It is suitable for specialty products.

Fig.10: Tubers of MP/17-330 and MP/17-834

Release of new potato variety: Processing advanced potato clone MP/9-45 named as variety Kufri Chipsona-5 (Kufri Himsona x CP1371) has been recommended in 41st AICRP (Potato) group meeting held at HAU, Hisar, Haryana during 18-20 October, 2023.The new variety is medium maturing (90-100 days) with yield potential of 30-35 t/ha and possesses a moderate level of late blight resistance, very good keeping and processing quality. It produces attractive white-cream round ovoid tubers with shallow-medium eyes, cream flesh and mealy texture (**Fig. 11**). It possesses 21% tuber dry matter, low reducing sugars (67 mg/100g fresh tuber weight) and acceptable chips colour score (2.5) and thus it is suitable for processing into chips. The new variety is suitable for growing in Haryana, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Gujarat and Rajasthan, Chhattisgarh.

Fig.11: New processing potato variety Kufri Chipsona-5

Project 5. Breeding for biotic stresses (late blight, viruses & cyst nematodes)

Project leader: Dr Salej Sood, **Component workers:** Drs Dalamu, Vikas Mangal, Sanjeev Sharma, Priyank Hanuman Mhatre, Clarissa Challam, Mehi Lal, Babita Chaudhary, Aarti Bairwa, Ravinder Kumar, Kailash Chandra Naga, Vinod Kumar, Ashwani Sharma, Tanuja Buckseth, Ajay Kumar Thakur, Yuvonne Angel Lygdoh

Hybridization: Sixty three successful crosses at Kufri/ Shimla and Ooty between PCN, late blight and virus tolerant parents having early to medium maturity, better quality traits and good adaptability resulted in 1,37,004 hybrid TPS.

Seedling raising and screening for late blight resistance: A total of 25000 TPS/14650 seedlings of 7 crosses were screened under controlled conditions against complex races of *Phytophthora infestans* at Shimla and a total of 1324 resistant seedlings were transplanted in the earthen pots and at harvest 813 clones were retained. The highest number of resistant seedlings (%) were obtained in the cross CP 4311 x Kufri Karan (16.7%), Kufri Kiran x CP 1971 (13%) and CP 1971 x MSP/17-89 (11.6%). At Shillong, 10,000 TPS of 4 crosses were raised and 5000 seedlings were screened of which 375 clones were selected At Ooty, among the 44,000 true seeds of 7 crosses sown, 20658 seedlings were transplanted and at harvest, 78 late blight resistant selections were made.

Initial clonal evaluations: In the initial stages (F_1C_2 to F_1C_4), 934 genotypes were evaluated under natural field conditions at Kufri/Ooty for their disease resistance and adaptability and 707 clones were selected.

Evaluation of advanced clones at Modipuram: Twenty eight advanced clones along with five control varieties were evaluated in two trials and at harvest eight promising advanced clones namely SM/14-335, SM/15-245 SM/14-342, SM/15-739, SM/15-135, SM/14-339, SM/15-486 and SM/14-347 were selected.

Yield trials at Kufri: Among the 14 advanced clones evaluated in 3 trials at Kufri, ten advanced clones were selected. In the F_1C_6 trial, SM/16-73, SM/09-82, SM/10-10, SM/10-255 and SM/10-103 were selected. In the F_1C_7 trial, SM/10-174, SM/08-04, SM/03-32, SM/10-117 and SM/10-243 were selected due to superior yield performance and late blight resistance.

Yield trials at Ooty: Among 30 advanced clones evaluated along controls, 14 advanced clones were selected based on agronomic traits and resistance to potato cyst nematodes and late blight. Among the advanced clones, OS/14-436, OS/14-318 and OS/14-208 recorded maximum yield (55.29, 44.96 and 37.64 t/ha respectively). Advanced clones OS14-318 and OS/14-208 were found highly resistant to late blight and showed resistance to both species of potato cyst nematode.

Yield trials at Shillong: Among 63 advanced clones evaluated in the preliminary yield trial, nine advanced clones were selected for confirmatory yield trial. In the confirmatory yield trial, out of five clones, SS/16-57 (22.58 t/ha) resulted in the highest tuber yield followed by K. Himalini (19.88 t/ha).

Evaluation of potato germplasm for tolerance to PCN: A total of 22 accessions were screened along with 5 susceptible potato cultivars against both the species of PCN at Kufri. Eleven accessions namely CP1137, CP1435, CP1674, CP1687, CP1736, CP3939, CP3871, CP3799, CP3222, CP1584 and JEX/A-15 were found highly resistance (HR) to both the species. Based on three years evaluation, four accessions namely CP1687, CP1736, CP3871 and CP3799) were found highly resistant accessions to both the species of PCN at Kufri. At Ooty, 337 accessions were screened for resistance to both the species, *Globodera pallida* and *G. rostochiensis* and results revealed that thirteen accessions namely CP1151, CP1218, CP1435, CP1584, CP1674, CP1687, CP1736(2), CP1988, CP2418, CP2285, CP3799, JEX/A-99 and JEX/A-317) were resistant to both the species of PCN.

Screening of advanced potato clones against whitefly (*Bemisia tabaci*): Thirty advanced clones were screened against whitefly using a choice assay with SM/11-120 as check, which in earlier screening assays was proven to be least preferred to whitefly. A total nine potato clones recorded less number of white fly adults compared to the check (SM/11-120) (**Fig. 12**) and hence these nine clones were further screened for egg laying and nymph development. These clones displayed a great variability in number of eggs laid and nymphs developed. The number of eggs ranged from 2.7 to 277 per leave on SM/17-636 and SM/17-629 respectively (**Fig. 13**). However, number of nymphs ranged from 1 to 151.3 / leave on SM/17-636 and SM/17-629 respectively**.** The present screening revealed that the clone SM/17-636 is least preferred by whiteflies.

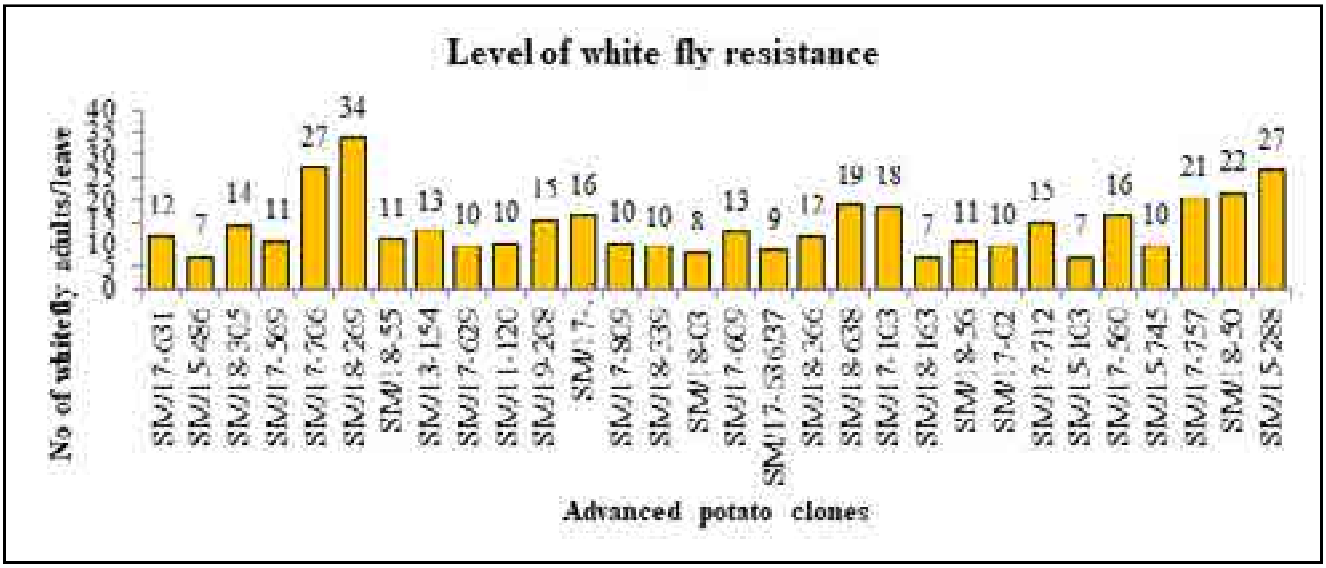


Fig. 12: Preference of whitefly adults to different potato hybrids under choice assay.

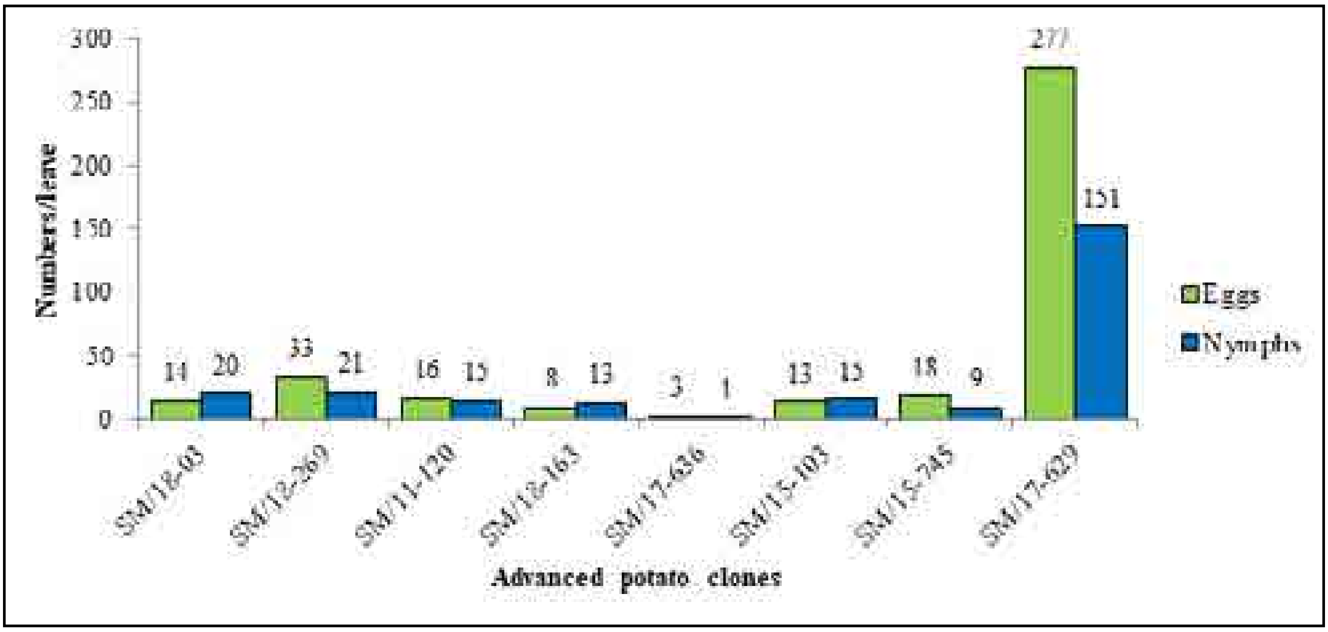


Fig. 13: Response of advanced potato clones for egg laying and subsequent nymph development.

Registration of genetic stock: An advanced clone SM/92-338 (HB/82-372 x K. Pukhraj) showed high average yield of 25t/ha in comparison to the best control K. Girdhari (23.5t/ha) at Kufri, Shimla and was found to be highly resistant to bacterial wilt under invitro conditions in the lab and sick plot field conditions. It has moderate resistance to late blight and produces attractive white-cream ovoid tubers with shallow eyes and cream flesh (**Fig.14**). It has 19% tuber dry matter

Fig.14: Tubers of SM/92-338

and excellent keeping quality. The advanced bacterial wilt resistant clone SM/92-338 was registered as genetic stock (INGR23063) with ICAR-NBPGR, New Delhi.

Project 6: Development of varieties with resilience to abiotic factors

Project leader: Dr Devendra Kumar, **Component workers:** Drs VK Gupta, Sanjay Rawal, Babita Chaudhary, Anuj Bhatnagar, Dalamu, Vikas Mangal, Brajesh Singh, Som Dutt, Sugani Devi, Milan Kumar.

Breeding for heat tolerance

Hybridization: A total **of** 91,971 TPS were recovered from the 74 crosses attempted at Kufri/Modipuram

Seedling stage: In all 15,885 seedlings were recovered from 84,991 TPS (69 crosses) and 881 clones of 38 crosses were selected.

Initial clonal stages: In all 148 promising clones were selected from the 679 clones evaluated in F_1C_1, F_1C_2 and F_1C_3 stages.

***Advanced clones evaluation at Modipuram*:** Twenty four advanced clones were evaluated in two trials of early season planted crop at 75 DAP and eight promising clones namely HT/20-515, HT/20-200, HT/20-260, HT/20-449, HT/20-544, HT/20-77 (preliminary yield trial), HTMK/17-12 and HT/17-164 (confirmatory yield trial) were selected.

Advance clones trial at Pune: Fifteen advanced clones were evaluated in Kharif planting season at 90 DAP and advanced clones namely HT/17-202, HTMK/17-12 and MP/13-1045 were found promising.

Advance clones trial at Bhubaneswar: Eighteen advanced clones were evaluated in the rabi season at 75 DAP. None of the clone significantly out yielded control Kufri Kiran, however, HTMK-10, HT/17-202 and HT/17-162 were found to be promising as compared to other clones.

Introduction in AICRP: Based on superior performance at Modipuram advanced heat tolerant clone HT/17-257 (HT/12-932 × HT/7-720) was introduced into AICRP for multi-location trials. The advanced clone (Fig. 15) has a 10 % higher total tuber yield than the best control Kufri Surya. It possesses 17% tuber dry matter and has a tolerance to hopperburn and mite burn, which are the main insect pests during early season crops. The storage capacity is very good under ambient conditions.

Fig. 15: Leaf and tubers of HT/17-257

Breeding for drought tolerance

Seedling stage: In all 4155 seedlings were recovered from 24100 TPS (12 crosses) and 320 clones were selected.

Initial clonal stages: In all 112 promising clones were selected from the 471 clones evaluated in F_1C_1, F_1C_2 and F_1C_3 stages.

Advanced stage trial: A total of 10 advanced clones were evaluated in trials under water stress and well-watered along with K. Thar-1 and K. Thar-3 Irrigations are regulated to be in equal quantity of water, using digital water meter. Besides, intermittent rains were recorded. and the field phenotypic traits viz. leaf vigor (SPAD value), stay-green trait and other associated traits viz. total yield tuber dry matter under stress, were recorded. At harvest six advanced clones namely WS/18-432, WS/18-602, WS/18-619, WS/18-622), WS/17-402 and WS/17-814 **(Fig. 16)** were retained.

Fig.16: Tubers of advanced potato clone WS/17-402 and WS/17-814

Introduction of advanced clone in AICRP: Based on three year consistent performance under water deficit conditions at Modipuram, advanced clone WS/14-32 **(CP3173 x YY6)** produced 11% higher total tuber yield under well watered control and >20% high total tuber yield under water stress than K. Thar-3. It produces white-cream, round-ovoid tubers with shallow eyes and cream flesh (Fig.17), >19% dry matter, moderate resistance to late blight, long tuber dormancy and very good keeping quality.

Fig.17: Tuber, flower, leaflet and sprout of advanced potato clone WS/14-32

Notification of Kufri Daksh: Advanced potato clone WS/07-113 was notified as 'Kufri Daksh'. It is a medium maturing (90 days), high-yielding variety (32 t/ha) under water & heat stress, moderately resistant to late blight and suitable for growing in Central and Eastern plains of India. The variety produces white cream, ovoid tubers with shallow eyes and creamy flesh (Fig.18) and has good storability under ambient storage conditions.

Fig.18: Morphological attributes of Kufri Daksh

Breeding for salt tolerance

Seedling stage: Two hundred fifty TPS of two crosses were used to raise the seedlings (90) and 8 clones were selected based on tuber shape, eye depth and deformity.

F_1C_1 stage: 167 clones of 16 crosses were evaluated in single-row trials (3-4 tubers each) and at harvest 44 clones were selected on the basis of desirable tuber characters.

F_1C_2 stage: 67 clones were evaluated in row evaluation and 17 clones were selected on the basis of desirable tuber characters.

F_1C_3 stage: 105 clones of the 14 crosses were evaluated in duplicate row trial and 44 clones were selected on the basis of desirable tuber characters.

Project 7. Development of nitrogen use efficient varieties

Project leader: Dr Raj Kumar, **Component workers:** Drs Manoj Kumar, Prince Kumar

Hybridization: A total of 105571 true potato seeds were obtained from 69 crosses.

Seedling stage: A total of 15141 selections were made from 41874 seedlings transplanted from the sowing of 80405 TPS of 45 crosses.

Evaluation in initial clonal stages: In all 8656 clones were evaluated and at harvest 1145 promising clones were selected.

Advanced clone evaluation: Among the 89 advanced clone evaluated in 6 preliminary yield trials at 90 days under normal planting conditions, 33 promising advanced clones namely N/18-8, N/18-38, N/18-44, N/18-106, N/18-162, N/18-12, N/18-19, N/18-41, N/18-101, N/18-377, N/18-393, N/18-16, N/18-96 and N/18-405 (3 preliminary yield trials), N/17-56, N/17-63, N/17-139, N/17-161, N/17-258, N/17-34, N/17-46, N/17-136, N/17-207, N/17-240, N/7-313, N/17-320, N/15-4, N/16-32, N/16-38, N/16-69, N/16-116 and N/16-216 (3 confirmatory yield trials) were selected.

Evaluation for nitrogen use efficiency: Nine advanced clones were evaluated at 90 days in replicated yield trials with different doses of N for evaluation of nitrogen use efficiency and advanced clone N/14-85 and N/15-53 performed better than the control.

Introduction in AICRP: Based on consistently good performance over years, advanced clones N/14-85 and N/15-53 (**Fig. 19**) has been introduced in AICRP Potato.

N/14-85 (J/92-159 x MS/83-398): N/14-85 gave 25% and 8% higher agronomic use efficiency over Kufri Gaurav and Kufri Pukhraj, respectively. Tuber dry matter of N/14-85 (17%) was significantly better than controls Kufri Pukhraj (15%) and Kufri Gaurav (15%). It produces white ovoid tubers with shallow eyes and white cream flesh.

N/15-53 (MS/83-398 X J/93-58): N/15-53 gave 30 % and 10% higher agronomic use efficiency over Kufri Gaurav and Kufri Pukhraj, respectively. Tuber dry matter of N/15-53 (17%) was significantly better than controls Kufri Pukhraj (15%) and Kufri Gaurav (15%). It produces white oblong tubers with shallow eyes and white cream flesh.

Fig. 19: Tubers of N/14-85 and N/15-53

Project 8. Diploid F_1 hybrid breeding in potato

Project leader: Dr Salej Sood, **Component workers:** Drs Vikas Mangal, Dalamu, Tanuja Buckseth, AK Sharma, Brajesh Singh, Sanjeev Sharma, Babita Chaudhary, Ajay Kumar Thakur

Founder lines maintenance and multiplication: A set of 37 founder diploid clones including di-haploids, in-vitro multiplied diploid clones and TPS derived diploid clones were tuber multiplied in the glasshouse at Shimla in the summer season. Besides, the elite Sli donor lines, BS 48-6 (108 mini tubers) and BS 49-1 (235 mini tubers) were multiplied for tuber production under the aeroponics unit at Shimla.

Evaluation of diploid clones: One hundred and fifty diploid lines (**Fig. 20**) were evaluated for tuber traits at Modipuram in the net house. The tuber yield varied from 0.54 - 10.8 kg/plot (plot size 0.6m^2) i.e., 0.9 - 18t/ha. The predominant tuber shape was ovoid (64) followed by round (62), pear (10) and kidney (10). The predominant flesh colour was cream (76) followed by yellow (34) and white (19). Most of the clones had shallow eyes (104) while few accessions observed medium deep (39) and deep eyes (4).

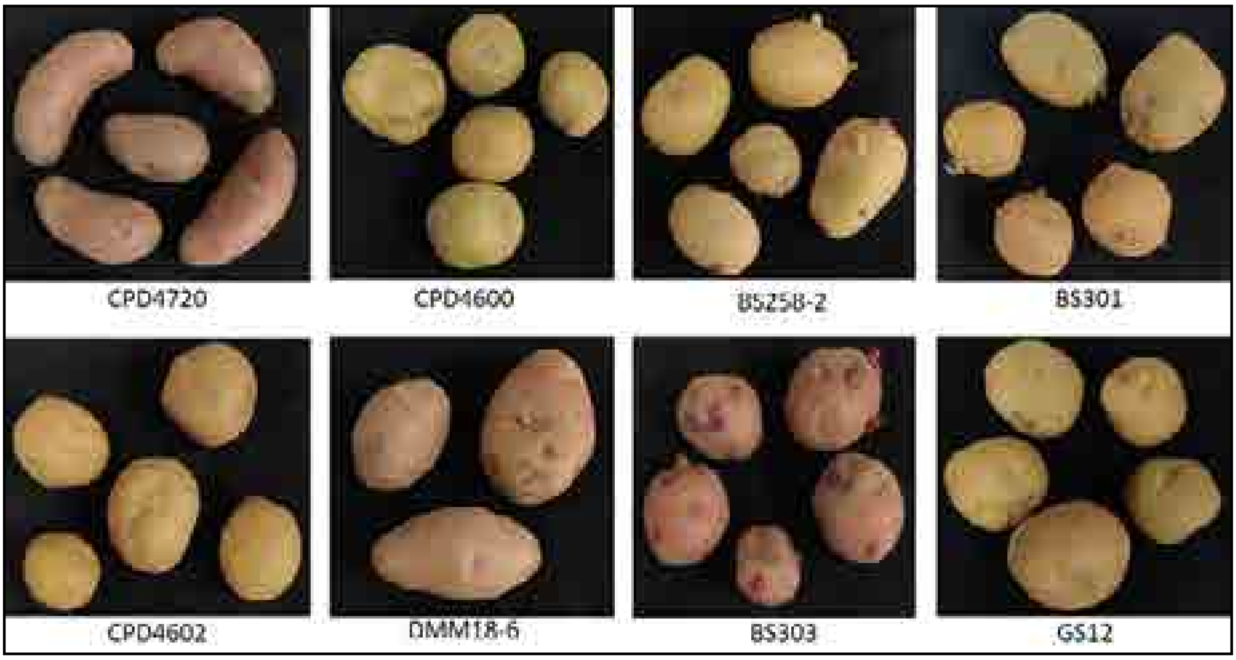


Fig. 20: Elite diploid clones

Late blight evaluation of diploid lines: One hundred and sixty-two progenies of 11 S_0 clones were evaluated for late blight resistance at Kufri, Shimla during the summer season. All the progenies showed very high susceptibility to late blight.

Inbred development programme: *Sli* gene was introgressed in 19 elite diploid lines through hybridization with Sli donor lines. In S_0 generation 15 *Sli* introgressed diploid clones were selfed to produce 10909 true potato seeds. In S_0 generation, dihaploids of Kufri Swarna (10) and Atlantic (6) observed selfing and produced 913 and 689 true potato seeds, respectively. Selfing revealed that these dihaploids have self-incompatibility inhibitor (*Sli*) gene present in them. Similarly, selfing resulted in 430 S_4 TPS of two families of the population DM×M18 and 114 S_5 TPS of four families of two populations viz., DM×M18 and DM×M6.

Homozygosity evaluation using SNP genotyping: 100 KASP markers were used for high throughput screening of homozygosity in founder diploid lines as well as progenies in selfing generations. The homozygosity analysis of diploid clones in different selfing generations through 99 SNP KASP assays spread across all the 12 chromosomes in the potato genome based on inbreeding by state (IBS) showed that the homozygosity in the founder diploid clones, including dihaploids varied from 20.1-78.3% with an average of 56.7%. The range of homozygosity in S_0, S_1, S_2 and S_3 generations was 45.6-80.9, 51.2-82.8, 59.5-85.4 and 69.3-87.6%, respectively (Table 1). The realized values of homozygosity were lower than the expected value for clones in all the generations.

Table 1. Homozygosity percentage in different diploid potato generations assessed through 99 KASP SNP markers

Inbreeding Generation	N	Homozygosity (%)			Expected homozygosity (%)*		
		Min	Max	Average	Min	Max	Average
Founder diploid clones	132	20.1	78.3	56.7	-	-	-
Sli introgressed lines	18	45.6	80.9	68.2	-	-	-
First generation selfing	62	51.2	82.8	65.8	72.8	90.5	84.1
Second generation selfing	95	59.5	85.4	76.6	86.4	95.3	92.1
Third generation selfing	50	69.3	87.6	80.7	93.2	97.6	96.1

N- number of plants/diploid clones assayed; *expected homozygosity worked out using the *Sli* introgressed lines homozygosity as base value

Pollen viability analysis: The pollen viability analysis of diploid clones and progenies in selfing generations showed varying degree of fertility with very high pollen viability in *Sli* gene donor (>70%) and progenies of two populations (DM×M18, DM×M6 (>70%), while other diploid clones had poor viability (10-40%) to complete sterility (Fig. 21). More than 50% self-incompatible diploid clones had poor (10-40%), while >80% of plants of S_0 to S_2 generation had high pollen viability (>70%).

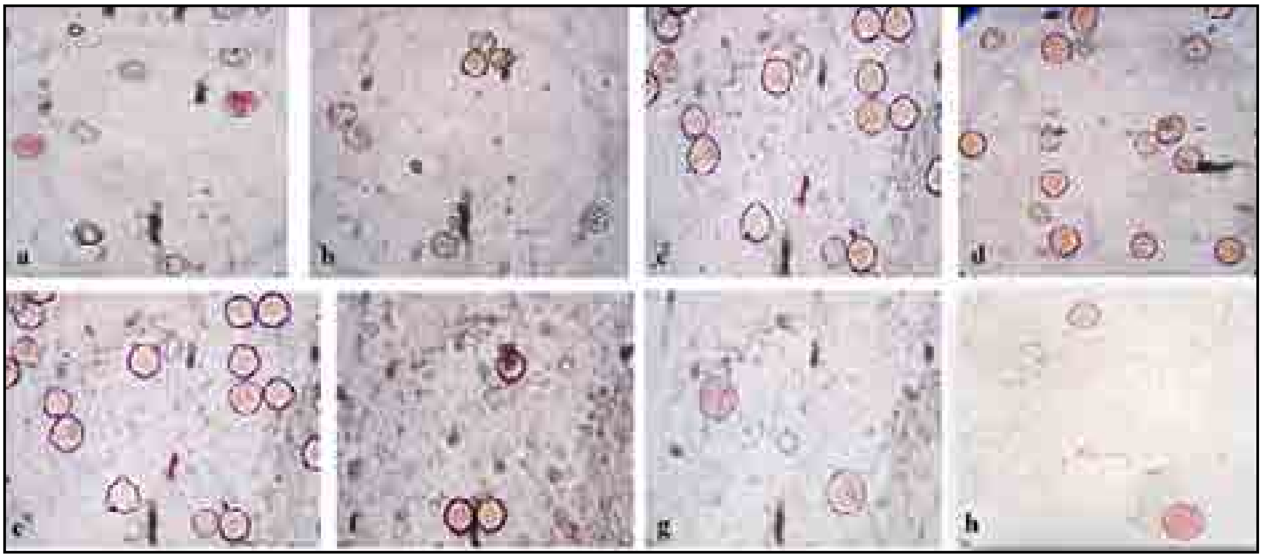


Fig. 21: Pollen viability analysis in different generations: Low pollen viability in a founder diploid clone (a & b), Viable pollen grains in DM×M18 population plants (c), Pollen viability in S0 generation plants (d), Pollen viability in S1 generation plants (e), Viable pollen grains in S2 generation plants (f) and pollen viability in two different S3 generation plants (g & h).

Hybridization for di-haploid induction: A set of 25 Indian and exotic potato varieties were grown under controlled conditions for hybridization with new haploid inducer line, PL-4 (Fig. 22). Crosses were attempted in all the 25 varieties but berry and seed setting were observed in 17 varieties only. The berries were small in size and poorly developed in most varieties. The TPS of individual berry was extracted separately in each cross to avoid self-pollinated TPS. The extracted seed was observed for preliminary screening based on embryo spot morphological marker to separate di-haploids from hybrid seeds. The number of putative di-haploid TPS ranged from 3-239 in 17 varieties, and total di-haploid TPS number was 1609 out of 2323 seeds.

Fig. 22: Hybridization for haploid induction: Crossing block at Kufri (a), Failure of berry setting and development in Kufri Jyoti (b), Successful berry setting and development in Kufri Chipsona-1 and 5 varieties (c & d)

Ploidy analysis for di-haploids identification: The sorted non-spotted TPS (1357) from 23 crosses between varieties and haploid inducer line (CP4590) was raised and 30 days old individual seedlings were transplanted in disposable cups for ploidy detection through flow cytometry (Fig. 5b & c). In total 607 seedlings of 20 varieties were raised and examined for ploidy. The ploidy analysis of the seedlings resulted in 152 confirmed dihaploids of 17 varieties. These 152 plants were grown further for flowering and maturity to check their self-compatibility and tuber formation (Fig. 23). At harvest, tubers of 129 dihaploids of 16 varieties were harvested for further use in diploid breeding programme. Maximum number of dihaploids were recovered in Kufri Swarna (56), followed by Atlantic (22) and Kufri Himsona (14) (Table 5).

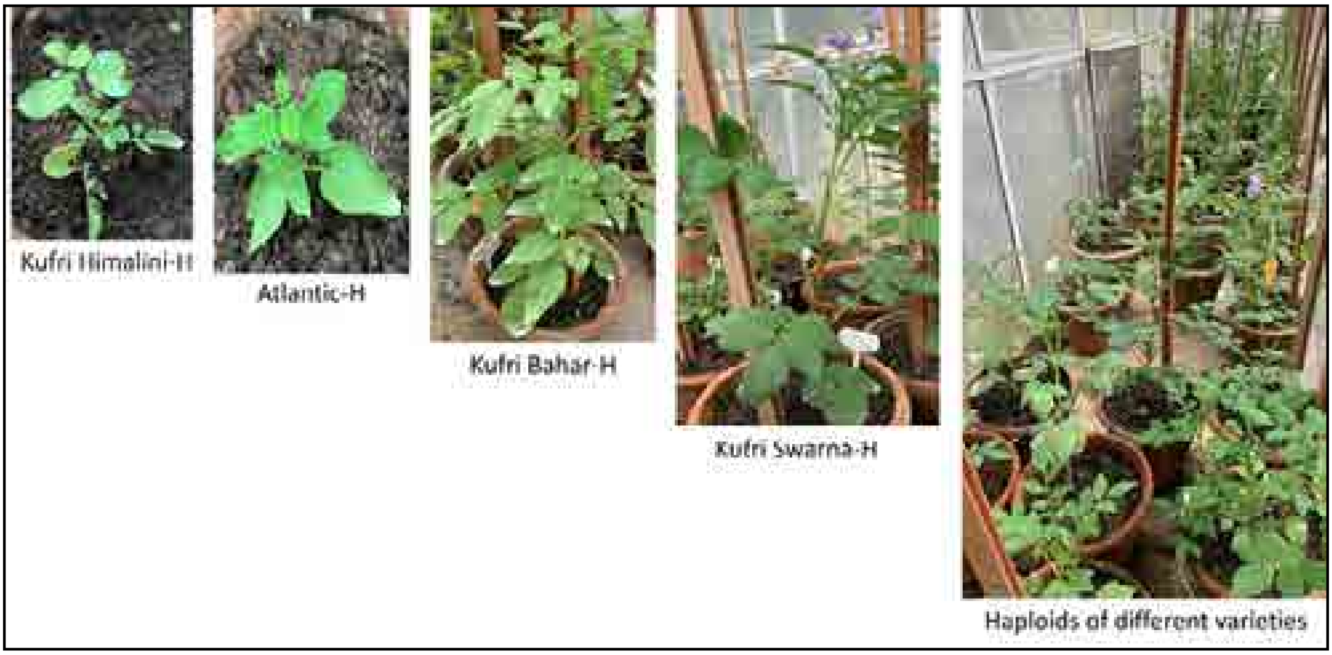


Fig. 23: Di-haploid of potato varieties. H-represent the haploid i.e. dihaploid in case of tetraploid potato varieties

PROGRAMME: DEVELOPMENT AND PRODUCTION OF NUCLEUS AND BREEDER SEED OF NOTIFIED POTATO VARIETIES THROUGH CONVENTIONAL AND HI-TECH SYSTEMS

To maintain higher productivity and yields, it is essential to have a scientifically sound seed production system through which a high degree of health standard of the seed crop is maintained. Therefore, a program entitled "Production of nucleus and breeder seed of important notified potato varieties" has been started under the Revolving Fund Scheme. The nucleus and breeder seed production is being monitored by the scientists of the Division at different stations located in various regions of the country. The nucleus and breeder seed production and supply status of breeder seed during the 2022-2023 cropping season are given below:

Project 1: Production of nucleus and breeder seed of important notified varieties of potato

Seed Production

A) Plains:

Total production of 27622.92 qtls nucleus and breeder seed was achieved from 129.44 ha. Of these, 21387.89 qtls production from 101.83 ha was through conventional and 6235.03 qtls from 27.61 ha through hi-tech seed production systems, respectively. The percentage of nucleus and breeder seed from the conventional system was 77.42 and 22.58 through the hi-tech system.

1. **Conventional Seed Production System:** A total no. of 17023 indexed tubers of different commercial potato varieties were tested at regional stations in the plains (Table 1).

Table 1: Tuber indexing and Field ELISA (Stage-I) Testing

Name of Station	Indexed Tubers		Field ELISA	
Plains	No of tubers tested	Healthy tubers No (%)	No of tubers/ hills tested	Healthy tubers/Hills No (%)
Modipuram	4844	4640 (95.78)	4516	4187 (92.71)
Jalandhar	8952	8104 (90.53)	8104	7780 (96.00)
Gwalior	2067	1974 (95.50)	1879	1553 (82.65)
Patna	1160	1043 (89.90)	974	951 (97.63)

2. **Station/stage-wise area and production of different potato varieties are given in Table 2.**

Stage-I: A total production of 194.97 qtls. was achieved from an area of 3.05 ha (Table 2) with an average production of 87.45, 44.96, 61.97, and 48.45 qtls./ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively.

Stage II: A total production of 836.36 qtls. was from an area of 6.14 ha (Table 2) with average production of 140.04, 96.69, 155.53, and 93.00 qtls/ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively.

Stage III: A total production of 3742.36 qtls. was from an area of 19.36 ha (Table 2) with average production of 228.97, 237.47, 134.07, and 177.8

qtls/ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively.

Stage IV: A total production of 16614.60 qtls. was from an area of 73.27 ha (Table 2) with average production of 265.94, 253.98, 174.01, and 131.97 qtls/ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively.

Table -2: Station & variety-wise area and production (qtls) in Conventional system 2023 (Plains)

Variety	Stage-I		Stage-II		Stage-III		Stage-IV		TOTAL	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
I. Modipuram										
K. Anand	0.05	5.05	0.16	16.00	0.50	109.00	1.20	374.00	1.91	504.05
K. Bahar	0.36	35.45	1.32	192.25	3.80	885.00	14.00	3816.50	19.48	4929.20
K. Khyati	0.05	4.10	0.20	29.50	0.55	128.70	3.50	943.50	4.30	1105.80
K. Mohan	0.04	4.35	0.23	44.20	0.60	151.00	2.00	455.00	2.87	654.55
K. Pukhraj	0.06	4.85	0.21	36.00	0.40	93.50	2.90	652.25	3.57	786.60
K. Surya	0.06	5.85	0.21	25.50	0.45	101.00	1.30	237.00	2.02	369.35
K. Chipsona-1	0.01	0.70	0.07	07.00	0.70	162.70	2.70	775.90	3.48	946.30
K. Chipsona-3	0.06	5.85	0.13	13.00	0.35	70.20	1.00	286.00	1.54	375.05
K. Frysona	0.05	4.80	0.12	12.00	0.45	84.00	1.70	438.00	2.32	538.80
K. Thar-2	0.015	1.95	0.05	3.50	0.03	6.15	-	-	0.095	11.60
K. Lima	0.015	0.30	0.01	1.31	0.06	13.00	-	-	0.085	14.61
K. Neelkanth	0.02	2.00	0.02	3.50	0.01	3.10	-	-	0.05	8.60
K. Sangam	0.06	5.70	0.06	6.90	0.08	19.90	-	-	0.20	32.50
K. Kiran	0.05	4.35	0.04	5.65	0.02	4.50	-	-	0.11	14.50
K. FryoM	0.04	1.00	-	-	-	-	-	-	0.04	1.00
K. Daksh	0.02	0.30	-	-	-	-	-	-	0.02	0.30
K. Chip-5	0.02	0.55	-	-	-	-	-	-	0.02	0.55
K. Bhaskar	0.02	0.30	-	-	-	-	-	-	0.02	0.30
Total	**1.00**	**87.45**	**2.83**	**396.31**	**8.00**	**1831.75**	**30.30**	**7978.15**	**42.13**	**10293.66**
II. Jalandhar										
K. Jyoti	0.63	23.28	0.510	43.50	1.56	391.35	8.74	2033.67	11.44	2491.8
K. Pukhraj	0.36	20.92	0.281	41.50	1.33	273.84	5.11	1418.24	7.081	1754.5
K. Badshah	0.056	2.40	0.087	2.15	0.12	23.63	0.44	115.10	0.703	143.28
K. Khyati	0.012	0.77	0.014	1.00	0.10	63.66	0.68	165.96	0.806	231.39
K. Surya	0.002	0.10	0.001	0.15	0.04	30.40	0.10	16.00	0.143	46.65
K. Himalini	0.080	4.10	0.099	6.00	0.19	9.50	1.12	371.00	1.489	390.6
K. Chipsona-1	0.008	0.04	0.005	2.10	0.07	17.40	0.34	78.30	0.423	97.84
Total	**1.148**	**51.61**	**0.997**	**96.4**	**3.41**	**809.78**	**16.53**	**4198.27**	22.08	5156.06
III. Gwalior										
K. Chandamukhi	0.07	5.02	0.23	31.50	0.76	99.65	2.09	409.00	3.15	545.17
K. Jyoti	0.08	4.26	0.23	29.84	0.72	118.50	3.56	547.00	4.59	699.6
K. Sindhuri	0.07	4.16	0.21	40.00	1.00	130.40	3.40	704.50	4.68	879.06
K. Lauvkar	0.08	4.45	0.18	22.00	0.53	60.00	1.02	193.51	1.81	279.96
K. Chipsona-I	0.08	4.75	0.28	36.50	0.92	192.74	5.25	890.14	6.53	1124.13
K. Chipsona-3	0.07	3.54	0.20	32.00	0.57	81.00	2.31	371.00	3.15	487.54
K. Surya	0.08	6.76	0.23	37.50	0.96	155.80	3.76	479.80	5.03	679.86
K. Pukhraj	0.07	5.88	0.20	35.73	1.17	80.50	1.18	332.50	2.62	454.61
K. Khyati	0.07	3.54	0.14	29.50	0.28	19.50	-	-	0.49	52.54

Variety	Stage-I		Stage-II		Stage-III		Stage-IV		TOTAL	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
K. Bahar	0.02	1.96	0.02	2.50	-	-	-	-	0.04	4.46
K. Lima	0.04	2.24	0.06	9.50	0.06	5.00	-	-	0.16	16.74
K. Thar-2	0.02	1.52	0.03	5.00	0.07	5.00	-	-	0.12	11.52
K. Sangam	0.04	2.16	0.03	5.50	0.03	1.50	-	-	0.1	9.16
K. Kiran	0.04	1.20	0.02	3.33	0.08	9.00	-	-	0.14	13.53
Total	**0.83**	**51.44**	**2.06**	**320.40**	**7.15**	**958.59**	**22.57**	**3927.45**	**32.61**	**5257.88**
IV Patna										
K. Himalini	0.012	0.62	0.03	3.00	0.05	10.00	0.35	26.51	0.442	40.13
K. Jyoti	0.018	0.67	0.04	4.00	0.12	13.40	1.10	106.81	1.278	124.88
K. Kanchan	0.006	0.30	0.01	1.30	0.05	8.50	0.12	16.38	0.186	26.48
K. Khyati	0.012	0.82	0.03	3.10	0.18	34.34	0.75	113.98	0.972	152.24
K. Lailt	0.006	0.36	0.02	2.50	0.12	32.00	0.65	87.15	0.796	122.01
K. Manik	0.003	0.06	0.01	-	0.02	4.90	-	-	0.033	04.96
K. Neelkanth	0.009	0.48	0.02	4.00	0.01	0.10	-	-	0.039	04.58
K. Pukhraj	0.012	0.37	0.06	4.22	0.15	26.50	0.40	89.16	0.622	120.25
K. Sindhuri	0.006	0.39	0.03	1.13	0.10	12.50	0.50	70.74	0.636	84.76
Total	**0.084**	**4.07**	**0.25**	**23.25**	**0.80**	**142.24**	**3.87**	**510.73**	**5.004**	**680.31**
Plains' Total	**3.05**	**194.57**	**6.14**	**836.36**	**19.36**	**3742.36**	**73.27**	**16614.60**	**101.83**	**21387.89**

3. **Hi-Tech Seed Production System:** Table 3 gives the station/generation-wise area and production of different potato varieties.

(i) **Generation-1:** A total production of 1366.16 qtls. was achieved in G-I from an area of 6.48 ha with an average production of 237.03, 247.23, 88.97, and 123.67 qtls / ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively (Table 3).

(ii) **Generation-2:** A total production of 4868.87 qtls. was achieved in G-2 from an area of 21.13 ha with an average production of 255.10, 252.96, 167.92, and 120.49 qtls / ha at Modipuram, Jalandhar, Gwalior, and Patna, respectively (Table 3).

Table 3: Station & variety-wise area and production (qtls.) in Hi-Tech system 2023 (Plains)

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
I. Modipuram						
K. Chipsona-1	0.80	171.00	3.80	1046.00	4.60	1217.00
K. Chipsona-3	0.35	90.50	0.60	170.00	0.95	260.50
K. Frysona	0.08	16.20	0.30	77.00	0.38	93.20
K. Ganga	1.00	276.00	1.00	339.75	2.00	615.75
K. Khyati	0.40	124.00	1.50	405.00	1.90	529.00
K. Mohan	0.95	165.50	3.00	680.00	3.95	845.50
K. Pukhraj	0.15	45.50	1.30	280.00	1.45	325.50
K. Surya	0.20	35.30	0.80	140.00	1.00	175.30
K. Sukhyati	0.08	22.00	-	-	0.08	22.00
K. Lima	0.06	16.00	-	-	0.06	16.00
K. Sangam	0.12	33.50	-	-	0.12	33.50
K. Thar-1	0.005	1.00	-	-	0.005	1.00
K. Thar-2	0.045	8.50	-	-	0.045	8.50

Variety	G1		G2		TOTAL	
	Area	Production	Area	Production	Area	Production
Total	**4.24**	**1005.00**	**12.30**	**3137.75**	**16.54**	**4142.75**
II Jalandhar						
K. Chandramukhi	0.07	12.75	0.83	237.45	0.90	250.20
K. Jyoti	0.11	23.36	0.35	68.50	0.46	91.86
K. Badshah	0.03	9.50	0.16	38.40	0.19	47.90
K. Pukhraj	0.24	71.90	1.17	268.60	1.41	340.50
K. Khyati	0.06	13.50	0.49	108.60	0.55	122.10
K. Himalini	0.11	21.50	0.74	244.40	0.85	265.90
K. Gaurav	0.06	22.00	0.22	56.89	0.28	78.89
K. Karan	0.05	10.50	0.38	66.05	0.43	76.55
K. Chipsona-1	-	-	0.16	39.20	0.16	39.20
K. Sukhyati	0.02	5.50	-	-	0.02	5.50
K. Pushkar	0.13	30.50	0.10	37.32	0.23	67.82
K. Himsona	0.02	1.50	0.10	23.50	0.12	25.00
Total	**0.90**	**222.51**	**4.70**	**1188.91**	**5.60**	**1411.42**
III Gwalior						
K. Jyoti	0.06	6.50	-	-	0.06	6.50
K. Chipsona-1	0.06	6.00	-	-	0.06	6.00
K. Chipsona-3	0.01	0.50	-	-	0.01	0.50
K. Surya	0.02	0.75	-	-	0.02	0.75
K. Pukhraj	0.03	2.50	-	-	0.03	2.50
K. Khyati	0.06	6.50	-	-	0.06	6.50
K. Lima	0.06	4.00	-	-	0.06	4.00
K. Himalini	0.15	13.00	-	-	0.15	13.00
K. Mohan	0.13	11.50	-	-	0.13	11.50
K. Karan	0.03	0.85	-	-	0.03	0.85
K. Ganga	0.17	17.30	0.38	65.50	0.55	82.80
K. Neelkanth	-	-	0.56	92.35	0.56	92.35
Total	**0.78**	**69.40**	**0.94**	**157.85**	**1.72**	**227.25**
IV Patna						
K. Ashoka	-	-	0.10	9.86	0.10	9.86
K. Chipsona-1	-	-	0.04	5.19	0.04	5.19
K. Kanchan	0.02	2.00	-	-	0.02	2.00
K. Himalini	0.10	14.00	1.20	131.44	1.30	145.44
K. Khyati	0.07	4.00	0.10	12.19	0.17	16.19
K. Neelkanth	0.20	25.00	0.80	133.96	1.00	158.96
K. Manik	0.01	1.00	-	-	0.01	1.00
K. Pukhraj	0.08	10.00	0.10	12.16	0.18	22.16
K. Sindhuri	0.04	6.00	0.25	25.63	0.29	31.63
K. Surya	0.04	7.25	0.60	53.93	0.64	61.18
Total	**0.56**	**69.25**	**3.19**	**384.36**	**3.75**	**453.61**
Plains Total	**6.48**	**1366.16**	**21.13**	**4868.87**	**27.61**	**6235.03**

3. Total supply of breeder seed

During 2023, a total of 21807.89 qtls of breeder seed was supplied to various government and private agencies, from plains Table 4 (A & B).

Table 4 (A): Station and variety-wise supply (qtls) during 2023

Sl. No	Variety	Stations				Total (q)
		Modipuram	Jalandhar	Gwalior	Patna	
1	Kufri Ashoka	-	-	-	9.84	**9.84**
2	Kufri Anand	386.00	-	-	-	**386.00**
3	Kufri Bahar	3967.50	-	-	-	**3967.50**
4	Kufri Badshah	-	159.50	-	-	**159.50**
5	Kufri Chipsona-1	1860.10	-	890.14	-	**2750.24**
6	Kufri Chipsona-3	502.20	-	367.90	5.05	**875.15**
7	Kufri Chandramukhi	-	237.78	409.00	-	**646.78**
8	Kufri Frysona	523.20	-	-	-	**523.20**
9	Kufri Gaurav	-	55.97	-	-	**55.97**
10	Kufri Ganga	390.00	-	65.50	-	**455.50**
11	Kufri Himalini	-	625.65	-	157.65	**783.30**
12	Kufri Himsona	-	23.33	-	-	**23.33**
13	Kufri Jyoti	-	2101.73	546.20	106.47	**2754.40**
14	Kufri Khyati	1374.70	286.19	-	125.79	**1786.68**
15	Kufri Karan	-	65.95	-	-	**65.95**
16	Kufri Kiran	0.50	-	-	-	**0.50**
17	Kufri Lalit	-	-	-	83.80	**83.80**
18	Kufri Lauvkar	-	-	192.36	-	**192.36**
19	Kufri Mohan	1202.90	-	-	-	**1202.90**
20	Kufri Neelkanth	0.10	-	92.35	133.56	**226.01**
21	Kufri Pukhraj	944.00	1669.67	314.85	100.92	**3029.44**
22	Kufri Pushkar	-	60.95	-	-	**60.95**
23	Kufri Surya	386.80	16.00	479.80	53.73	**936.33**
24	Kufri Sindhuri	-	-	704.00	96.21	**800.21**
25	Kufri Sukhyati	22.00	-	-	-	**22.00**
26	Kufri Sangam	8.40	-	-	-	**8.40**
27	Kufri Thar-2	1.65	-	-	-	**1.65**
	Total	**11570.05**	**5302.72**	**4062.1**	**873.02**	**21807.89**

B. Hills:

- **Multiplication of basic material maintenance of mother stock:** A total of 44 pots of 22 varieties were planted and tested with ELISA/PCR against different potato viruses. After conducting a series of tests through PCR/ELISA, all healthy varieties were shifted in vitro and included in the microplant multiplication and supply chain. A total of 14726 culture tubes of 46 varieties were multiplied under tissue culture. In aeroponics, 13089 mini tubers of different varieties/ diploids/ advanced hybrids were harvested.

- **Maintenance of buffer stock in the field at CPRS, Kufri:** On account of interception of Potato Cyst Nematode (PCN) at Kufri and Fagu farms and subsequent imposition of quarantine by Govt. on India during Nov./ Dec. 2018; the nucleus and breeder seed potato production of CPRS Kufri-Fagu Unit has been suspended since 2018. However, as per the approved scheme, a limited quantity of buffer seed stocks of varieties viz., K. Jyoti, K. Himalini, K. Girdhari, K. Giriraj, K. Shailja, K. Kanchan, K. Himsona and K. Karan under different seed stages of Conventional and Hi-tech systems are being maintained. The produce obtained from such buffer seed stages is used in planting the trap crop (as a measure to eradicate the PCN from farms) and as seed for planting buffer seed stages during the following year. The surplus quantities, if any, are disposed of in local sabzi mandi as ware potatoes.

C. Supply of Microplants to Different Seed Agencies:

A total of 334 virus-free in vitro culture tubes of basic seed material of 31 varieties (Fig 1) were supplied to 40 different seed-producing organizations in India (Table 5), and a revenue of Rs. 16,70,000/- was generated. Rs.1,00,000 was received as a registration fee @ Rs. 1,40,000/ firm, valid for five years.

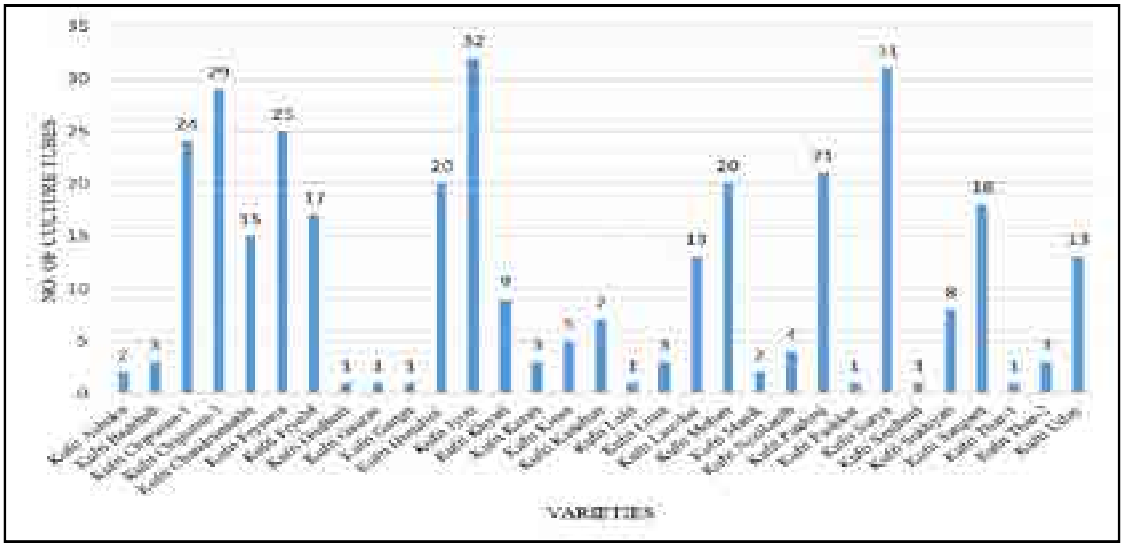


Fig 1: Variety-wise supply to different seed organizations

Table 5: Microplants supply to different Seed Production Organizations

S. No.	Firms	Varieties Supplied
1	M/s Anuj Agri Farm, Bisauli, Badayun, UP	K. Chipsona-1
2	M/s Merino Industries Limited, Village- Achheja, PO- Hapur, UP	K. Pukhraj, K. Mohan, K. Surya, K. Jyoti, K. Frysona, K. Chipsona-3 and K. Lauvkar
3	M/s Sekhon Biotech Pvt. Ltd, Jalandhar, PB	K. Jyoti, K. Chipsona-1, K. Chipsona-3, K. Frysona, K. FryoM, K. Sangam, K. Mohan, K. Khyati, K. Surya, K. Kiran, K. Lalit and K. Uday
4	M/s Bhatti Tissue Tech. Vill.-Alipur, PO- Mithapur, Teh & Distt.- Jalandhar, PB	K. Pukhraj, K. Lauvkar, K. Chandramukhi, K. Himalini and K. Badshah
5	M/s Hyfun Agrilink Pvt, Ltd., Gujarat	K. FryoM
6	The Project Officer, Centre of Excellence for Potato, Vill. - Dhogri, Jalandhar, Punjab	K. Chipsona-3, K. Chandramukhi, K. Khyati, K. Pukhraj and K. Jyoti

S. No.	Firms	Varieties Supplied
7	M/s Rahul Biotech Seed, Singhirampur, Farrukhabad, Uttar Pradesh	K. Surya, K. Chipsona-3, K. Kiran, K. Manik, K. Thar-1, K. Kanchan, K. Pushakar, K. Himalini, K. Gaurav, K. Chandramukhi
8	Dr. Ravindranath Reddy, International Potato Centre (CIP), c/o College of Horticulture, GKVK, Bengaluru	K. Uday, K. Himalini, K. Sangam, K. Pukhraj, K. Chipsona-1, K. Chipsona-3, K. Thar-2, K. Karan, K. Mohan, K. Surya and K. Jyoti
9	M/s GRS Bioplants Pvt. Ltd., (Shanti Devi Cold Storage), Aroan road, Kabirpur, Sirsaganj Distt.-Firozabad,U.P. - 283151	K. Sangam, K. Pukhraj, K. Mohan and K. Sukhyati
10	Dr. Vijay Koul, Associate Director, Institute of Horticulture, Greater Noida, Uttar Pradesh,	K. Jyoti, K. Sindhuri, K. Pukhraj, K. Badshah, K. Chipsona-1, K. Chipsona-3, K. Chandramukhi, K. Himalini, K. Neelkanth, K. Surya, K. Girdhari, K. Kanchan and K. Ashoka
11	M/s International Potato Centre (CIP), Bhubaneswar	K. Uday, K. Himalini, K. Karan and K. Jyoti
12	M/s Banas Dairy, Palanpur, Gujarat	K. Frysona
13	Mr. Dharmbir Singh TomarMarketing and Sales, The Energy and Resources Institute, TERI-GRAM, Gurgaon India	K. Chipsona-1, K. Chipsona-3, K. Sangam, K. Thar-2, K. Surya, K. Pukhraj and K. Jyoti
14	M/s KF Biotech Pvt. Ltd, Theniyur Village, Sulibele Post, Bangalore Rural 562129, Karnataka	K. Mohan
15	M/s Utkal Tubers India Pvt. Ltd. No. 306, The Arcade, Brigade Metropolis, Whitefield Road, Garudacharapalya, Bangalore	K. Jyoti, K. Pukhraj, K. Lauvkar, K. Chipsona-1, K. Chipsona-3, K. Chandramukhi, K. Frysona, K. Mohan, K. Himalini and K. Sangam
16	M/s Jain Irrigation Systems Limited, Jain Hills, Shirsoli Road, Jalgaon, Maharashtra	K. Chipsona-1, K. Sangam, K. Surya, K. Kiran, K. Manik, K. Lauvkar, K. Mohan, K. Himalini, and K. Sukhyati
17	M/s Handa Bio. Agritech, Potato Seed Company, Shahbad Markanda, Kurukshetra, Haryana	K. Uday
18	The District Manager, West Bengal State Seed Corporation Ltd., beej Bhawan, Midnapore, Paschim Medinipore, West Bengal	K. Jyoti, K. Pukhraj, K. Himalini, Chandramukhi, K. Sangam, K. Lima, K. Kanchan, K. Mohan, K. Neelkanth, K. Sukhyati, K. Khyati, K. Surya, K. Ashoka and K. Lauvkar
19	The CIP-PTC, Karnal, Haryana	K. Uday, K. Lima, K. Mohan, K. Chipsona-1, K. Sangam, K. Thar-2 and K. Frysona
20	Dr. Shishir Kumar, CIP, Bhuvneshwar, Odisha	K. Uday, K. Jyoti and K. Chandramukhi
21	Dr. Sanjeev K. Chauhan, Director of Research, Dr YSP University of Horticulture and Forestry, Nauni, Solan (HP)	K. Khyati and K. Himalini
22	Dr. R. K. Tomar, Director, Horticulture and Food Processing Department, Udhyan Bhawan, 2-Sapru Marg, Lucknow, UP	K. Khyati, K. Mohan and K. Kanchan.

S. No.	Firms	Varieties Supplied
23	M/s Madhav Agri Tech, House No.- 172, Bhagwati Nagar, Station Road, Tundla, Firozabad, UP	K. Sangam, K. Mohan, K. Uday, K. Ganga, K. Surya, K. Jyoti, K. Sukhyati, K. Chipsona-1, K. Khyati and K. Pukhraj
24	M/s S.F. Agritech Pvt. Ltd., Etawah, UP	K. Sukhyati, K. Surya, K. Kiran and K. FryoM,
25	Mr. Ram Kumar JurielAgra, Uttar Pradesh	K. Sangam, K. Mohan, K. Uday, K. Chipsona-3, K. Sukhyati and K. Surya
26	M/s GMS Agritech Pvt. Ltd., Research & Development, Bahiri, Birbhum, West Bengal	K. Jyoti, K. Himalini, K. Pukhraj and K. Chandramukhi
27	M/s Narmada Jivan Agrotech Pvt Ltd, Bareilly, Uttar Pradesh	K. Chipsona-3, K. Chipsona-1 and K. Surya
28	M/s Nazia Hussain Agritech Co., Plant Tissue Culture Lab, VPO- Dakala, Teh & Distt.- Patiala, Punjab	K. Jyoti, K. Surya, K. Sangam, K. Himalini and K. Lauvkar
29	M/s UPL Sustainable Agri Solutions Limited, Mumbai, Maharashtra	K. Chipsona-1, K. Frysona, K. Chandramukhi, K. Surya and K. Lauvkar
30	M/s Shandil Plantech Pvt. Ltd., Palampur, Dist.- Kangra, HP	K. Jyoti
31	Mr. S. Chauhan, Bangalore, India	K. Frysona
32	M/s Sangha Biotech, Jalandhar, PB	K. Himalini, K. FryoM, K. Sukhyati, K. Khyati and K. Jyoti
33	M/s Sashanka Agro Tech. Pvt. Ltd., Morabadi, Ranchi, Jharkhand	K. Chipsona-1, K. Chipsona-3, K. Frysona, K. Chandramukhi, K. Himalini and K. Pukhraj
34	Mr. Rahul Chaudhary, M/s Kavya Agro Potato Seeds, Distt.- Bulandshehar, UP	K. FryoM
35	M/s HBS Agro & Aqua Services Pvt. Ltd., C/o HBS Agro & Aqua Services Pvt. Ltd., 2-214/2, Thammara, City- Kodad, Telangana,	K. Chipsona-1, K. Chipsona-3 and K. Frysona
36	The Directorate of Research Services, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Raja Pancham Singh Marg, Gwalior (M.P.),	K. Chipsona-1, K. Chipsona-3, K. Surya, K. Neelkanth and K. Jyoti
37	M/s Technico Agri Sciences Ltd., VPO Manpura, Tehsil Baddi, District-Solan, H.P.	K. FryoM
38	M/s Govardhan Dass Pal Biotech Seed Farm, Singhirampur, Farrukhabad, Uttar Pradesh	K. Chipsona-1, K. Pukhraj, K. Surya, K. Sukhyati, K. Kiran and K. Uday
39	M/s Falcon Agrifriz Foods Private Limited 804, Z-One, Bodakdev, Ahmadabad, Gujarat	K. FryoM
40	M/s Kisan Agritech (Jai Ganga), Noida, Uttar Pradesh	K. Chipsona-1, K. Chipsona-3, K. Surya, K. Frysona, K. Jyoti, K. Himalini and K. Pukhraj

A total of 605 culture tubes of 30 varieties were supplied to different seed production stations/ centers, namely Modipuram, Jalandhar, Patna, Shillong, Ooty, and Gwalior.

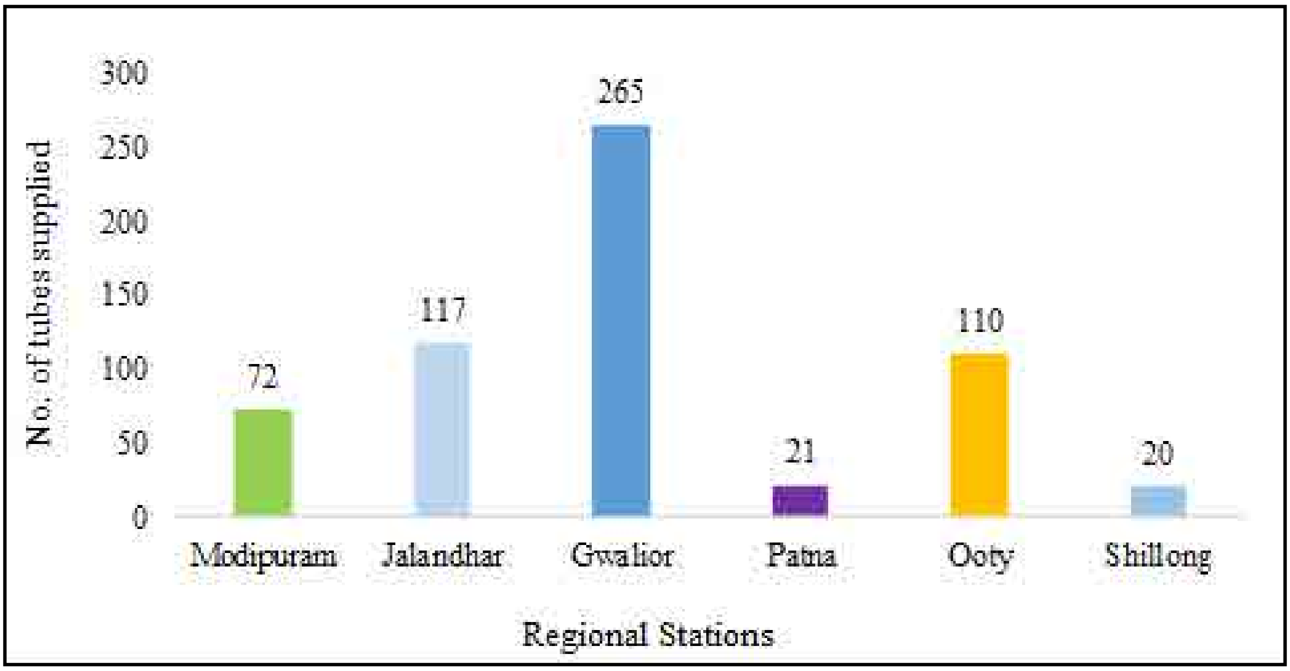


Fig 2: Station-wise micro plant supply to different seed centers

D. Production and supply of quality seed:

Production of quality seed 2023 (Ooty): 64.24 tons of quality seed was produced from 4.06 ha, summing all three crop seasons (spring/summer/ autumn) during 2023. Out of which, 13.52 t of quality seed was supplied to the farmers, 1.2 t to SCSP farmers, and 2.82 t to the govt. organization, and 0.9 t was disposed of as table potatoes and miscellaneous to the ICAR- CPRS staff/ market. About 5.2 t of quality seeds were used for the summer experiments, 5.6 t of quality seeds were used for the autumn experiments, and the remaining 39.11 t were kept for supply and use for 2024. A total of Rs. **12,05,249**/- revenue was generated, which includes last year's seed sold during this financial year.

Table 6. Details of quality seed produced during 2023

Variety	Area (ha)	Quantity harvested (t)	Average yield (t/ha)
Kufri Swarna	0.92	10.1	10.87
Kufri Sahyadri	1.12	17.3	15.45
Kufri Girdhari	0.38	7.8	20.53
Kufri Karan	1.12	19.4	17.32
Kufri Himalini	0.42	9.0	21.43
Kufri Jyoti	0.1	0.64	6.4
Total	**4.06**	**64.24**	**15.82**

Table- 4 (B) Variety/stage & agency-wise breeder seed supply from plains (qtls) during 2023

S. N.	Variety	AS*	CG*	HP*	JK*	DL*	ML*	PB*	UK*	UP*	WB*	NHRDF*	NSAI*	NSC*	Uni.*	ICAR	Auctioned	Farmers/ Pvt.	Total
1	K. Anand	-	-	-	-	-	-	-	-	315.47	-	-	15.53	-	-	-	47.00	8.00	**386.00**
2	K. Ashoka	-	-	-	-	-	-	-	-	-	-	9.75	-	-	-	-	-	0.09	**9.84**
3	K. Badshah	-	-	-	20.00	-	-	-	-	119.50	-	-	-	-	-	5.00	-	15.00	**159.50**
4	K. Bahar	-	-	-	-	-	-	-	-	2850.90	32.10	-	-	-	20.00	65.50	652.50	346.50	**3967.50**
5	K.Chandramukhi	-	160.50	-	-	-	-	28.00	-	-	128.00	60.00	-	-	15.00	14.05	-	241.23	**646.78**
6	K. Chipsona-1	-	-	-	-	-	-	9.14	-	2138.26	-	-	93.24	-	-	5.90	198.70	305.00	**2750.24**
7	K. Chipsona-3	-	200.00	-	183.00	0.30	-	-	-	25.00	-	-	-	-	66.00	104.00	96.20	200.65	**875.15**
8	K. Frysona	-	-	-	20.00	-	-	-	-	200.00	-	-	-	-	45.00	6.50	49.70	202.00	**523.20**
9	K. Gaurav	-	-	-	19.15	-	-	-	-	-	-	-	-	-	-	-	-	36.82	**55.97**
10	K. Ganga	-	59.50	-	-	-	-	-	-	180.00	-	40.00	-	-	5.00	34.00	80.00	57.00	**455.50**
11	K. Himalini	-	-	115.45	50.00	-	10.00	243.00	29.95	-	150.72	31.80	-	33.00	-	38.53	-	80.85	**783.30**
12	K. Himsona	-	-	-	20.00	-	-	-	-	-	-	-	-		-	-	-	3.33	**23.33**
13	K. Jyoti	-	-	320.00	90.00	-	40.00	700.00	104.85	-	460.48	30.00	-	95.00	-	44.06	-	870.01	**2754.40**
14	K. Karan	-	-	25.00	-	-	-	-	-	-	-	-	-	-	-	31.10	-	9.85	**65.95**
15	K. Kiran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	**0.50**
16	K. Khyati	-	-	-	40.00	-	-	15.00	-	1129.30	116.50	150.00	-	-	05.00	44.00	153.70	133.18	**1786.68**
17	K. Lauvkar	-	50.00	-	-	0.35	-	-	-	77.51	-	-	-	-	44.00	-	-	20.50	**192.36**
18	K. Lalit	-	-	-	-	-	-	-	-	-	3.00	80.00	-	-	-	-	-	0.80	**83.80**
19	K. Mohan	-	67.90	-	17.05	-	-	203.70	-	475.35	81.50	135.80	-	-	-	8.00	121.30	92.30	**1202.90**
20	K. Neelkanth	-	-	-	-	-	-	-	45.30	110.40	45.00	-	-	-	9.00	-	0.10	16.21	**226.01**
21	K. Pukhraj	-	-	-	52.12	0.35	-	550.00	-	472.00	267.50	150.00	-	-	149.00	581.08	106.00	701.39	**3029.44**
22	K. Pushkar	-	-	-	-	-	-	-	-	-	5.80	27.20	-	-	-	9.50	-	18.45	**60.95**
23	K. Sindhuri	-	-	-	50.00	-	16.84	54.00	-	580.00	4.50	30.00	-	-	-	12.50	-	52.37	**800.21**
24	K. Surya	43.25	50.00	-	27.00	-	-	-	50.00	613.00	10.00	-			11.00	-	41.80	90.28	**936.33**
25	K. Sangam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.40	-	**8.40**
26	K. Sukhyati	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22.00	-	**22.00**
27	K. Thar-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.65	-	**1.65**
	Total	**43.25**	**587.90**	**460.45**	**588.32**	**1.00**	**66.84**	**1802.84**	**230.10**	**9286.69**	**1305.10**	**744.55**	**108.77**	**128.00**	**369.00**	**1019.72**	**1579.55**	**3501.81**	**21807.89**

* AS: Assam; CG: Chhattisgarh; HP: Himachal Pradesh, JK: Jammu & Kashmir; DL: New Delhi; ML: Meghalaya; PB: Punjab; UK: Uttarakhand; UP: Uttar Pradesh; WB: West Bengal; NHRDF: National Horticulture Research and Development Foundation; NSAI: National Seed Association of India; NSC: National Seeds Corporation.

Project 2: Standardization and refinement of seed production techniques under hi-tech system

1. Effect of number of mini-tubers/hill on the production behaviour of Kufri Karan under field conditions.

Multiplication of <3g mini-tubers directly under field conditions is a big challenge because of their smaller size. So, considering the problem, an experiment was conducted to standardize the planting methodology for <3g mini-tubers of new potato cultivar K. Karan under field conditions at Fagu during Kharif 2023 with varying numbers of mini tubers/hill. The number of tubers/ha were significantly affected by the mini-tubers planted/hill. The number of tubers showed an increasing trend with the increasing number of mini-tuber plants/hills. Total tubers/ha were significantly higher with 03 mini-tubers/hill while it was statistically at par between 01 and 02 mini-tubers/hill. However, the yield/ha was significantly higher (410.9 q/ha) when 02 mini-tubers were planted/hill, while it was almost the same with 01 and 03 mini-tubers/hill (Table 1).

Table 1: Effect of No. of mini-tubers /hill on the production behaviour of K. Karan under field conditions

S. No.	Treatments	% estab.	Plant height /plant (cm)	Shoots/ plant	Leaves/ plant	Haulms weight/ m^2 (Kg)	Total tubers ('000 /ha)	Yield /ha (q)	% seed size (20-80g) tubers	%Under-size tubers (<20g)
1	01 mini-tuber/hill	98.0	73.3	1.3	28.5	0.67	1104.7	378.2	43.3	47.9
2	02 mini-tubers/hill	100.0	77.13	1.5	28.6	0.58	1194.7	410.9	49.5	40.7
3	03 mini-tubers/hill	99.3	67.5	2.0	36.5	0.55	1338.0	377.4	43.1	51.1
	$CD_{0.05}$	N/A	6.6	0.3	2.9	0.05	179.4	27.7	4.0	2.7

The results revealed that though <3g mini-tubers can be successfully multiplied under field conditions by planting a single mini-tuber / hill, but for obtaining higher yield with a better tuber size distribution, 02 mini-tubers should be planted per hill and for obtaining maximum rate of multiplication or tubers/unit area, 03 mini-tubers should be planted/hill. The finding will be helpful to potato seed growers in managing the tuber grades and yield as per the requirements.

2. Effect of method of planting on the production behaviour of potato mini-tubers under field conditions.

A study was conducted to standardize the method of planting for mini-tubers of new potato cultivar K. Karan under field conditions at Fagu during the Kharif 2023. 03 grades of mini-tubers (<3g, 3-10 g, and 10-20g) and 02 planting methods viz. Flatbed and Ridge systems were used for the study. The increasing size of the mini-tuber planted increased the weight of haulms, and it was significantly higher with the Ridge method of planting than the Flatbed (Table 2). Number of tubers/ha were significantly more with larger seed tubers (similar with 3-10 and 10-20g mini-tubers) than smaller seed size of <3g. With the planting method the Flatbed method of planting resulted in a significantly higher number of tubers than the Ridge system, whereas yield /ha was significantly higher with the Ridge system of planting (Table 3). The increasing size of the mini-tuber planted also resulted in a significant increase in the yield of potatoes. Yield was maximum (414.9 q) with 10-20g mini-tubers, followed by 3-10g mini-tubers (302.8 q) and was minimum (240.4 q) with <3g mini-tubers.

Table 2: Production behaviour of small grades of mini-tubers of K. Karan in different planting methods under field conditions.

Treatment	C. Leaves /plant			Haulms weight/m²(g)			'000 tubers/ha		
Size of mini-tuber	Flatbed	Ridge	Mean	Flatbed	Ridge	Mean	Flatbed	Ridge	Mean
<3g	31.0	25.8	28.4	52.8	60.7	56.7	949.3	790.0	869.7
3-10g	30.9	25.8	28.3	64.8	92.9	78.9	932.7	917.3	925.0
10-20g	29.8	31.6	30.7	108.8	219.4	164.1	887.0	967.7	927.3
Mean	30.6	27.7		75.5	124.3		923.0	891.7	
CD0.05									
Size of mini-tuber (S)		1.4			48.3			25.6	
Method of planting (M)		1.2			39.4			20.9	
S x M		2.0			N/A			36.3	

Table 3: Production behaviour of small grades of mini-tubers of K. Karan in different planting methods under field conditions.

Treatment	Yield (q/ha)			% seed size (20-80g) tubers			% undersize (<20g) tubers		
Size of mini-tuber	Flatbed	Ridge	Mean	Flatbed	Ridge	Mean	Flatbed	Ridge	Mean
<3g	257.0	223.7	240.4	49.5	48.5	49.0	48.3	47.8	48.1
3-10g	292.9	312.7	302.8	55.3	56.4	55.8	40.7	37.5	39.1
10-20g	374.1	455.7	414.9	57.9	56.8	57.4	30.5	26.7	28.6
Mean	308.0	330.7		54.2	53.9		39.9	37.3	
CD0.05									
Size of mini-tuber (S)		11.5			2.5			1.2	
Method of planting (M)		9.4			N.S.			0.9	
S x M		16.3			N.S.			1.7	

The proportion of seed-size tubers (20-80g) was significantly influenced only by the size of the mini-tuber planted, whereas the proportion of undersize (<20g) tubers was affected by both the factors, viz. size of the mini-tuber as well as the method of planting. The undersized tubers were significantly higher with the small size of mini-tubers planted (48.1%) and minimum (28.6%) with the largest mini-tubers (10-20g). Undersized tubers were used more with the flatbed method than with the ridge method. Results concluded that the number of tubers/ha is greater with the Flatbed method of planting, whereas yield /ha is significantly higher with the Ridge system. The proportion of seed-size tubers (20-80g) was similar between both planting systems. The undersize (<20g) tubers are more with the Flatbed method, while the Large and oversize tubers are more with the Ridge system. Increasing the size of mini-tubes planted results in higher yield and number of tubers per unit area. The proportion of >20g tubers increases while the proportion of <20g (undersize)tubers decreases with the increasing size of mini-tubers planted.

3. Agronomical manipulations for effective field multiplication of potato aeroponic minitubers of newly released varieties

Study was conducted with 8 popular varieties viz Kufri Sangam, Kufri Thar 2, Kufri Lima, Kufri Pukhraj, Kufri Chipsona-3, Kufri Chipsona-1, K. Khyati and K. Mohan and two spacing combinations 30×10 cm (333333 plants/ha) and

30× 15 cm (222222 plants/ha). No significant difference was recorded among varieties for germination and among spacing. Higher total number of tuber (000/ha) was recorded in Kufri Mohan (1883), Kufri Pukhraj (1856) and Kufri Chipsona-1 (1444) over Kufri Lima (901). Among spacing 30 x 10 cm recorded significantly higher total tuber number (1510 thousand/ha) over 30 x15cm (1135 thousand/ha) Fig 1. For weight Kufri Pukhraj (25.74t/ha) recorded higher total tuber wight followed by Kufri Mohan (25.56), and Kufri Khyati (23.09) over Kufri Lima (11.40 t/ha) Fig 1. 30×10 cm spacing (18.71 t/ha) recorded non significantly higher total tuber weight over 30×15 cm spacing (17.03 t/ha). Kufri Thar-2 recorded the highest <3g minituber % (42.17 by number and 6.81 by weight). Similarly, 30×10 cm spacing (36.62% by number and 4.79 by weight) recorded significantly higher <3g minituber% over 30×15 cm spacing (32.31 by number and 4.58 by weight). Kufri Khyati by number (10.82) and Kufri Mohan (34.34) by weight recorded the highest 41-80g mini tuber % over other varieties. 30×15 cm spacing (7.45% by number and 23.65% by weight) recorded non-significant higher 41-80g minituber over 30×10 cm spacing.

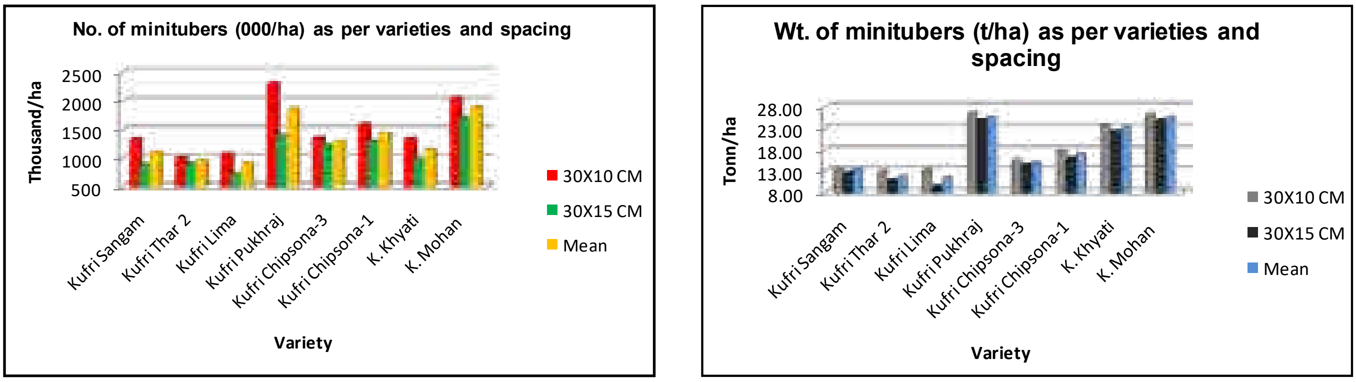


Fig. 1: Effect of spacings on variety-wise production of mini tubers and its weight

4. Evaluation of potato varieties for mini tuber production through Apical Rooted Cuttings (ARC) under Gwalior Conditions.

To see the feasibility of ARC for seed production under Gwalior conditions, six varieties were evaluated, i.e., Kufri Mohan, Kufri Chipsona-I, Kufri Chipsona-III, Kufri Lima, Kufri Khyati and Kufri Pukhraj. The highest total tuber number (4169000/ha) and weight (44.29 t/ha) was recorded in K. Mohan (Fig 2) and lowest in Kufri Chipsona-1 (2104000/ha by number and 24.06 t/ha by weight). The highest < 3g tuber by number was recorded in K Pukhraj (45.01%) and by weight in K. Lima (12.21%).3 cuttings were taken to fit into the seed window. Since no aeroponic facility is available at the center, this technology can be effectively used under hi-tech seed production.

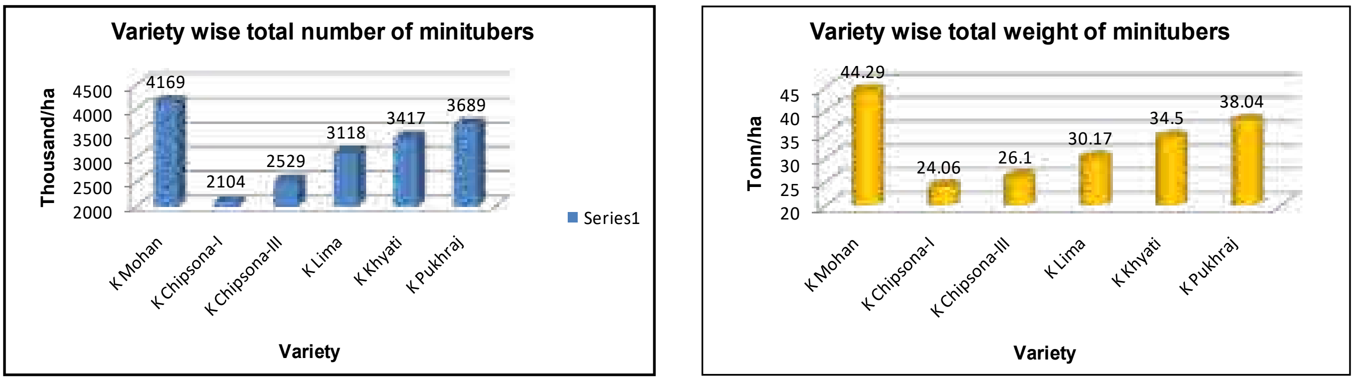


Fig. 2: Evaluation of varieties for number and weight of mini tubers under ARC

5. Tuber shape variation in variety K. Bahar: Unexpectedly, during our routine micropropagation, we observed the tuber shape variation (elongated) in one of the most popular variety Kufri Bahar in the tuber produce of tissue-culture raised plants, which originated from the mother tuber having a round shape. These elongated tubers with sugary tapering end are highly undesirable and also unsuitable for commercial seed production, and results in rottage and early decay of seed stocks during storage. To achieve healthy and quality seed tubers, maintenance of genetic identity of tissue culture-derived plants is very crucial in potato. Later, considering the growth regulator (GA_3@100µl/lt, NAA @10µl/lt) as a culprit for tuber shape variation, a decision of exclusive use of hormone-free media for potato tissue culture was taken. Various studies were conducted, viz., influence of photoperiod and EDTA salts on endogenous GA concentration of tissue culture-grown potato microplants and Methylome and transcriptome analysis for identifying candidate genes for tuber shape variation in tissue culturederived potato, but nothing conclusive came out. Later, the original conventional mother tubers were collected and shifted in vitro. Since the original K. Bahar had Potato Virus X, a meristem tip culture was followed to eliminate this virus. For the fast growth in MTC, GA is needed to grow micro-clones. We tried to grow meri clones on GA-free media. Though it took a long for the mericlones to grow, we got some mericlones. They were tested for all the existing viruses, and we found some virus-free mericlones. Now we have four sets of plants (a: Grown with GA during Mericloning, b: Grown without GA during Mericloning, c: The one with elongation problem, d: original conventional tubers). Subsequent evaluation of these sets under net-house conditions in Modipuram (Fig 3) revealed that sets a and b showed a majority of round tubers (70-80%) resembling the original K. Bahar variety. In comparison, set c exhibited a higher proportion (90%) of elongated tubers. Further multiplication of these tubers under field conditions in Modipuram is planned. The genetic fidelity of all four sets and their hormonal pathway will be studied for scientific validation. This investigation highlights the challenges in maintaining genetic identity and desired traits during tissue culture propagation of potato varieties.

Fig 3: Harvested tubers of four sets of K. Bahar plants

5. Production potential of PGPR-treated micro plants for aeroponic mini tuber production

A preliminary study evaluated the efficacy of inoculating potato microplants with pure cultures of Bacillus cereus (Kufri strain, SGL-6) on their microclonal propagation behavior and ex vitro production potential under aeroponics. Five potato varieties were used: Kufri Khyati, Kufri Pukhraj, Kufri Himalini, Kufri Jyoti, and Kufri Chipsona-3. For inoculation, two conc. viz., 0.02 ml and 0.05 ml portions of the bacterial suspensions were added to culture tubes containing 10 ml of MS medium. Control plants were grown in tubes containing bacteria-free MS medium. The viability of the bacterial population in the medium was assessed, considering bacterial colonization. After 21 days of in vitro growth in a controlled environment (21±1°C, 16-hour photoperiod, light flux 50-60 µmol $m^{-2}s^{-1}$), the cuttings of both control and inoculated microplants were transferred to aeroponics. By day 4 of growth, cuttings began to develop 3-4 rootlets. No bacterial films or other types of contamination were observed around the microcuttings or on the surface of the medium. Although there were no significant differences observed in microplant height and node number between inoculated and control plants (Fig 4), however, inoculation had a positive effect on plant vigor across all cultivars. Furthermore, no mortality was observed when the plants were transferred to aeroponics. The inoculated plants showed early tuberization and yielded more mini tubers under aeroponics than the control (table 4). The number of tubers formed by the inoculated and control plants were not significantly different and were dependent to a greater extent on the peculiarities of the cultivar used. A lower concentration of bacterial suspension was found to be more effective. Since this was a preliminary study, more comprehensive research is needed to evaluate further the efficacy of *Bacillus cereus* inoculation on potato microplants, including optimization of inoculation methods, concentration, and potential long-term effects on plant growth and tuber production.

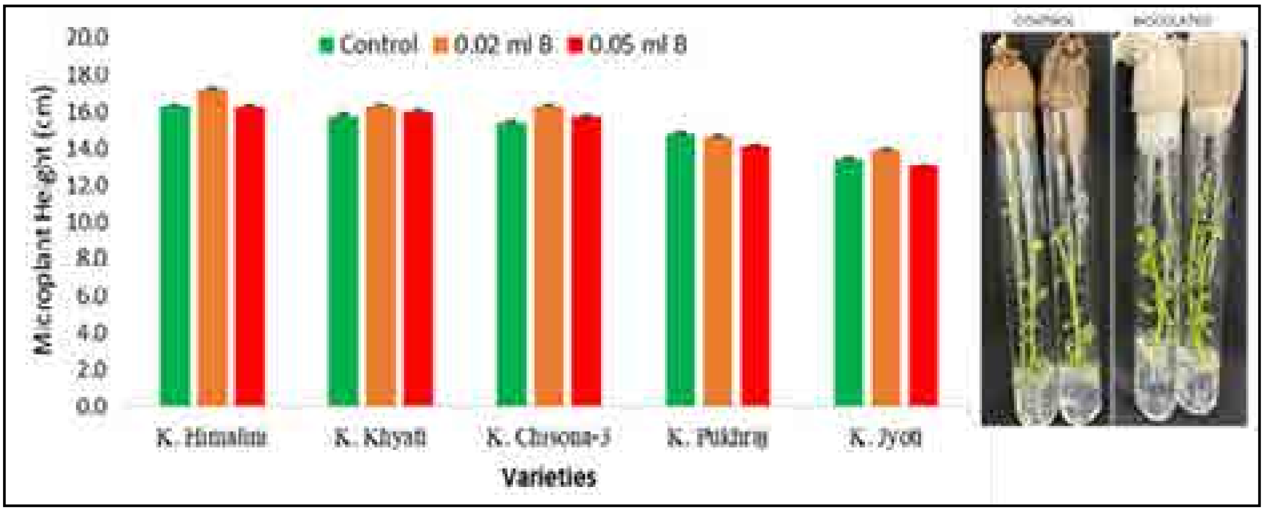


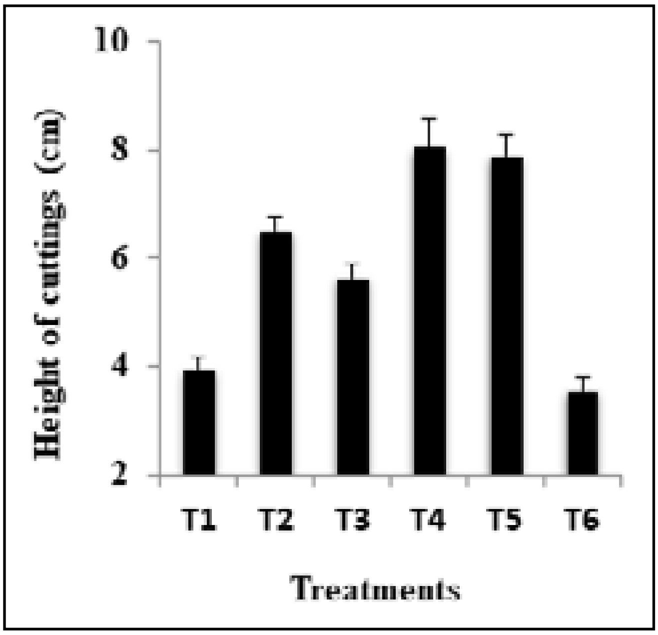
Fig 4: Effect of *Bacillus cerus* inoculation on micro plant height and vigor

Table 4: **Performance of PGPR inoculated micro plants under aeroponics**

Varieties/ Treatments	Days to tuberization				No. of minitubers/plant			
	Control	0.02ml B	0.05 ml B	Mean	Control	0.02ml B	0.05 ml B	Mean
K. Himalini	42.00	37.33	42.00	40.44	45.00	48.67	43.00	45.56
K. Khyati	43.67	41.00	45.33	43.33	50.33	52.33	50.00	50.89
K. Chipsona-3	49.33	47.00	49.00	48.44	39.67	42.33	44.67	42.22
K. Pukhraj	32.00	29.67	31.33	31.00	53.67	56.67	49.67	53.33
K. Jyoti	40.00	39.00	41.67	40.22	31.00	34.67	30.33	32.00
Mean	41.40	38.80	41.87		43.93	46.93	43.53	
CD0.05								
Varieties			2.19				2.67	
Treatments			1.71				2.07	
V x T			N.S.				N.S.	

6. Influence of different growing media on apical rooted cuttings vigour

The study investigated the efficacy of different growth media treatments for cultivating potato apical rooted cuttings (ARC) derived from young, rounded-leaf mother plants, focusing on enhancing transplanting success and producing high-quality seed tubers. The six growth media treatments (T1-T6) consisted of various combinations involving cocopeat, vermiculite, perlite, tea dust, and wood dust. After a 15-day evaluation period, the study measured several growth parameters, including survival percentage, plant height, leaf count, and fresh weight. Results indicated that treatments T5 and T6 performed notably well (Fig 5), followed by T2, whereas T4 exhibited the least favorable outcomes. Particularly, T6 surpassed T5 regarding leaf count, while T4 demonstrated the poorest performance. Moreover, T3 yielded the highest fresh weight, followed by T6, with T4 displaying the lowest fresh weight. The study underscores the superiority of treatment T6, which incorporated tea dust into the growth medium. This finding suggests that tea dust could be a cost-effective and accessible alternative for growth media, as it can be obtained affordably from tea factories. Repurposing tea dust offers potential economic and environmental benefits by reducing the need to purchase conventional growth media. However, caution is advised when considering wood dust as a growth medium due to its variable nutrient content, pH levels, and suitability for potato cultivation. Despite its potential drawbacks, the study highlights the potential of tea dust as a viable alternative for raising ARC, emphasizing its economic feasibility and positive environmental implications.



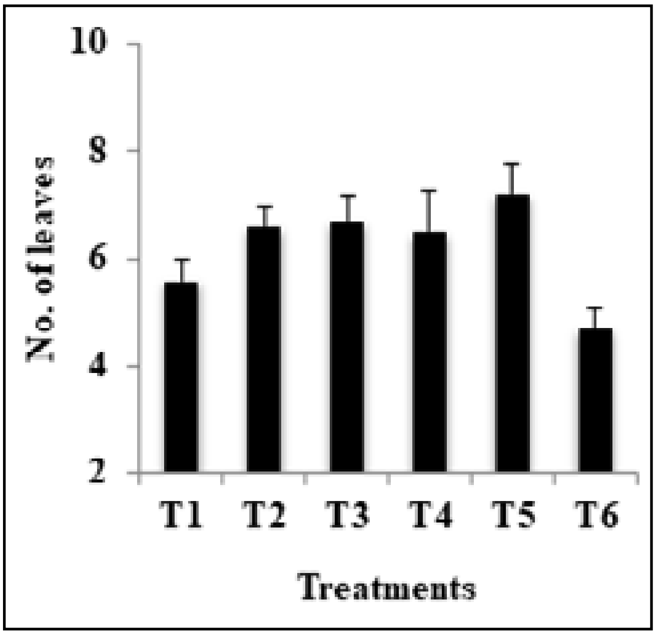


Fig 5: Effect of growing media on ARC's height and no. of leaves

Project 3: Development of agro-techniques for enhancing seed potato quality.

1. Evaluation of potato varieties under different spacing and canopy management practices for producing seed-size tubers.

At Gwalior, 5 spacing combinations viz S1-Ridge and furrow 60×20 cm, S2-Ridge and furrow 60×15cm, S3-Flat Bed Paired row 90 cm bed length (two rows 20 cm plant to plant spacing), S4-Flat bed Paired row 90 cm bed length (two rows 15 cm plant to plant spacing) and S5-Flat bed triple row 90 cm bed length (three rows 20 cm plant to plant spacing) and 2 haulm killing dates viz H1-70 and H2-80 days with three replications were used for the study. No significant difference was reported for final emergence among spacing combinations and haulm killing and 50% and among haulm killing days. A significant increasing difference was reported for <25 g tuber number and weight (t/ha), and the highest was reported in S5 (453 thousand and 4.09 t/ha number and weight, respectively). An increasing trend was reported with the treatments in the 25-125g category of tubers, and the significantly highest seed tubers were recorded in S4- 611 thousand tuber number and by weight in S5-31.93 t/ha seed size tuber yield (fig 1 and 2). Higher seed size tubers were reported in 80 days of haulm killing both by number only by weight (29.18 t/ha) fig 3 and 4. Non-significant differences were reported for seed size (25-125g) tuber % among haulm killing days (fig 5). Significantly higher seed size tuber % was recorded in S1 (63.21) and S2 (82.47) by number and weight, respectively, fig 6.

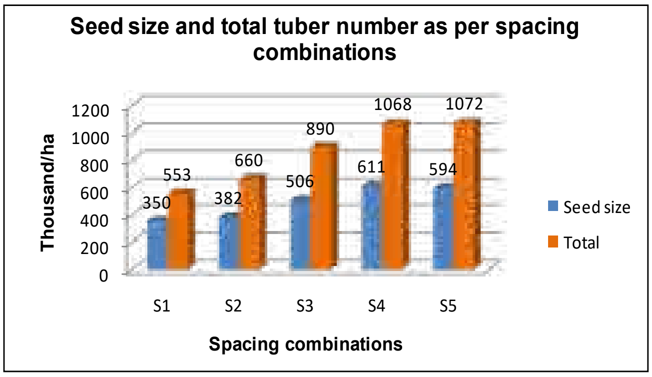


Fig 1

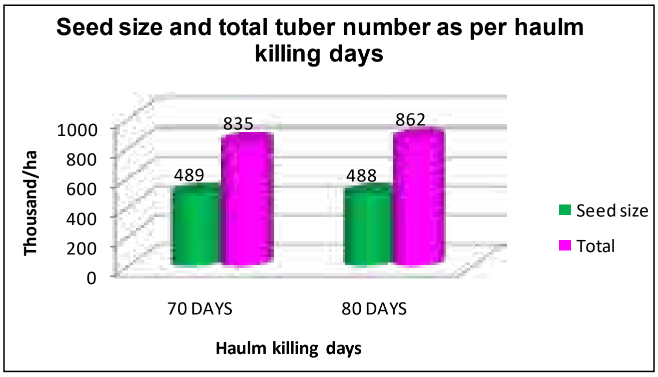


Fig 2

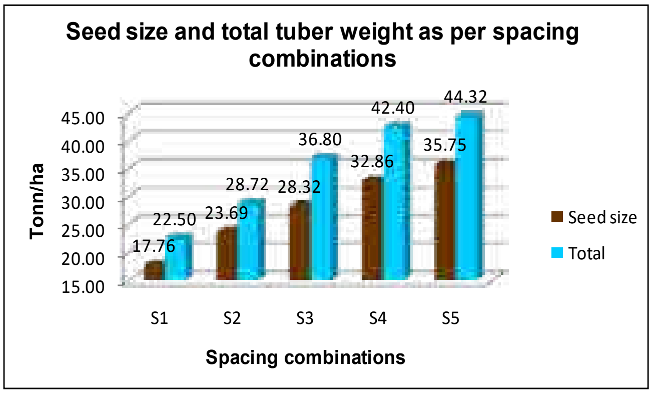


Fig 3

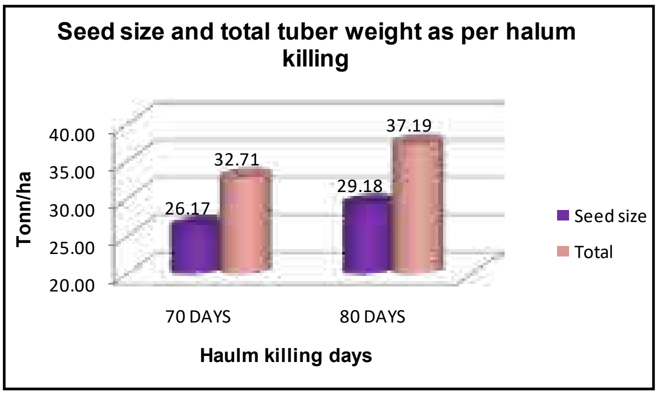


Fig 4

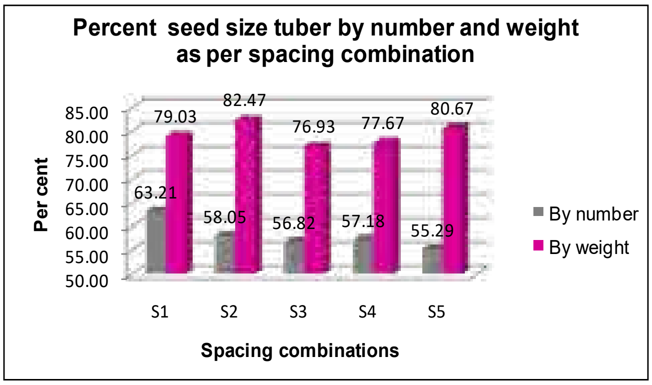


Fig 5

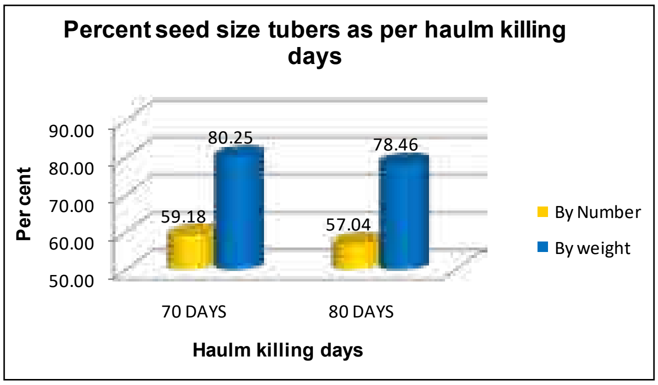


Fig 6

At Jalandhar, it was observed that the highest seed size (753 thousand/ha) and total seed tubers (1345 thousand/ha) were recorded in S5-Flat bed triple row 90 cm bed length (three rows 20 cm plant to plant spacing). Higher seed size (37.29 t/ha) and total tuber weight (53.78/ha) were recorded at 80 days of haulm killing. The highest percentage of seed-size tubers by number was recorded in S4 (57.31%) and by weight in S5 (75.81%). The highest net tuber by number (1187 thousand/ha) in S4 and by weight (49.43 t/ha) was obtained in S5-Flat bed triple row 90 cm bed length (three rows 20 cm plant to plant spacing).

2. Studies on the degeneration of potato seeds of different varieties under changing climate scenario

Seven varieties viz V1. K. Chandramukhi (Early), V2. K. Lauvkar (Early), V3. K. Surya (Early), V4. K. Jyoti (Medium), V5. K. Chipsona – 1 (Mid - late), V6. K. Chipsona – 3 (Mid-late) and V7 K. Sindhuri (late) and 3 seed type viz S1- Fresh breeder seed used as control every year, S2- 2nd Carryover breeder seed raised as per "Seed Plot Technique" methodology (Roguing and plant protection measures are taken from time to time). A significantly higher emergence % was recorded in fresh breeder seed (90.07) over 2nd-year COSPT (88.27) and 2nd-year COWSPT (86.16) seed type. Fresh breeder seed (654000 and 31.08 t/ha) reported higher total tuber number and weight follwed by 2nd year CO SPT (615000 and 27.70 t/ha) over 2nd year COWSPT (52800 and 25.18t/ha) fig 7 and 8. Variability was recorded for number and weight of tuber/ha among varieties and Kufri Sindhuri recorded significantly highest total number of tuber fig 9 and 10.

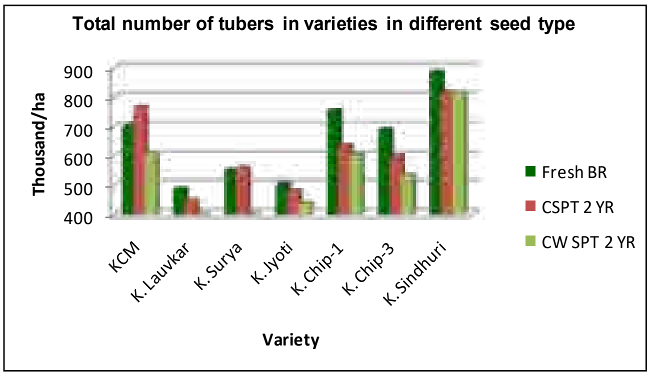


Fig 7

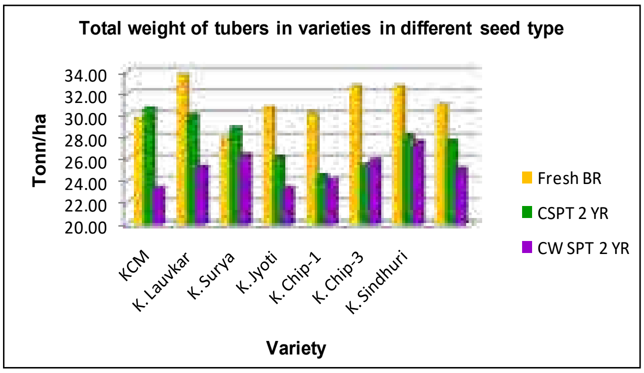


Fig 8

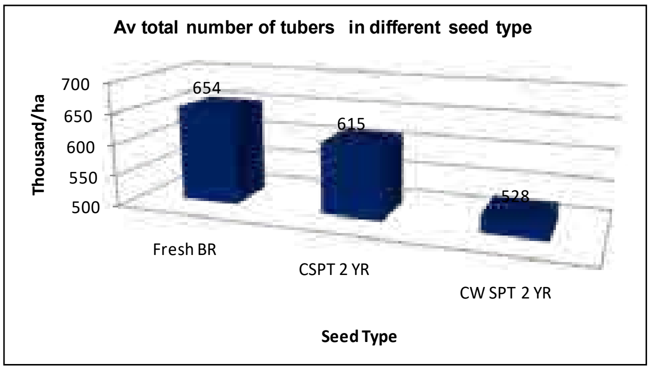


Fig 9

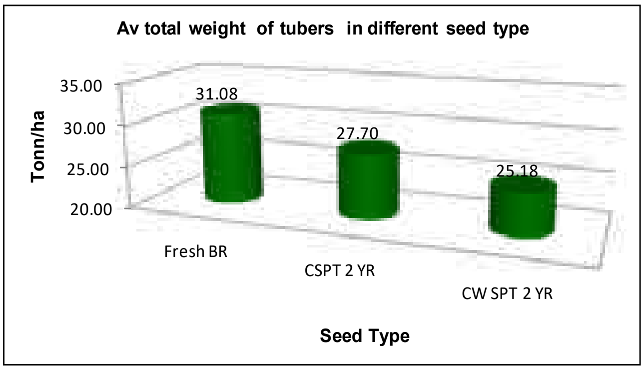


Fig 10

3. Manipulation of seed tuber size in potato with foliar application of N fertilizer in seed potato production.

An experiment was conducted with varieties Kufri Mohan at Gwalior and Kufri Jyoti at Patna to manipulate potato seed tuber size. A total of nine treatments viz.T1- Control RDF (50% basal N+ 50% top dressing at 25 DAP), T2- 50% basal N + 25% top dressing at 25 DAP, T3- 25% basal N + 25% top dressing at 25 DAP, T4- 50% basal N + 25% top dressing at 25 DAP+ one foliar spray @ 2% urea at 40 DAP, T5- 25% basal N + 25% top dressing at 25 DAP+ one foliar spray @ 2% urea at 40 DAP, T6- 50% basal N + 25% top dressing at 25 DAP + two foliar spray @ 2% urea at 40 & 55 DAP, T7- 25% basal N + 25% top dressing at 25 DAP + two foliar spray @ 2% urea at 40 & 55 DAP, T8-50% basal N + three foliar spray @ 2% urea at 25, 40 & 55 DAP and T9- 25% basal N + three foliar spray @ 2% urea at 25, 40 & 55 DAP. At Gwalior, by number % small size (25-50g) seed tuber and seed size (25-125g) was highest in T6-N as basal (50%) + N as top dressing at 25 DAP (25%) + N as foliar spray of 2% urea at 40 & 55 DAP (29.87) and T5-N as basal (25%) + N as top dressing at

25 DAP (25%) + N as foliar spray of 2% urea at 40 DAP (62.26) treatment respectively. T5 – 25% basal N + 25% top dressing at 25 DAP + one foliar spray @ 2% urea at 40 DAP recorded significantly the highest total tuber yield (40.83 t/ha). At Patna, by number % small size (25-50g) seed tuber was highest in T6-N as basal (50%) + N as top dressing at 25 DAP (25%) + N as foliar spray of 2% urea at 40 & 55 DAP (38.08). T1 Control -N as basal (50%) + N as top dressing at 25 DAP (50%) recorded significantly the highest total tuber yield (27.82 t/ha). The experiment was planted in November 2023 at both locations, and observations on vegetative and yield-attributing aspects are being recorded at suitable intervals.

4. Study the effect of irrigation method, irrigation scheduling, and mulching on seed tuber yield and quality (seed size distribution)

At Jalandhar, four irrigation scheduling strategies, viz., furrow irrigations at IW: CPE 2.5 (M1), 2-weeks interval upto 70 DAP (M2), at 2-weeks interval upto 56 DAP (M3) and drip irrigation at 100 % open pan evaporation rate (M4) were compared. Each of these scheduling strategies were further evaluated against two different rates of paddy straw mulching applications i.e. @ 2.5 t ha-1 and 5.0 t ha-1 and without mulch (fig 11). Total (30.2 t/ha) and seed size (18.8 t/ha) tuber yields both were highest under Drip Irrigations @100 % Open Pan-E followed by Furrow Irrigations-Climatological approach at IW: CPE 2.5 (fig 12).

Fig.11: Experimental seed potato crop under drip and furrow irrigation systems (25 DAP)

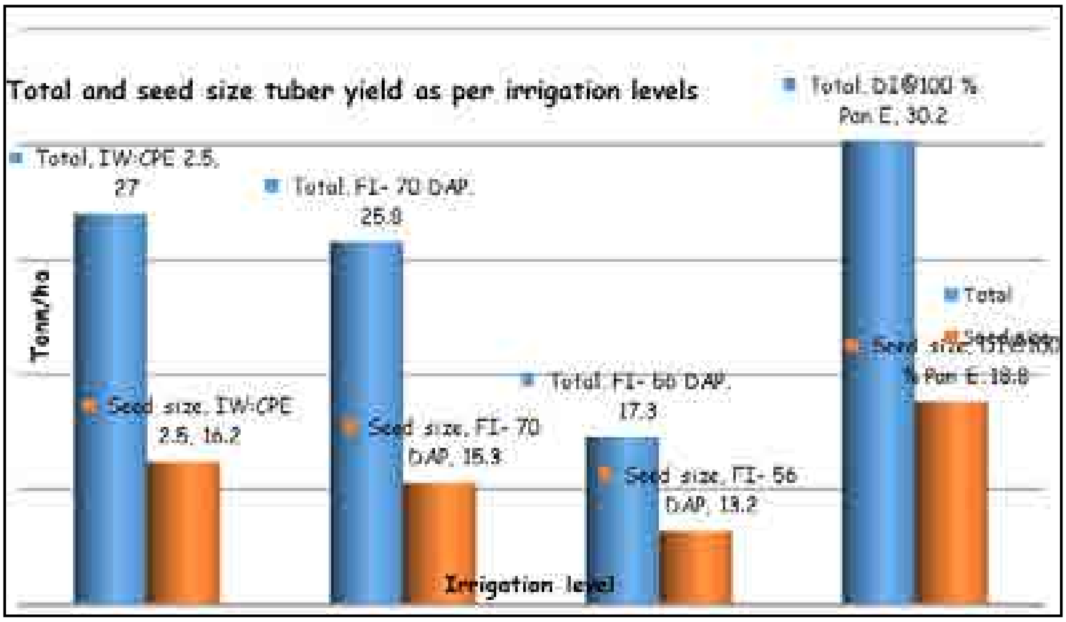


Fig.12: Total and seed grade tuber yields under various irrigation scheduling treatments

5. Effect of bio-agent *Bacillus cereus* (Kufri strain, SGL-6) treatments on the production behaviour of potato mini-tubers of K. Karan under field conditions during 2023.

To test the efficacy of the bio-agent *Bacillus cereus* (Kufri strain, SGL-6) on the production behavior of potatoes under field conditions, a preliminary study was conducted using 04 dilutions of original culture viz. 25, 50, 75, and 100%. Potato mini-tubers of 3-10g size were dip treated in respective solutions for 30 minutes followed by surface drying and were planted on the same day in field at 50x20cm spacing in four replications. Data were collected on the number of total tubers and yield /ha.

A perusal of the data presented in **Table 1** reveals that the potato's number and yield were significantly affected by the dip treatment of seed tubers in *Bacillus cereus* solution. A gradual increase in the number of tubers/ha was noticed with increasing concentration of bioagent solution. The number of tubers was found to be maximum with 75% concentration of *Bacillus cereus* solution and minimum in control (no treatment). The number of tubers was statistically at par between 25 and 50% concentration, while the treatment with 100% dose was at par to 75% concentration. The yield/ha also showed a trend similar to the number of tubers. Yield/ha was also significantly higher with 75% concentration (338.3 q/ha), which was closely followed and at par (336.0q/ha) with 100% *Bacillus cereus* solution. Yield/ha was almost similar between 25% concentration and Control (no treatment).

Table 1: Effect of *Bacillus cereus* treatments on the number of tubers and yield of potato

S. No.	Treatments (Conc. of solution for tuber dip)	Total Tubers ('000/ha)	Yield (q/ha)
1	**25%**	875.5	315.2
2	**50%**	886.8	328.4
3	**75%**	923.5	338.3
4	**100 %**	896.0	336.0
5	**Control (Water dip)**	813.0	317.1
	CD $_{0.05}$	31.3	9.9

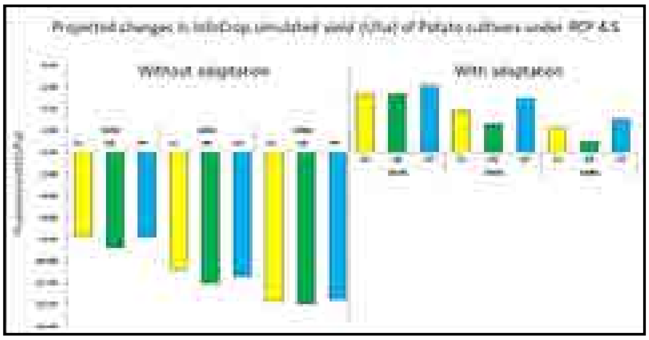
From the preliminary studies, it appears that for improving the productivity of potato, dip treatment of seed tubers with Bacillus cereus solution (75%) can be applied successfully.

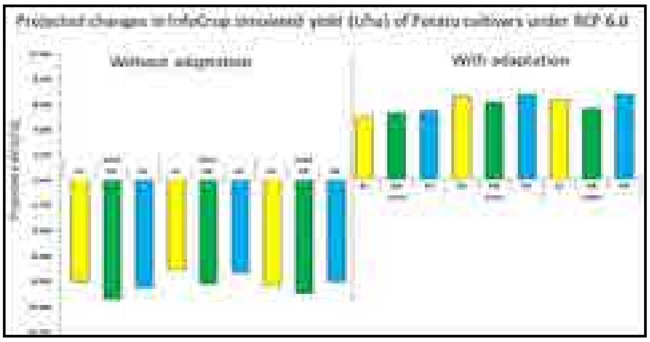
DIVISION OF CROP PRODUCTION

PROGRAMME: VULNERABILITY AND RESILIENCE TO CLIMATE CHANGE FOR SUSTAINABLE POTATO PRODUCTION

Project 1. Climate change impact assessment and devising suitable adaptation strategies for potatoes: Implementation of modelling and GIS tools.

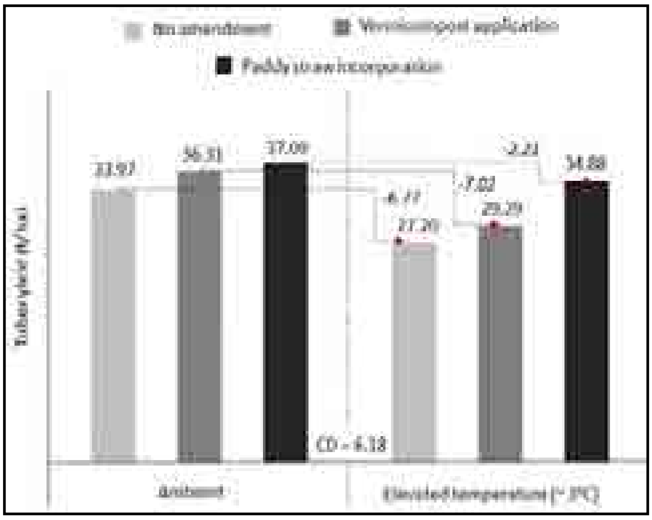
During this study simulation results showed that under RCP 4.5 about 4.3-6.5% tuber yield increase is likely in three potato cultivars of early (K. Pukhraj), medium (Kufri Jyoti), and late maturity (K. Badshah) while reducing the irrigation interval from 7 to 5 days and N dose from 150 to 180 kg/ha using InfoCrop simulation model for Madhya Pradesh under 2030, 2050 and 2080 scenarios of temperature and CO_2 fertilization. Whereas under RCP-6.0, about 4.2–6.6% tuber yield increase is likely in three potato cultivars of early (K. Pukhraj), medium (Kufri Jyoti), and late maturity (K. Badshah) while reducing the irrigation interval from 7 to 5 days and N dose from 150 to 180 kg/ha using InfoCrop simulation model for Madhya Pradesh under 2030, 2050 and 2080 scenarios of temperature and CO_2 fertilization.





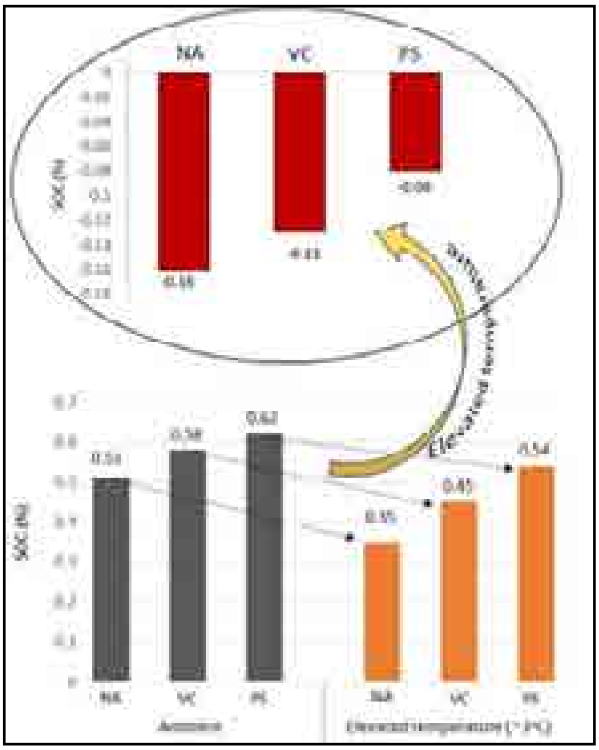
Project 2. Evaluation of newly released potato cultivars/ hybrids under elevated CO_2 and rising temperature.

During OTC studies for evaluating performance of Thar 3, it was observed that tuber yield decreased with temperature elevation of 3°C (approx.). The decrease was statistically non-significant in case of paddy straw incorporation but the same was significant in case of vermicompost application and control. The extent of decrease in tuber yield due to temperature elevation was less in soils where paddy straw was incorporated (-2.21 t/ha) compared to vermicompost application (-7.02 t/ha) and no amendment (-6.77 t/ha)



Project 3: Carbon fraction dynamics (CFD) and budgeting under elevated CO_2 and temperature conditions in Potato growing soils.

Effect of elevated temperature on SOC in soils with different organic amendments was studied. Soil Organic carbon in all the treatments decreased with temperature elevation but the extent of decrease in SOC was lesser in soils where paddy straw was incorporated (0.08%). The same was 0.13% in soils where vermicompost was applied and 0.16% in soils with no amendment. This suggests that by maintaining or increasing SOC the climate change effect can be countered to some extent



NA: No amendment; VC: Vermicompost application;

PS: paddy straw incorporation

Project 4: Carbon footprint estimation of potato production under different agro-ecological zones.

Among all greenhouse gases (GHG), carbon dioxide is a major culprit for climate change in current scenario. Hence, the carbon-footprint estimation in potato production under different agro-ecological zones needs to be chalked out to assess their impact on GHG-emissions at field level. Carbon footprint (CFs) estimation of potato production under different regions is an important ecological indicator that explains how the potato crop management/technologies do behave towards GHG-emissions at regional level. To mitigate future climate change scenarios and design strategies that minimize its harmful effects, the information about carbon budgeting and CFs is of utmost importance. Overall, this analysis is crucial for devising environment friendly packages of practices for potato production in different agro-ecologies. Hence, during 2021-23, an estimation of GHG emissions and carbon footprints under potato production in wet and dry-temperate region of Himachal Pradesh in NW Himalayas was done through field-surveys using survey schedule approach in four districts *viz.*, Chamba (Pangi valley), Lahaul and Spiti (Lahaul and Spiti valleys), Kinnaur and Shimla districts where majority of farmers were growing Kufri Jyoti and Kufri Chanderamukhi potato cultivars. Highest total GHG-emission equivalents from the inputs were observed for Lahaul valley (3237.8 CO_2-e kg ha^{-1}) and least in Chamba (2415.8 CO_2-e kg ha^{-1}) with respective field level emissions of 103.6 and 148.5 CO_2-e kg Mg^{-1} for fresh tuber yield (Table 1).

Table 1. GHG-emissions of potato cultivation in different districts/valleys in wet and dry-temperate region of Himachal Pradesh.

Distt/valleys	GHG-emissions (CO_2-e kg ha^{-1})								Fresh Tuber yield (t/ha)	CFy (CO_2-e kg Mg^{-1})
	Animal draft	Human labour	Planting tubers	NPK fertilizers	FYM	Herbicides/ fungicides/ pesticides	N_2O from farm	Total		Fresh tuber yield basis
Chamba (Pangi valley)	262.3	410.2	1020	280	91	51	301.3	2415.8	16.27	148.5
Lahaul valley	298.8	510.3	1275	580	181	51	341.7	3237.8	31.25	103.6
Spiti valley	290.2	510.3	1275	116	362	0	423.0	2976.5	28.67	103.8
Kinnaur	280.7	510.3	1275	580	181	51	341.7	3219.7	25.25	127.5
Shimla	275.5	415.1	1275	290	121	51	184.5	2612.1	21.75	120.1
Average	281.5	471.2	1224	429	187	41	318.4	2892.4	24.64	120.7

Table 2. Carbon-footprints (CFs) of potato cultivation in different districts/valleys in wet and dry-temperate region of Himachal Pradesh.

Distt/ valleys	Fresh tuber yield (t/ha)	C-output (kg CE ha^{-1})	C-input (kg CE ha^{-1})	Carbon-efficiency	Carbon sustainability index (CSI)	Carbon-footprint (CF) (kg CE kg^{-1} tuber fresh matter yield)	Carbon-footprint (CF) (kg CE kg^{-1} tuber dry matter yield)
Chamba (Pangi valley)	16.27	2035.0	658.9	3.09	2.09	0.040	0.201
Lahaul valley	31.25	3967.1	883.0	4.49	3.49	**0.028**	**0.139**
Spiti valley	28.67	3603.9	811.8	4.44	3.44	**0.028**	**0.140**
Kinnaur	25.25	3111.1	878.1	3.54	2.54	0.035	0.176
Shimla	21.75	2558.6	712.4	3.59	2.59	0.033	0.166
Average	24.64	3055.1	788.8	3.87	2.87	0.032	0.160

On an average, highest total carbon input were observed in Lahaul valley (883 kg CE ha^{-1}) followed by Kinnaur (878.1 kg CE ha^{-1}) and least in Chamba (658.9 kg CE ha^{-1}) (Table 2). Total carbon output varied between 2035–3967.1 kg CE ha^{-1} with carbon efficiency of 3.09–4.49, carbon sustainability index (CSI) of 2.09–3.49 in the study area with highest magnitude in Lahaul valley and least in Chamba (Table 2). Carbon-footprints varied between 0.028–0.040 kg CE kg^{-1} e, fresh tuber yield basis with least C-footprints in Lahaul valley and highest in Chamba; with overall average of 0.032 and 0.160 kg CE kg^{-1} on fresh and dry tuber yield basis in Himachal Pradesh (Table 2).

Project 5. Biology and management of potato pests and diseases under climate change.

Aphid occurrence as influenced by various weather parameters in early and main crop of potato was studied. Temperature, especially maximum and minimum, appears to have a significant impact on Aphid occurrences in early crop. In main crop temperature showed varied influence across seasons, with a positive correlation during the year. So far as relative humidity is concerned the evening relative humidity showed a potential influence on Aphid populations in early crop but in main crop a weak or non-significant correlations suggested these factors may not strongly influence aphid occurrence.

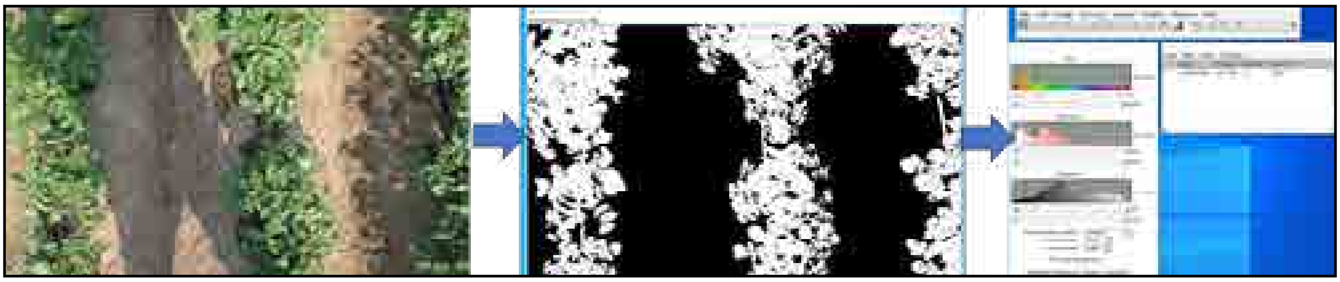
In case of Whitefly it was observed that maximum and minimum Temperatures appear to have a significant impact on Whitefly occurrences in early crop. The same was non-significant in case of main crop. Relative humidity and rainfall did not show any significant correlations across seasons in both early and main crop. It was further observed that increased sunshine hours correspond to increased whitefly occurrences, in both early and main crop.

Project 6: Impact of climate change on black scurf and early blight of potato.

For black scurf, resistant group (Kufri Sherpa and Kufri Deva) and susceptible (K Sindhuri & Atlantic) were selected. Result revealed that highest disease incidence was recorded on both the sets of varieties on 2 Nov, 2021 date of planting except cvs Atlantic (susceptible) and Kufri Sherpa (resistant). These two varieties recorded maximum disease incidence on 17 Nov, 2021 date of planting. While lowest disease incidence was recorded on 17 Oct, 2021 date of planting. Date of planting, varieties and weather parameters do have their influence on black scurf incidences.

Project 7. Evaluating Aqua crop simulation model for forecasting the potato productivity under changing climatic conditions.

In this activity a pprotocol for Estimating Green Canopy Cover Percentage, CC (%) was developed that includes a Field-friendly protocol/imaging methodology. Images are to be acquired acquired in a range of environmental conditions i.e. clear and cloudy sky and at different times of the day spanning through the crop season (33-93 DAP in 9 dates). Images are to be captured from chest height (~1.5 m height), invariably from around the centre of the experimental plots measuring 12 m2 and each scene covering ~15 % area of the plot. Image is than analysis using open source software, ImageJ (based on Hue, Saturation and Brightness Criteria)



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

Developing low-cost technology capsule using organic and inorganic sources of nutrients and micro-irrigation methods in potato (Name Singh, Sanjay Rawal Manoj Kumar, Prince Kumar Sunayan Saha and, Jagdev Sharma)

Nutrient management using crops, organic and inorganic sources of nutrition and micro irrigation methods: A field trial was conducted during 2022-23 at Modipuram to study the effect of different nutrients management options i.e. green manure, pulses, organic and inorganic sources of NPK under drip, sprinkler and furrow irrigation for enhancing water and nutrient use efficiency in potato (cv. Kufri Bahar). The study revealed that drip irrigation method produced highest average yield (25.3 t ha^{-1}) and tuber numbers (543 000 ha^{-1}) against furrow irrigation (22.1 t ha^{-1} and 483 000 ha^{-1}) under different manurial practices. Sprinkler irrigation method was found intermediate and produced 22.8 t ha^{-1} yield and 412 000 tubers ha^{-1}. In case of fertility level, 100% NPK dose produced highest yield under drip (29.1 ha^{-1}), sprinkler (25.1 ha^{-1}) and furrow irrigation (25.2 t ha^{-1}) method (**Table 1**). Organic nutrition consisting of 15 t/ha FYM+ crop residue (5 t/ha) + seed tubers treated with *Azotobacter* and PSB (BF) produced lowest tuber yield and number under all irrigation methods. On an average green manuring of preceding pulse/ green manure crop could save 25% NPK whereas FYM @15 t/ha could save 50% NPK.

Table 1. Effect of irrigation methods and nutrient management options on potato (Modipuram)

Treatment	Tuber yield (t ha^{-1})			Mean	Tuber number (000 ha^{-1})			Mean
	Furrow	Sprinkler	Drip		Furrow	Sprinkler	Drip	
100 % of NPK	25.1	25.0	29.1	26.4	545	389	594	509
75 % of NPK+ preceding pulse crop	24.9	24.3	27.2	25.5	560	495	615	557
75 % of NPK+ preceding green manure crop	25.7	24.9	28.1	26.3	538	414	591	514
50 % of NPK + 15 t FYM/ha	24.0	24.6	27.5	25.3	452	421	540	471
Crop residues + BF + 15 t FYM/ha	11.0	15.0	14.6	13.5	319	340	377	346
Mean	22.1	22.8	25.3	-	483	412	543	-
CD (p=0.05)	Irrigation (I) = 0.8	Fertility (F) = 1.1	Interaction (I X F) = 1.8		Irrigation (I) = 23	Fertility (F) = 30	Interaction (I X F) = 52	

Irrigation and nitrogen economy in potato: A field experiment was conducted during 2022-23 at Modipuram to economize water and N nutrition through agronomic manipulations in potato crop (cv. Kufri Pukhraj) for developing low cost production technology. Treatments were: T_1= Recommended irrigations at 20 mm CPE (RI)+180 kg N/ha (90 kg N basal+90 kg N at earthing), T_2 = RI + 140 kg N/ha (60 kg N basal + 60 kg N at earthing up+ 2 sprays of 2% urea at tuber initiation and bulking), T_3 = RI + 120 kg N/ha (90 kg N basal + 3 spray of 2% Urea at earthing, tuber initiation and bulking), T_4 = Irrigation at critical stages + FYM @ 15 t/ha + 180 kg N/ha (90 kg N basal + 90 kg N at earthing), T_5 = Irrigation at CS+FYM @ 15 t/ha +140 kg N/ha as in case of treatment T_2, T_6 = Irrigation at CS + FYM @ 15 t/ha + 120 kg N/ha as in case of treatment T_3. It was found that tuber number and yield remained statistically comparable among all the treatments and highest productivity (33.5 t ha^{-1}) and tuber numbers (857 000 ha^{-1}) were recorded in T_4 (**Table 2**). The results of this study revealed that irrigations applied at critical stages of crop along with application of FYM @ 15 t/ha could save two irrigations (28% irrigation water).

Table 2. Effect of different combinations of water and nitrogen application on potato (Modipuram)

Treatment	Tuber yield (t ha^{-1})				Tuber number (000 ha^{-1})			
	Large (>75 g)	Medium (25-75 g)	Small (< 25 g)	Total	Large (>75 g)	Medium (25-75 g)	Small (< 25 g)	Total
T_1	6.3	22.4	3.7	32.4	29	469	409	907
T_2	6.8	21.7	3.8	32.3	30	388	448	866
T_3	6.5	18.3	6.0	30.9	54	370	404	828
T_4	6.0	21.2	6.3	33.5	47	398	412	857
T_5	5.9	19.6	6.5	32.0	53	387	406	846
T_6	6.7	18.6	5.6	30.9	48	367	457	872
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Optimizing irrigation and macro-nutrient requirements of newly released water stress tolerant potato variety Kufri Thar- 3: The trial was conducted during 2022-23 at Modipuram to work out water and NPK requirement of potato variety Kufri Thar-3. Results revealed that irrigations applied at 20 mm CPE produced significantly higher tuber yield (22.3 t ha^{-1}) and numbers (531 000 ha^{-1}) as compared to other treatments. The effect of nutrient levels was found to be non-significant, however, 100% recommended dose of NPK produced maximum yield (21.4 t ha^{-1}), while tuber numbers (518 000 ha^{-1}) were highest in 75 % N + 100% PK treatment. Interaction effects of irrigations and NPK levels were not significant (**Table 3**).

Table 3. Effect of irrigation water quantity and NPK levels on potato cv. Kufri Thar-3 (Modipuram)

Treatment	Tuber yield (t ha^{-1}) Irrigation at mm CPE			Mean	Tuber number (000 ha^{-1}) Irrigation at mm CPE			Mean
	20	25	30		20	25	30	
100 % NPK	23.5	20.6	20.1	21.4	509	533	439	494
75 % N + 100% PK	22.4	18.6	18.7	19.9	548	495	511	518
75 % P + 100 % NK	21.9	21.8	19.2	21.0	519	535	435	496
75 % K + 100 % NP	22.0	21.3	19.1	20.8	521	495	478	498
75 % NPK	21.6	19.7	18.9	20.1	560	484	445	496
Mean	22.3	20.4	19.2	-	531	508	461	-
CD@0.05	Irrigation (I) = 0.9	Fertility (F) = NS	Interaction (I X F) = NS		Irrigation (I) = 38	Fertility (F) = NS	Interaction (I X F) = NS	

Low cost technology development by adopting various nutrient management options and micro-irrigation methods: An experiment comprising irrigation methods i.e. drip, sprinkler and furrow, and five crop sequence and nutrition levels was conducted during 2022-23 at Gwalior. The treatments were as follows: [S1N1: Fallow-potato (100% RDF NPK); S2N2: Green gram-potato (75% RDF NPK); S3N3: *Sesbania*- potato (75% RDF NPK); S4N4: Fallow- potato (FYM 15 t ha^{-1} + 50% RDF NPK); S5N5: Fallow-potato (FYM 7.5 t ha^{-1} + crop residue 7.5 t ha^{-1} + Biofertilizers (*Azotobacter* and PSB)]. Results revealed that highest total tuber number (627000 ha^{-1}) were recorded with sprinkler irrigation followed by drip irrigation (605000 ha^{-1}). Among nutrition options, maximum total tuber number (673000 ha^{-1}) was recorded with 100% RDF NPK (**Fig. 1**). Highest total tuber yield (29 t ha^{-1}) was recorded in sprinkler irrigation which was at par with drip irrigation (28 t ha^{-1}). Among nutrient levels, highest total tuber yield (33 t ha^{-1}) was observed in Sesbania- potato (75% RDF NPK+ FYM15 t ha^{-1}) which was closely followed by 100% RDF NPK (31 t ha^{-1}) as depicted in **Fig. 2**.

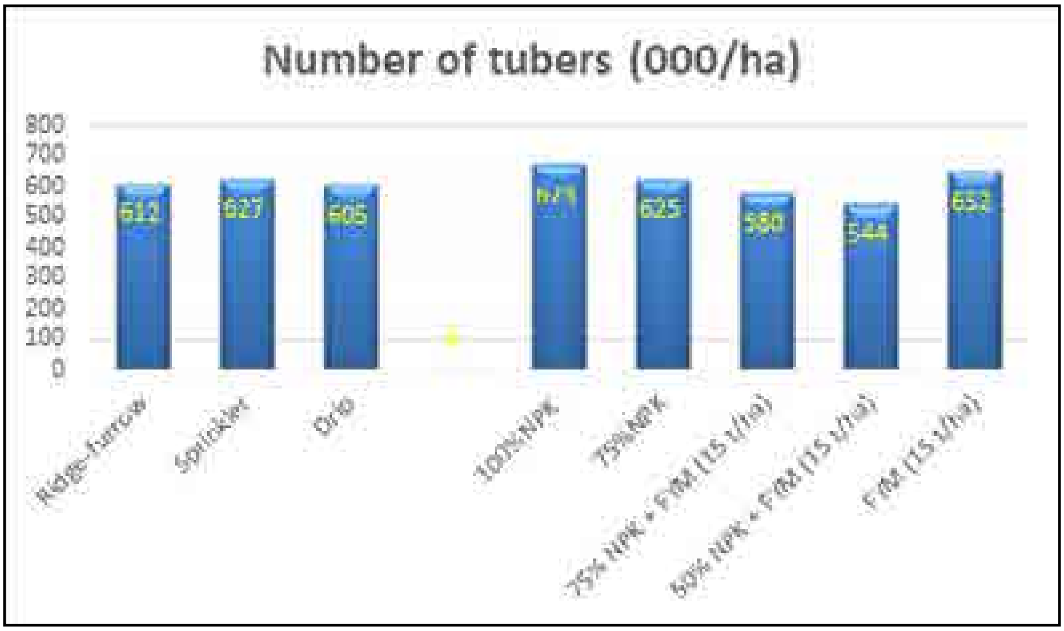


Fig. 1: Total tuber number (Gwalior)

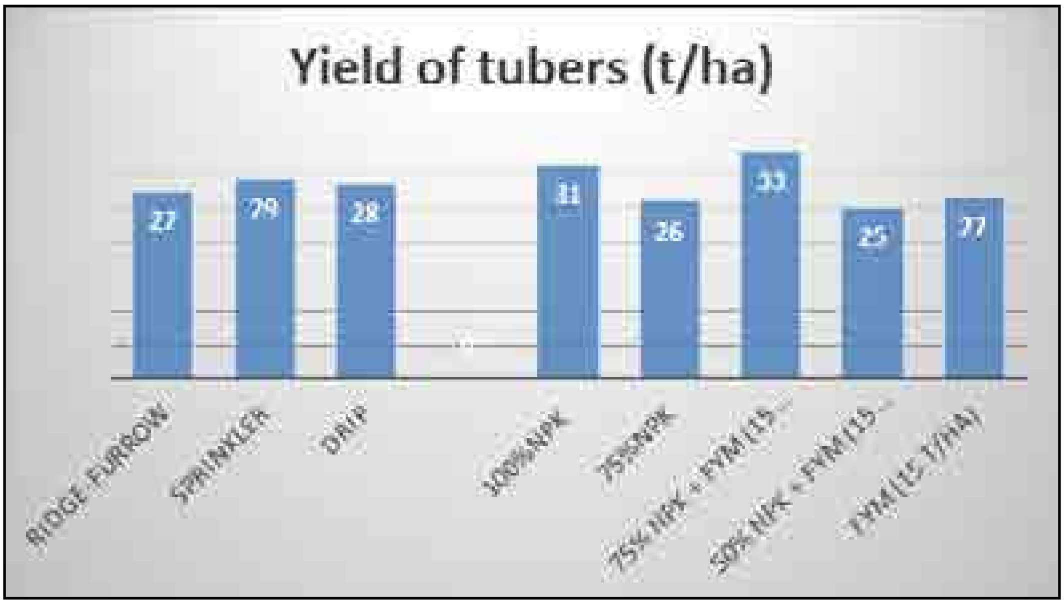


Fig. 2: Total tuber yield (Gwalior)

Assessment of consumptive water use pattern and exploring water efficient technologies for potato under changing hydro-climatic regimes (Sunayan Saha, Name Singh, VK Dua, SP Singh, RK Singh, Prince Kumar, Jagdev Sharma, Anil Sharma, Manoj Kumar Nanda, Brajesh Nare)

Improving water use efficiency for potato crop: Field experiment was conducted during *rabi* season of 2022-23 at Jalandhar to assess different irrigation scheduling strategies and usefulness of various chemicals (Thio-Urea, KNO_3 and Salicylic acid) spray and paddy straw mulching in enhancing yield and/or tuber quality under water stress condition for the variety Kufri Jyoti. The amount of water applied through drip irrigation during 10-85 DAP (emergence to onset of senescence phases) was: M1= 36 mm, M2= 44 mm, M3= 66 mm and M4= 101 mm. The seasonal mean temperature was observed as 15.5 °C (**Fig. 3**). Difference in crop growth under different irrigation scheduling was precisely quantified by periodic acquisition of digital images in 9 slots during 33-93 DAP from each experimental plot and subsequent analysis using image processing software.

Crop growth**:** From early tuber bulking phase onward, the visual differences in crop growth due to irrigation scheduling became quite apparent (**Fig. 4 & 5**). Mean canopy cover (CC%) during the crop growth phase were in order of M1<M2<M3<M4. The differences in CC % between M1 & M2 and between M2 & M3 were statistically significant ($p<0.05$). However, canopy growth in M4 was statistically at par with M3. Harvest biomass was significantly higher when rate of water applications was at the rate of 100% ETref (M3) or more.

Tuber yield and number**:** Amongst the four scheduling strategies, mean total tuber yields (> 5 g) ranged between 26.6 - 39.4 t ha^{-1} and marketable tuber yields (> 25 g tubers) between 23.2 - 36.8 t ha^{-1}. Total as well as marketable yields were lowest at M1 (26.6 & 23.2 t ha^{-1}) and highest in M4 (39.4 & 36.8 t ha^{-1}). The differences in yields between any two irrigation scheduling treatments were statistically significant ($p < 0.01$). Tuber number (>5 g) was found to be significantly higher in M2. Under the water-limited condition (M1), the yields at sub-plot level as a result of application of various chemicals spray or mulch did not show any significant difference (**Fig. 6 & 7**).

Tuber quality (cracking)**:** Percentage of cracked tubers (>1-inch length) within marketable category (>25 g) was lowest in minimal water application treatment as well as stage-specific irrigation scheduling (M1 & M2, each ~7%) and highest in maximum water application (M4, ~18 %). Further, while considering percent distribution of cracked tubers in different size grades it was found that within M1, SS-I grade (25-75 g) was most affected; in M2, SS-II (75-125 g) and in the rest two irrigation scheduling OS grade (>125 g) showed highest vulnerability to cracking (**Fig.8**).

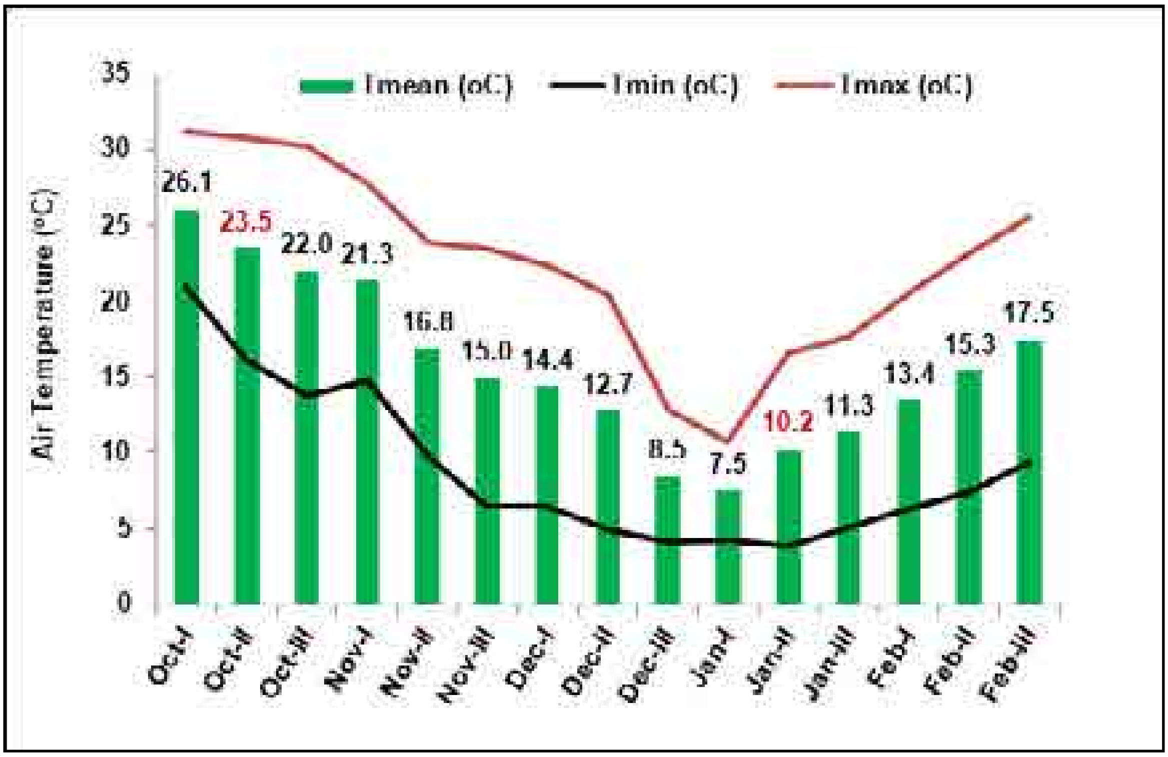


Fig. 3: Seasonal temperature dynamics during 2022-23 at Jalandhar

Fig. 4: Crop at 50 DAP under different drip-irrigation scheduling at Jalandhar

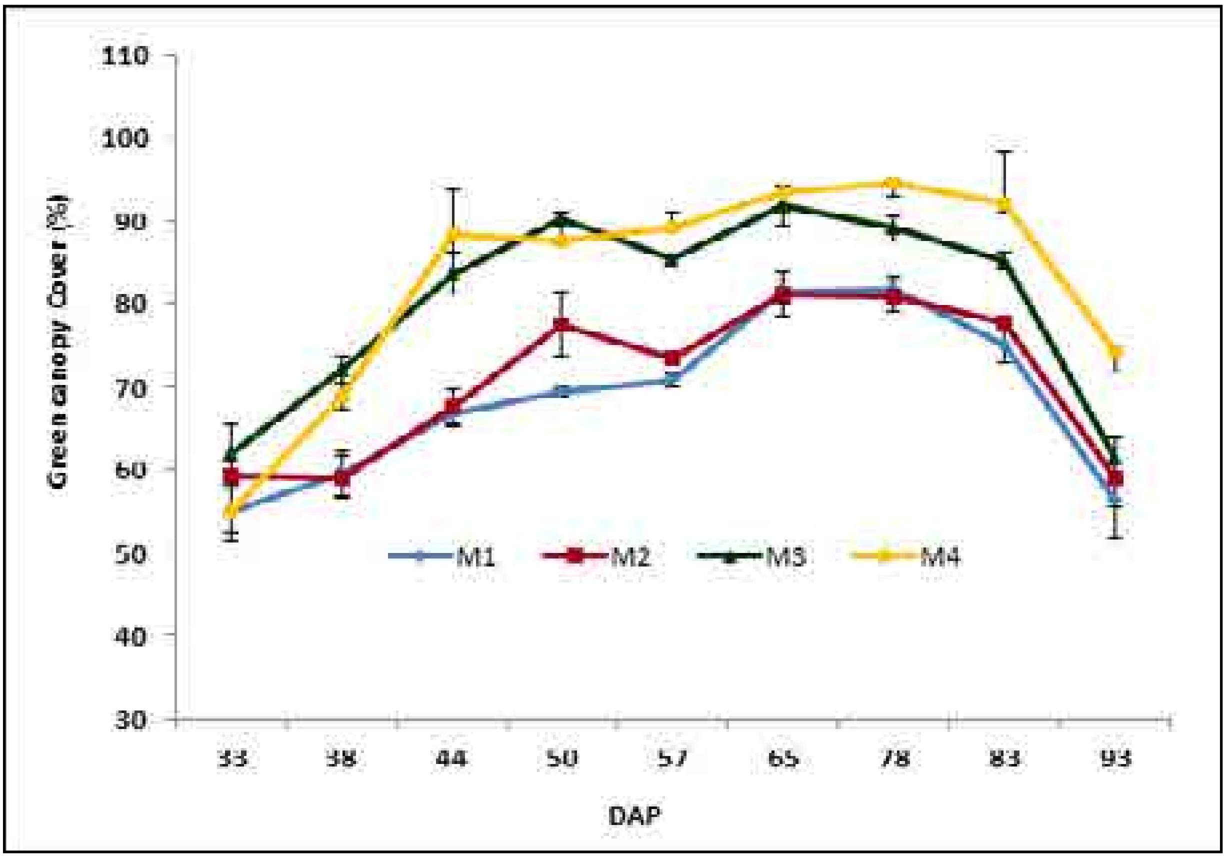


Fig. 5: Dynamics of canopy growth under various irrigation scheduling in potato cv. K. Jyoti at Jalandhar

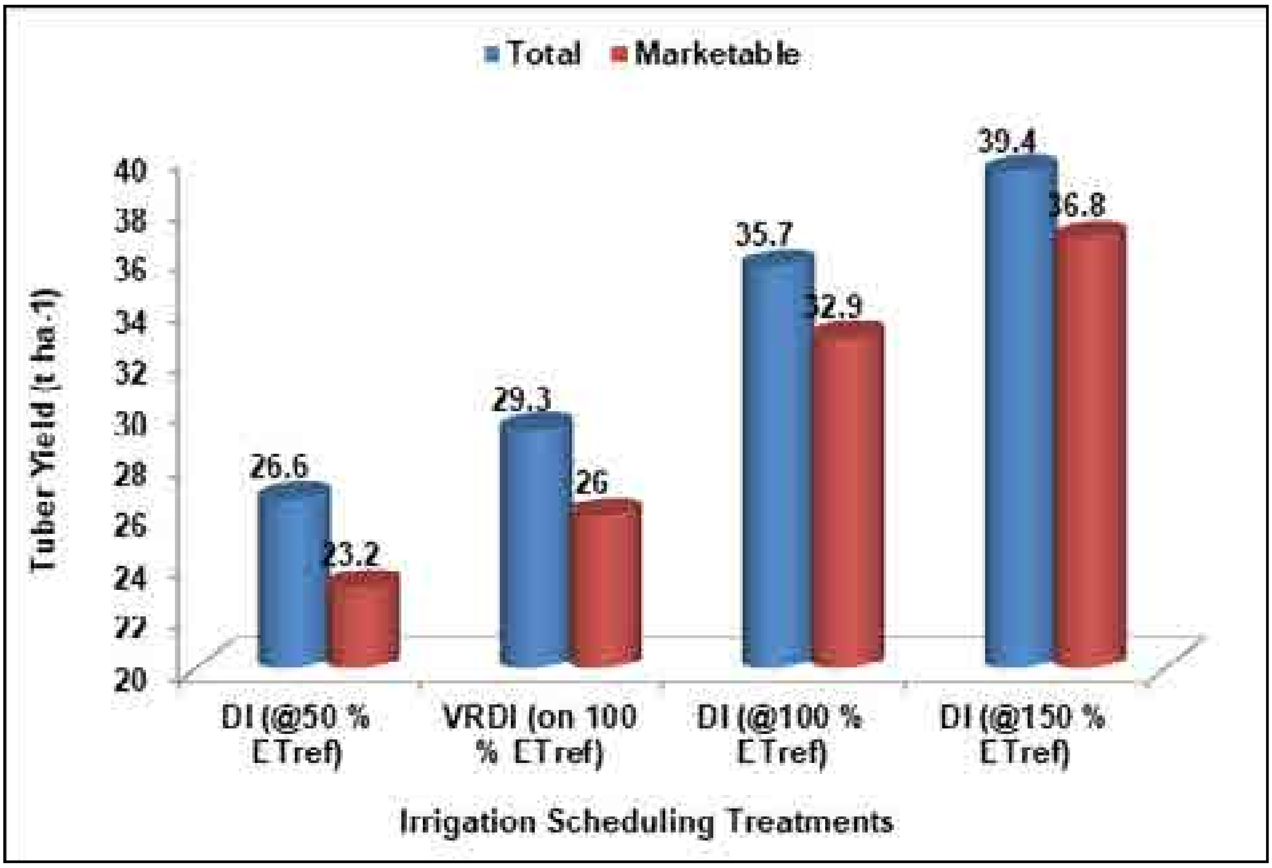


Fig. 6: Mean total and marketable tuber yields under various irrigation scheduling at Jalandhar

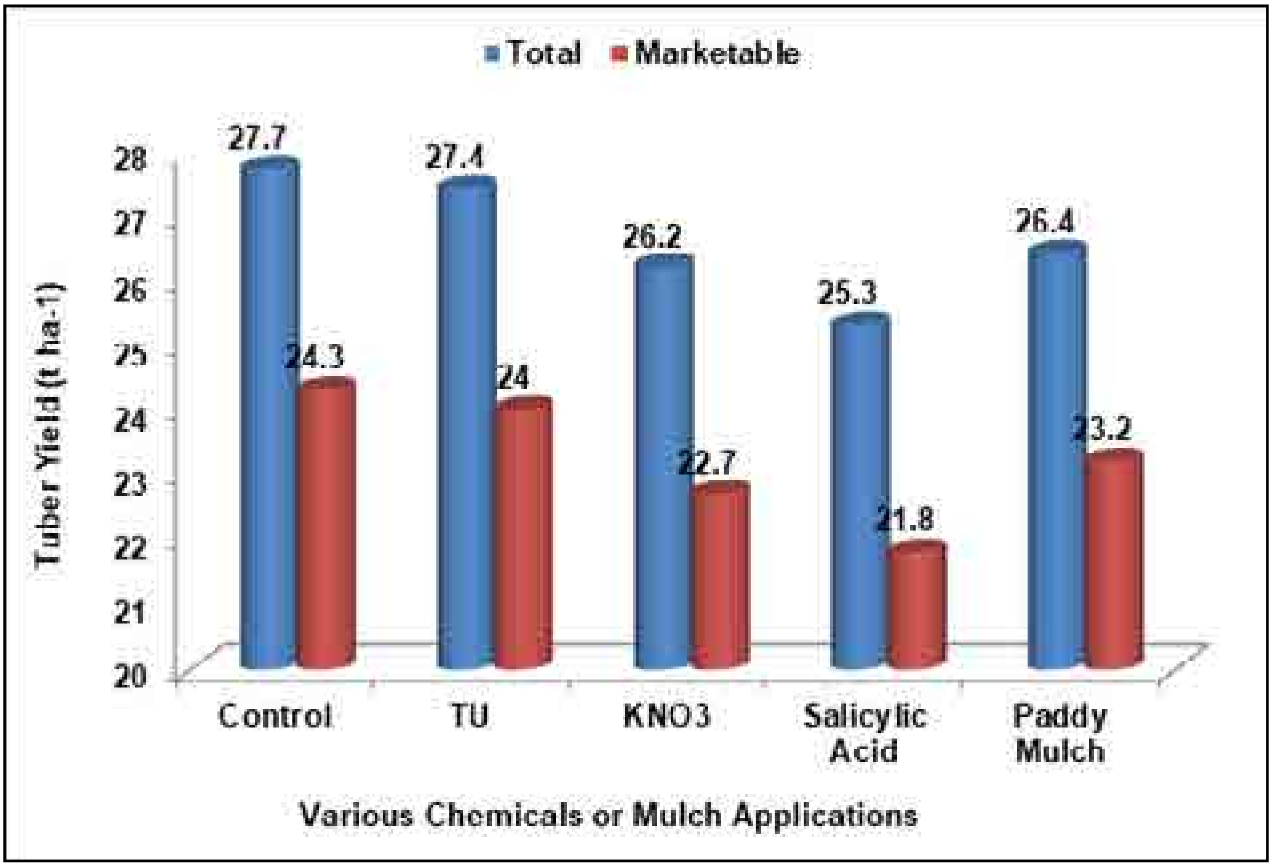


Fig. 7: Total and marketable tuber yields in various chemicals and paddy straw mulch application under limited water condition (M1) at Jalandhar

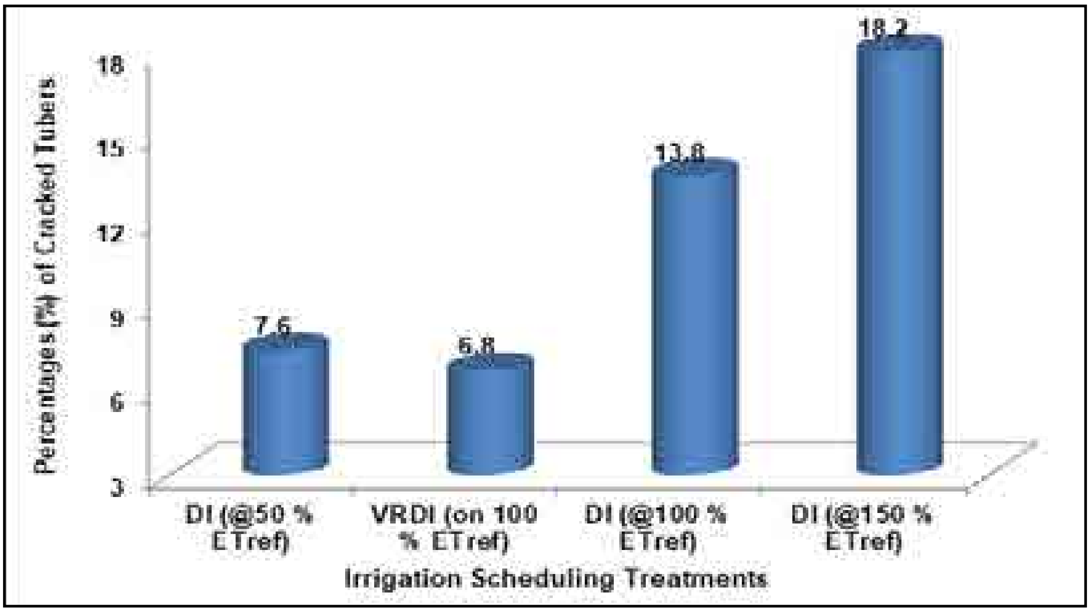


Fig. 8: Percentages of cracked tubers under various irrigation scheduling treatments at Jalandhar

Developing strategies for improving phosphorus use efficiency in potato (Jagdev Sharma; VK Dua, Manoj Kumar, Anil K Choudhary, Anil Sharma, Prince Kumar, P Janani, Divya K Lekshmanan, Dharmendra Kumar, Ajay Kumar Thakur, SP Singh, Sarla Yadav and Dalamu)

Use of rice husk ash (RHA) to improve P use efficiency: Rice husk ash is a by-product of rice mills. Studies on some of the crops have shown that rice husk ash (RHA) can be a substitute for inorganic fertilizers as it contains nutrients besides being a major source of silica or can be used in combination along with inorganic fertilizers, as an amendment. It can increase the nutrient availability and can also affect the hydro-physical properties. Compared to N and K, phosphorus use efficiency is very low in potato crop. To improve the P use efficiency, use of alternate sources on phosphorus including agro-industrial wastes is an important area. At Jalandhar, black carbonized ash (RHA) along with graded doses of P was used to study its effect on crop performance and saving in P fertilizers. It was the third year of the study highest tuber yield (41.4 t ha^{-1}) of Kufri Pukhraj was obtained with the treatment where 20t RHA/ha was applied along with 75% of recommended P and 100% of recommended NK remaining at par with the treatment (38.5 t ha^{-1}) where 10t RHA was applied along with 75% recommended P, and 100% recommended N and K (**Fig 8**). Over the results revealed that use RHA improved the P use efficiency during all the three years of study.

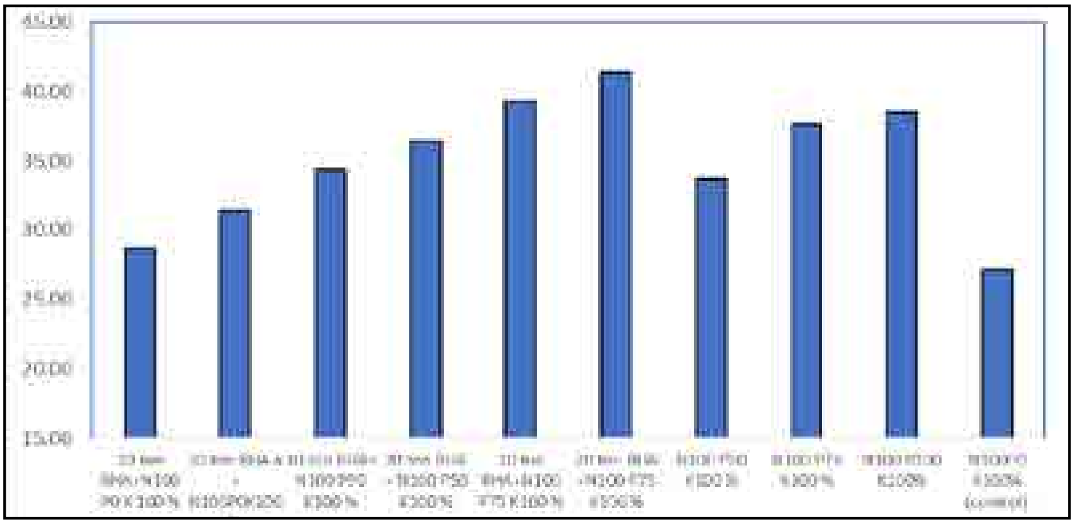
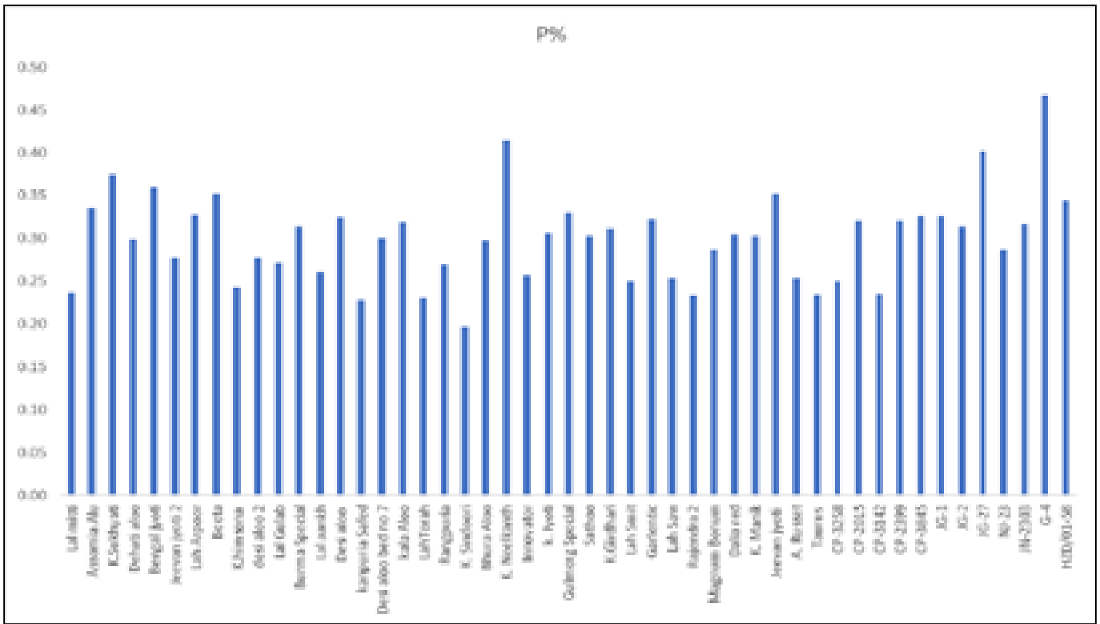


Fig. 8: Effect of RHA and NPK on total tuber yield (t/ha)

Screening of potato clones for P use efficiency: Identification of P-efficient potato genotypes is a need of the hour to sustain yield in P-deficient soils. Studies have shown an array of adaptive strategies to cope with limited P availability and allow efficient P acquisition in different crop species. Keeping this in view potato genotypes were evaluated for P acquisition in acidic soils at Shimla with an objective to identify the parents which can be used in developing P efficient commercial cultivars. Phosphorus concentration was determined in leaves of potato genotypes raised under uniform fertilizer regime. A large genotypic variability in leaf P concentration (0.20- 0.47%) was observed with a mean value of 0.30% (**Fig. 9**). This variability will be utilized for breeding P efficient varieties.



In another trial at Jalandhar, nineteen germplasm number and seven varieties were planted in single row of twelve tubers of each germplasm/variety under two levels of phosphorus including four check varieties to evaluate their P use efficiency. On tuber yield basis, clone J/15-91, J/14-242 and CP- 4444 performed better than check varieties and selected for further evaluation.

Improving phosphorus use through co-inoculation of AM-fungi and PSB in potato in Himalayan acid Alfisol: A field experiment was conducted Shimla comprising different P-levels as sole or in combinations with AM-fungi @ 12.5 kg/ha (*Glomus mosseae*) and PSB @ 500 g/ha (*Pseudomonas striata* & *Bacillus polymyxa*, *10^8 cfu*), besides foliar-P (FSP) fertilization. Application of P_{20} (20% of the recommended dose) + PSB + AMF, P_{20}+2FSP (two sprays of 2% mono-ammonium phosphate (MAP) applied at vegetative-stage (VS) and tuberization-stage (TS)]; and P_{20}+PSB+AMF+2 FSP significantly enhanced tuber productivity over sole use of P_{20} (**Fig. 10**). Alike, P_{40} (40% of the recommended dose) + PSB + AMF, P_{40}+2FSP and P_{40}+PSB+AMF+2 FSP led to 10.4, 7.3 and 16.5% higher tuber yield over sole use of P_{40}. Further, higher P application i.e. sole use of P_{80} and P_{100} had non-significant, but had 3.3 and 6.5% higher tuber yield over P_{40}+PSB+AMF+2 FSP. At lower soil applied-P, the response of PSB + AMF or foliar-P was better over their application at the higher soil applied-P (10.4–16.5%).

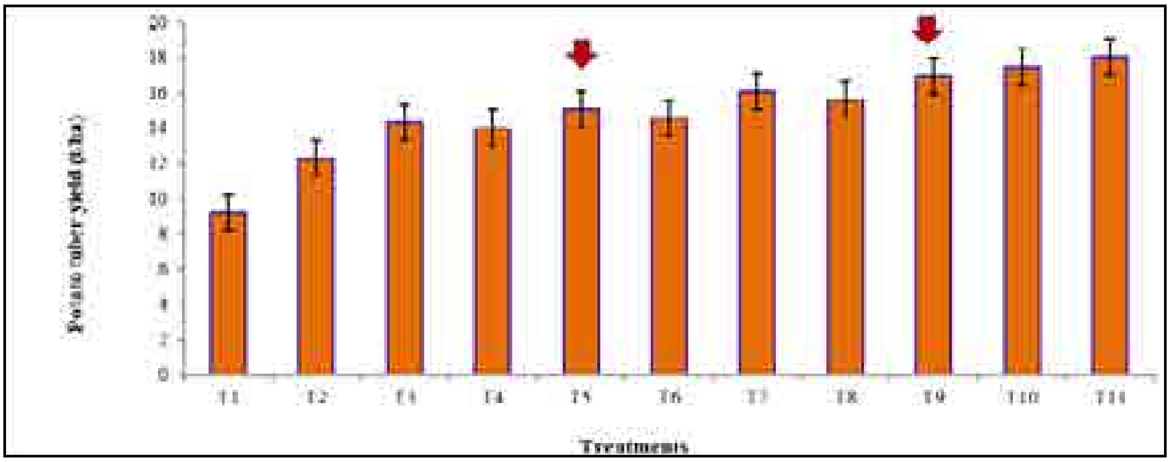


Fig. 10: Effect of P-fertilization practices on tuber yield at Shimla

[**Note**: T1: P_0; T2: P_{20}; T3: P_{20} + PSB + AMF; T4: P_{20} + 2 foliar sprays of P through 2% MAP (2 FSP); T5: P_{20}+ PSB + AMF + 2 FSP; T6: P_{40}; T7: P_{40}+ PSB + AMF; T8: P_{40}+ 2 FSP; T9: P_{40}+ PSB + AMF + 2 FSP; T10: P_{80}; T11: P_{100}]. *(The vertical bars represent $LSD_{0.05}$ values).*

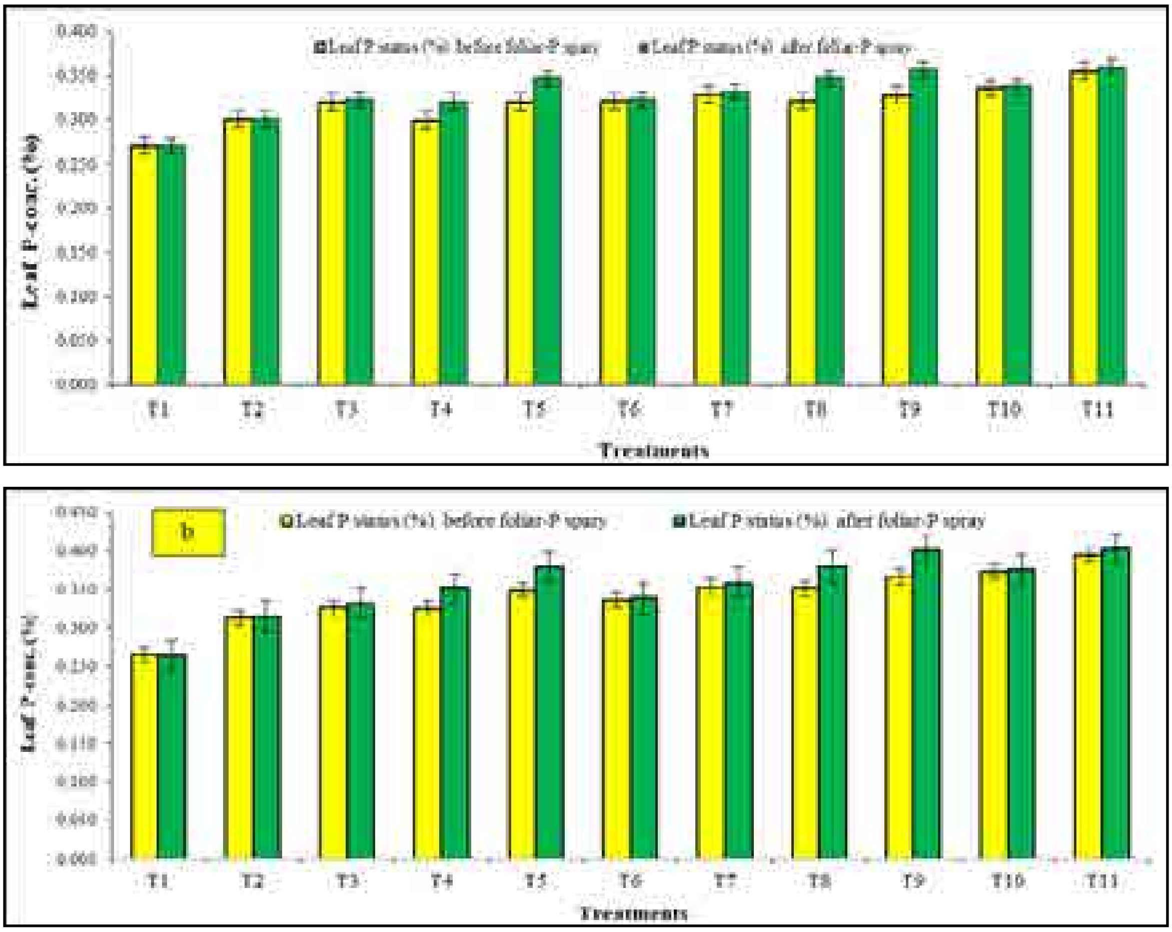


Fig .11a and **11b:** Effect of P application practices on leaf P-concentration before and after foliar-P spray at (a) vegetative stage (VS), and (b) tuberization stage (TS) at Shimla

[T1: P_0; T2: P_{20}; T3: P_{20} + PSB + AMF; T4: P_{20} + 2 foliar sprays of P through 2% MAP (2 FSP); T5: P_{20}+ PSB + AMF + 2 FSP; T6: P_{40}; T7: P_{40}+ PSB + AMF; T8: P_{40}+ 2 FSP; T9: P_{40}+ PSB + AMF + 2 FSP; T10: P_{80}; T11: P_{100}].

P-content in potato leaves has also shown marked variations among different treatments (Fig. 11a and 11b). Among P-fertilization practices, the P_{100} had highest P-content at VS (0.355; 0.359 %) and TS (0.396; 0.402%) before and after foliar-P spray, respectively; which was followed by P_{40}+PSB+AMF+2FSP for leaf-P content after foliar-P spray at VS (0.357%) and TS (0.401%), though it remained at par with P_{100}. Likewise, application of P_{20} + PSB + AMF, P_{20}+2FSP; and P_{20}+PSB+AMF+2 FSP led to ~2.3, 2.3 and 7.7% higher TSS over sole use of P_{20}; while P_{40} + PSB + AMF, P_{40}+2 FSP; and P_{40}+PSB+AMF+2 FSP led to 2.3, 5.4 and 7.8% higher TSS over sole use of P_{40}. Sole use of P_{80} and P_{100} had non-significant but TSS content over P_{40}+PSB+AMF+2 FSP. The starch content also followed the similar trend to that of TSS **(Fig. 12).** Integrated P-use through soil applied-P, foliar-P and microbial inoculants like PSB + AMF can be a low-cost crop management technology under low soil applied-P in the acid alfisols.

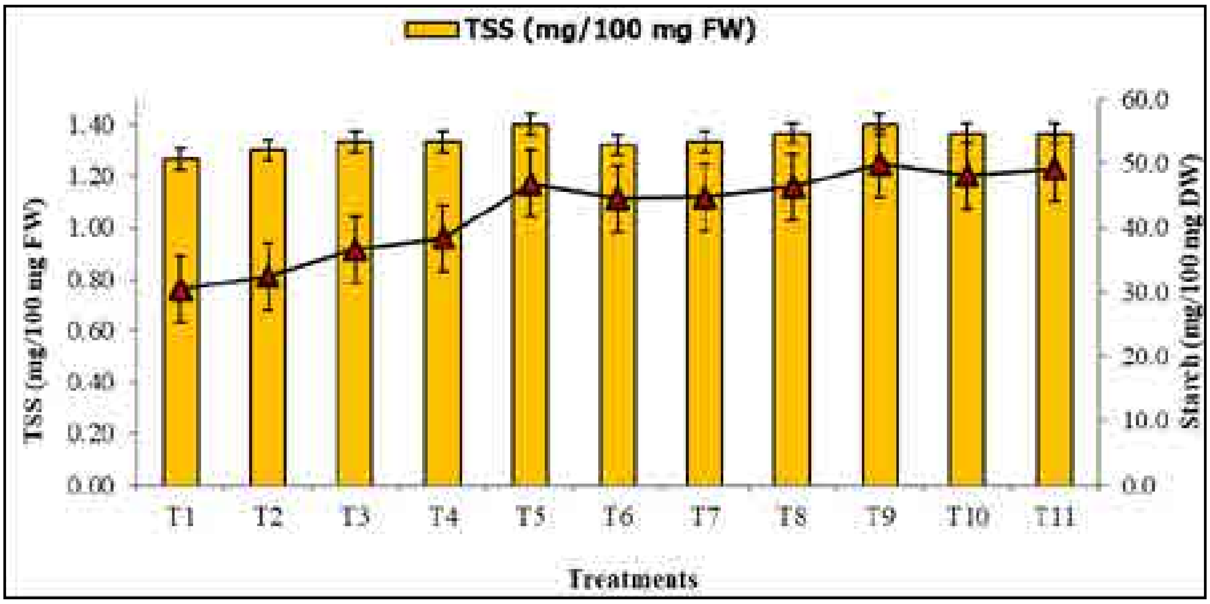


Fig. 12: Effect of P-fertilization practices on TSS and starch content in potato tubers at Shimla

[T1: P_0; T2: P_{20}; T3: P_{20} + PSB + AMF; T4: P_{20} + 2 foliar sprays of P through 2% MAP (2 FSP); T5: P_{20}+ PSB + AMF + 2 FSP; T6: P_{40}; T7: P_{40}+ PSB + AMF; T8: P_{40}+ 2 FSP; T9: P_{40}+ PSB + AMF + 2 FSP; T10: P_{80}; T11: P_{100}).

Effect of P-fertilization practices on growth, yield and quality of potato crop under Low P soils in north- eastern Himalayas: A preliminary field experiment was conducted in the summer seasons of 2023 at Shillong to study the effect of soil and foliage-applied P on growth, yield, and quality of potato cv. Kufri Girdhari under rainfed conditions. Phosphorous was added to soil at the rate of 20, 40, 80 and 100% of the recommended dose combined with or without biofertilizers (PSB and AMF), and two foliar P applications (2% mono ammonium phosphate) at vegetative stage (VS) and tuberization stage (TS). There was noticeable increase in yield with combined use of P applied as SSP (20 and 40% of the recommended dose) + PSB (Pusa microphos) + AMF (Pusa mycorrhiza) + two foliar P applications compared to 20 and 40% of the recommended P alone. The effect of foliar P sprays without bio-fertilizers was insignificant. The study shall be repeated in coming crop seasons to verify the findings.

Isolation and characterization of Phosphorus Solubilizing Bacteria (PSB): Potential PSBs were isolated from various sources, including rhizosphere soil, compost, and plant roots. Individual bacterial colonies were screened for their ability to solubilize phosphate from rock phosphate and 15 isolates were selected for further characterization using morphological characteristics, and biochemical and molecular tests **(Table 5)**.

Table 5. Identification of isolated PSB

S.No.	Isolates	Microbes	Similarity (%)
1.	*PSB10*	*Serratia marcescens*	99
2.	*PSB 35*	*Serratia spp.*	98.4
3.	*PSB 26*	*Bacillus thuringiensis*	99.90
4.	*PSB 31*	*Bacillus magaterium*	100
5.	*PSB 47*	*Bacillus toyonensis*	99.70
6.	*PSB 43*	*Bacillus wiedmannii*	98.0%
7.	*PSB 16*	*Serratia sp.*	99.8
8.	*PSB 1*	*Bacillus cereus*	100
9.	*PSB 3*	*Priestia aryabhattai*	99.5
10.	*PSB 5*	*Bacillus mycoides*	100
11.	*PSB 53*	*Serratia marcescens*	100
12.	*PSB 50*	*Serratia marcescens*	99.4
13.	*PSB 28*	*Bacillus sp.*	100
14.	*PSB 13*	*Lysinibacillus fusiformis*	97
15.	*PSB 22*	*Serratia marcescens*	98

Soil management for improving nutrient availability in low pH soil

Effect of spent mushroom substrate (SMS) on yield of potato in north- eastern hills: This study was conducted to evaluate the effect of SMS on growth and yield of potato in acidic soil of Meghalaya. Naturally composted SMS of three and six months were compared with FYM and recommended inorganic fertilizer doses along with the control. Results revealed that SMS amendment in soil significantly improved the growth parameters *viz.*, plant height, number of shoots and number of leaves per plant as well as the yield attributes. Total and marketable tuber yield of potato (**Fig. 13**) was significantly higher in six month old naturally weathered SMS when applied @ 20 t ha^{-1}+ RDF (26.6 and 22.8 t ha^{-1}) than FYM applied @ 15 t ha^{-1}+ RDF (22.3 and 17.2 t ha^{-1}) and control (5.0 and 2.8 t ha^{-1}).

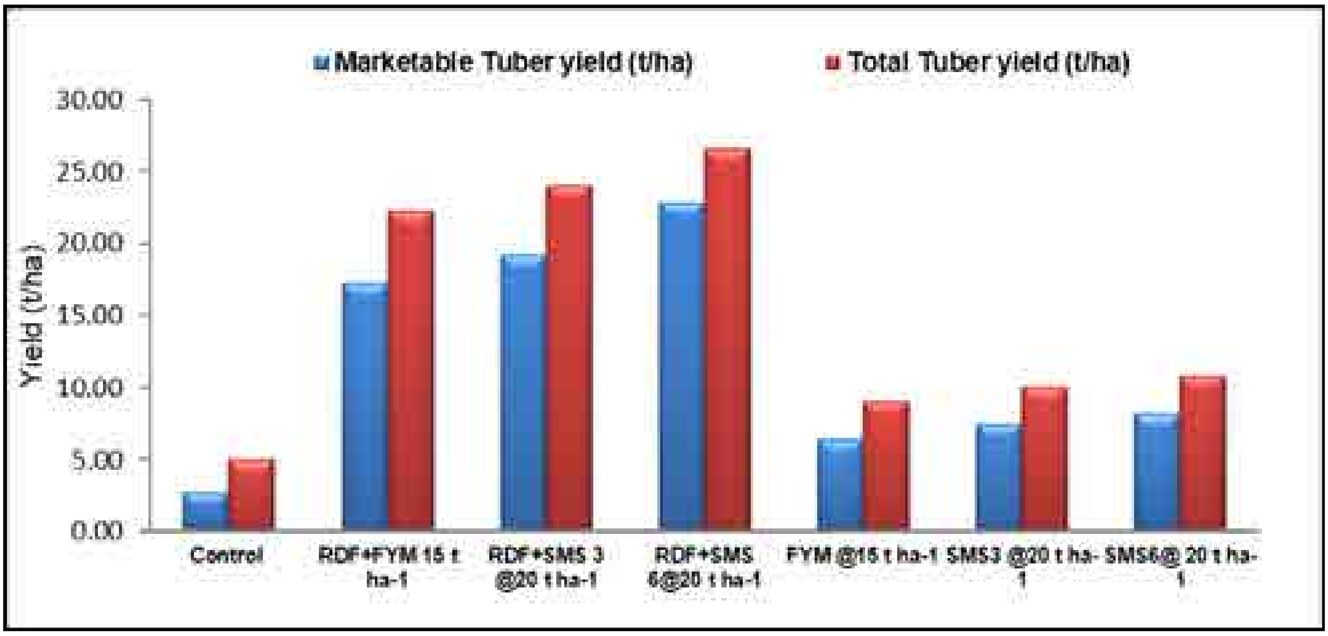


Fig.13: Effect of SMS on potato productivity in Meghalaya

Effect of spent mushroom substrate (SMS) on yield of potato in southern hills: An experiment was conducted during the spring season at Ooty utilizing three months withered SMS further enriched with 2% rock phosphate to evaluate its effect on growth and yield attributes of potato cv. Kufri Swarna. Five treatments consisted, T_1: Control, T_2: Recommended dose of fertilizer (90:135:90 kg NPK ha^{-1}) + farm yard manure (15 t ha^{-1}), T_3: RDF + SMS (20 t ha^{-1}), T_4: FYM alone (15 t ha^{-1}), T_5: SMS alone (20 t ha^{-1}). Nutrient content of enriched SMS contained, 1.2%N, 2.3% P and 1.4% K on dry weigh basis. The results were significant and highest total 34.8 t/ha) as well as marketable tuber yield was recorded in treatment T_2 (and 31.6 t ha^{-1}) followed by the treatment T_3 (total yield 33.8 marketable yield t ha^{-1}), while the lowest tuber yield was recorded in the control (**Fig. 14**).

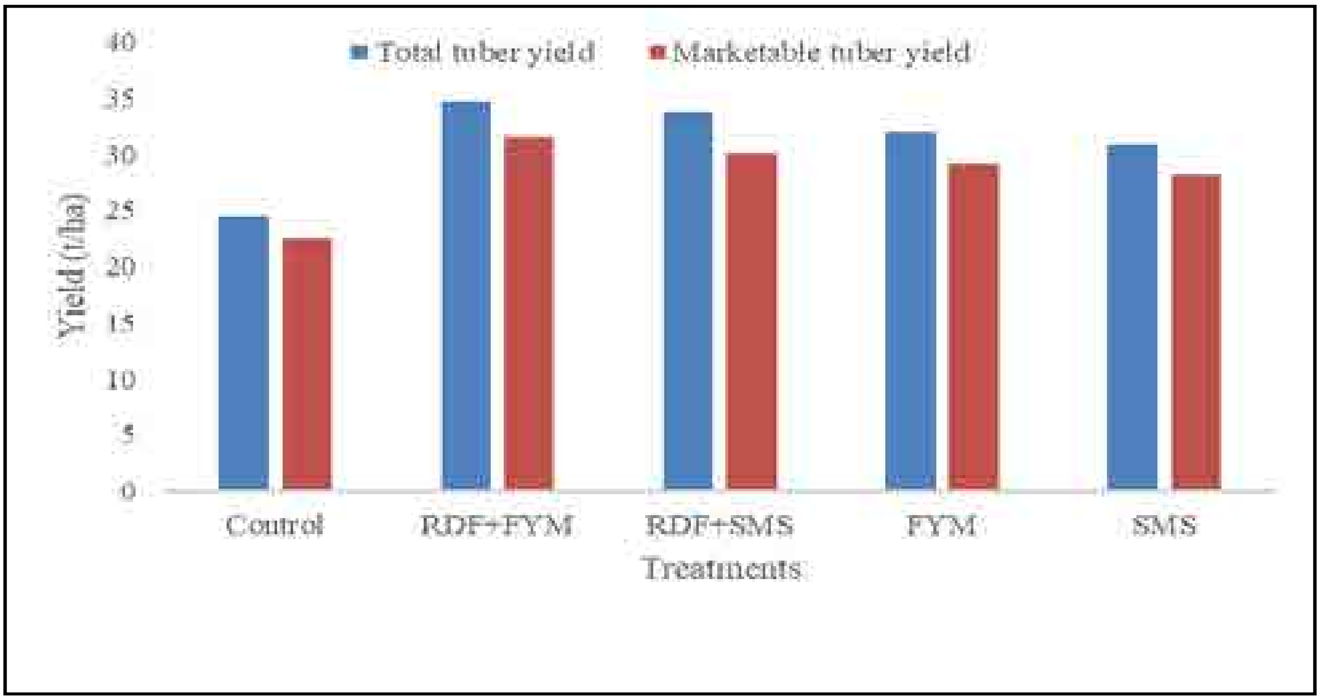


Fig. 14: Effect of SMS on potato productivity in southern hills at Ooty

PROGRAMME: TECHNOLOGY DEVELOPMENT AND REFINEMENT FOR POTATO AND POTATO BASED CROPPING SYSTEMS

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

(PI: Pooja Mankar; Co-PI: Sanjay Rawal, Sanjeev Sharma, SK Luthra, VK Gupta, Devendra Kumar, Mehi Lal, Subhash S)

Field screening of advanced clones at Modipuram for export potential: Thirty four advanced hybrids and check varieties were evaluated for export parameters i.e. shape (oblong and round), size (>55 mm), tuber dry matter content (>18%), skin colour, shine and texture *etc*. Clone HT/12-751, MS/13-391, HT/12-830, MP/14-505, MS/14-243, MS/15-1001, MS/14-1381 were found promising during the third year of evaluation (**Fig. 1**). Among all, twenty advanced clones and check were selected during 2022-23 and planted in the field for further screening at Modipuram during 2023-24.

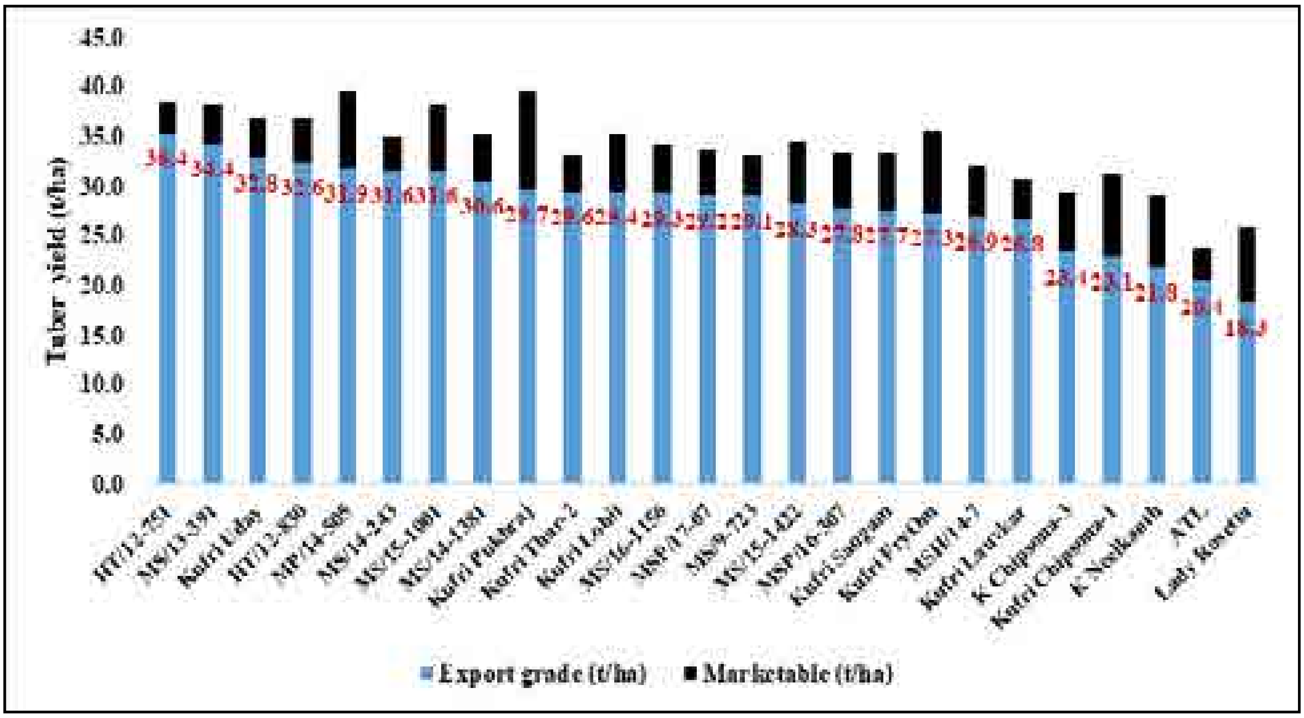


Fig.1: Yield performance of advanced potato clones at Modipuram

Developing production technology for certified organic seed potatoes

(PI: SP Singh, Co-PI: S Katare, M Sadawarti)

Organic seed potato production: Organic seed production includes growing of seed crop by a set of guidelines that prohibit the use of synthetic products or chemicals. During organic seed production soil fertility and pest management is achieved through cropping patterns, organic manure, bio-fertilizers, cultural practices and bio-pesticides including plant derived products. A field experiment was conducted at Gwalior using six nutrient treatments [F0-Control; F1-100% FYM + *Neem* cake (2.5 t ha^{-1}) + vermi-wash; F2-200% FYM + *Neem* cake (2.5 t ha^{-1}) + vermi-wash; F3-100% FYM + *Mahua* cake (2.5 t ha^{-1}) + bio-fertilizers; F4-200% FYM + *Mahua* cake (2.5 t ha^{-1}) + bio-fertilizer; F5- RDF NPK)] and two varieties i.e. Kufri Chipsona-1 and Kufri Chandramukhi (**Fig. 2- 5**). Highest seed size tuber numbers were recorded in Kufri Chipsona-1 (3,07 ,000 ha-[1]) followed by Kufri Chandramukhi (275 000 ha-[1]), while total tuber numbers and seed size tuber yield were statistically on par in both the varieties. Application of , 200% FYM + *Mahua* cake + bio-fertilizer produced maximum seed size tubers (3,03, 000 ha-[1]) , which were comparable to recommended NPK doses (298 000 ha-[1]). Similar trend was observed in total tuber numbers. Seed size tuber yield (12.0 t ha-[1]) of 200% FYM + *Mahua* cake + bio-fertilizer treatment was statistically at par with 100% RDF treatment (14.2 t ha-[1]).

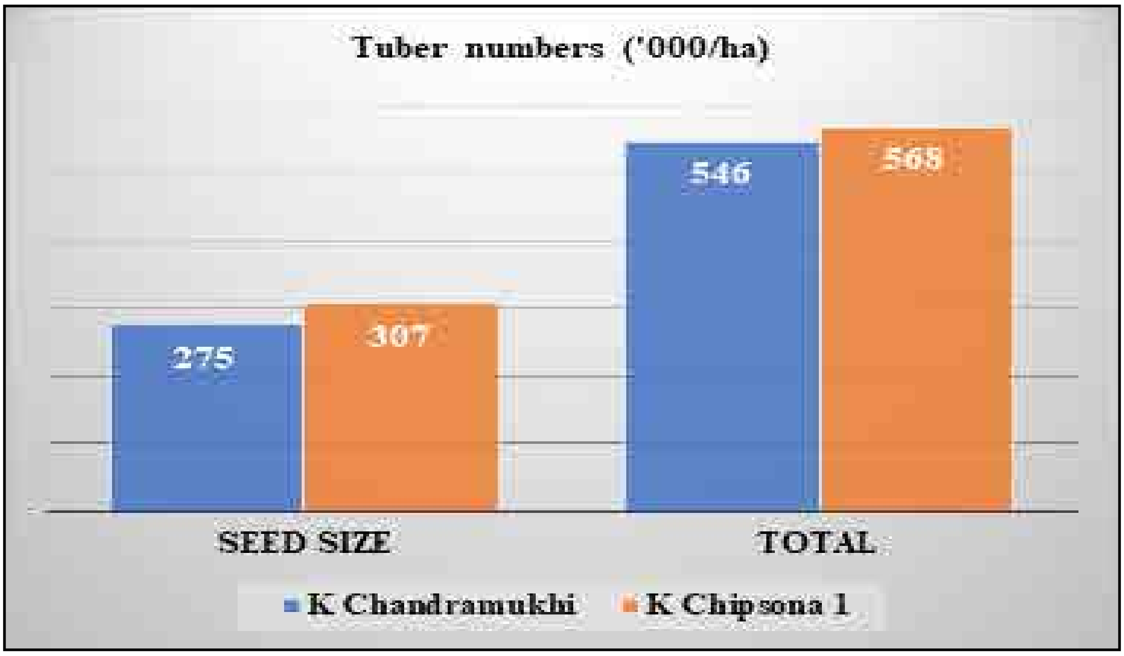


Fig.2: Graded and total tubers in potato varieties

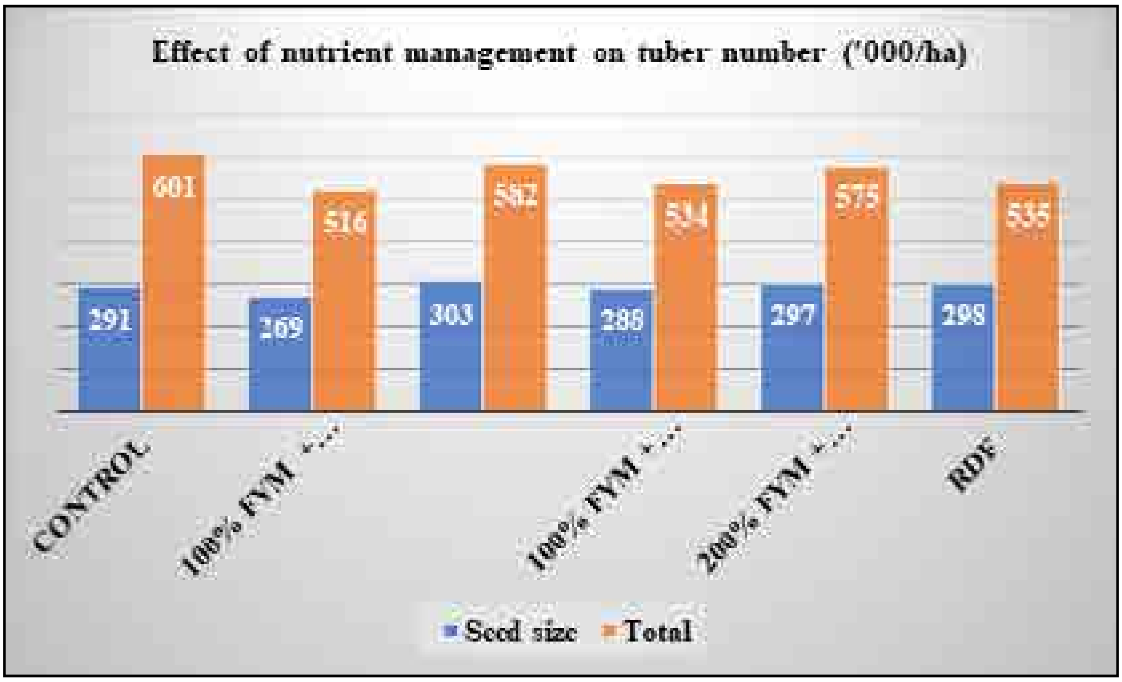


Fig.3: Graded and total tubers in different nutrient combinations

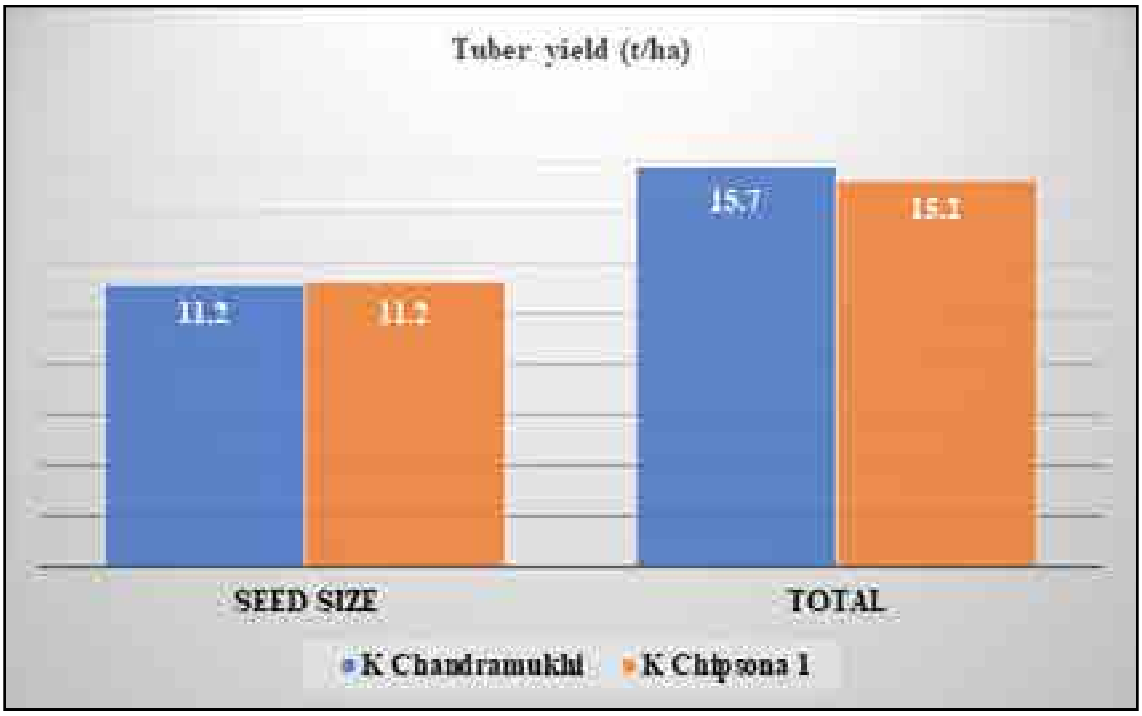


Fig.4: Graded and total tuber yield in potato varieties

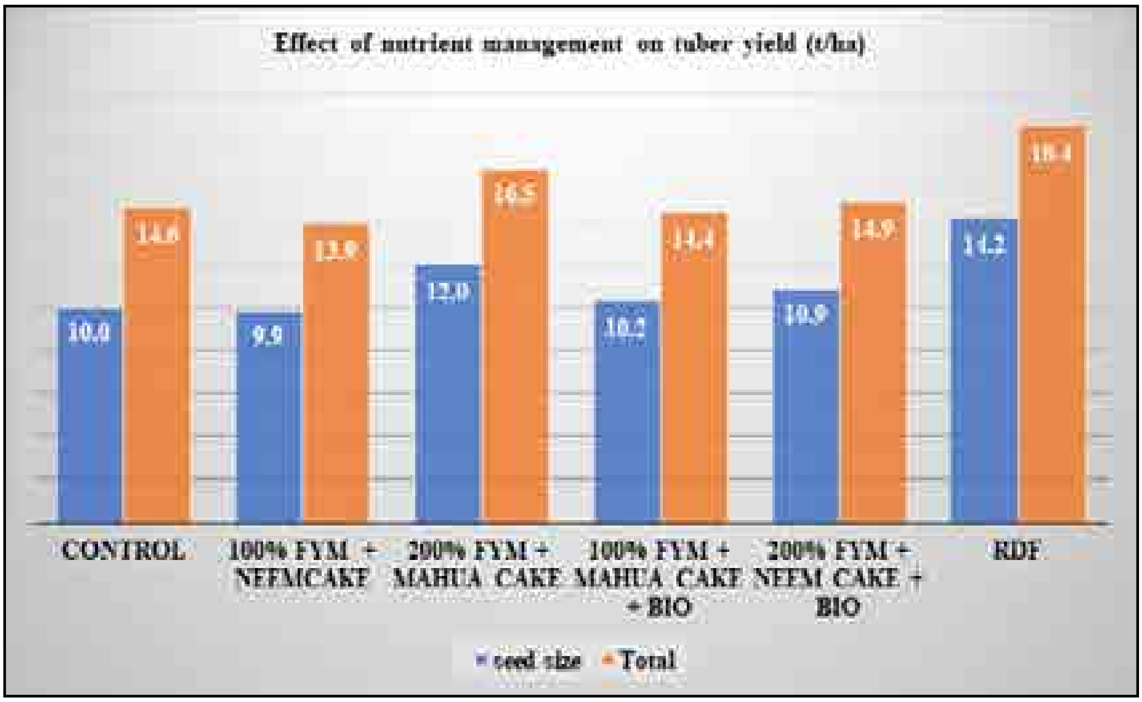


Fig.5: Graded and total tuber yield in different nutrient combinations

Refining system based organic potato production technologies

(PI: Janani P; Co-PI: SK Luthra, VK Gupta, Clarissa Challam, N Sailo, S Rawal, Anil K. Choudhary, Pooja Mankar, SP Singh, M Sadawarti)

Germplasm evaluation: Promising 34 advanced clones/hybrids were evaluated during 2022-23 under organic production systems at Modipuram. Selections were made for their earliness, yield performance, resistance to diseases and pest, appearance of tubers, dry matter content etc. The promising advance clones recorded during the crop season were MS/13-391, MS/15-1001, MSP/17-07, MCIP/11-185, HT/12-830, MS/15-1422, MS/14-243, MS/14-1381 under organic production system (**Fig. 6**). Fourteen advance clones including checks were selected during 2022-23 and planted in the field for further evaluation at Modipuram during 2023-24.

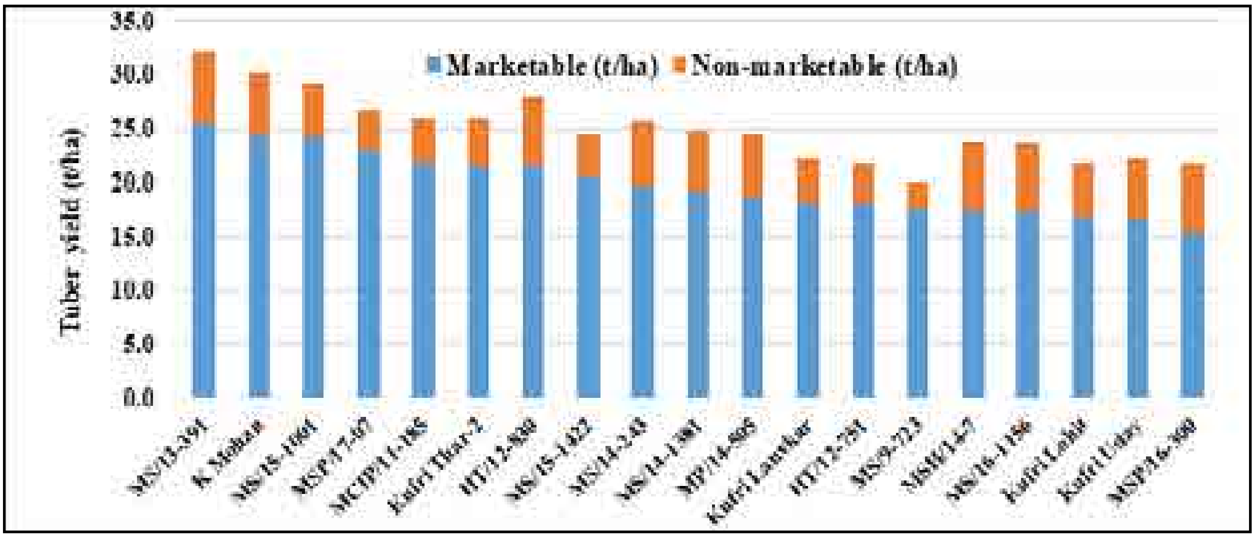


Fig.6: Yield performance of advanced clones under organic production system at Modipuram

Influence of long-term natural farming vs. conventional farming practices on tuber productivity and soil health in wet-temperate north-western Himalayas: A field experiment has been conducted for three years during *Kharif* 2021- 2023 at Shimla to study the impact of organic and integrated crop management (ICM) practices on potato productivity and profitability in comparison to conventional farming (CF). Treatment were: T_1: FYM @ 25 t/ha (100% FYM); T_2: Vermicompost, VC @10 t/ha (100% VC); T_3: FYM @ 12.5 t/ha + VC @ 5 t/ha (50% FYM+50%VC); T_4: FYM @ 9.375 t/ha + VC @ 3.75 t/ha + Microbial consortia, MC (37.5% FYM+37.5%VC+MC); T_5: 50% NPK + FYM @ 12.5 t/ha(50% NPK + 50% FYM); T_6: 50% NPK + VC @ 5 t/ha (50% NPK + 50% VC); T_7: 50% NPK + FYM @ 6.25 t/ha + VC @ 2.5 t/ha (50% NPK + 25% FYM + 25%VC); T_8: 50% NPK + FYM @ 3.125 t/ha + VC @ 1.25 t/ha +MC (50% NPK + 12.5% FYM + 12.5% VC + MC); T_9: 100% NPK @ 150:100:100 kg NPK/ha (100% NPK); T_{10}: Absolute control. The microbial consortia comprised of IARI NPK-biofertilizer liquid formulation along with AM-fungi (*Glomus spp*.).The results revealed that application of 100% RDF (T_9) led to highest tuber yield (17.5 t ha^{-1}) which remained at par with ICM treatments T_5-T_8 (**Table 1**). Among organic treatments, T_2 led to comparatively higher tuber yield (14.7 t ha^{-1}) remaining at par with T_1- T_4 and absolute control yielded lowest (9.12 t ha^{-1}). On an average, the conventional (T_9) and ICM practices (T_5- T_8) had ~23.6 and 18% higher yield over the organic practices (T_1- T_4). Cost of cultivation was highest under organic cultivation followed by ICM practices and conventional practice, respectively (**Table 1**). Gross (Rs. 2,28,050 ha^{-1}), net returns (Rs. 1,32,290 ha^{-1}) and B: C ratio (2.38) were higher under chemical nutrition practice (T_9) i.e., followed by ICM (T_5-T_8), and organic nutrition (T_1- T_4). Three years' study concluded that conventional practice of 100% RDF led to significantly higher potato tuber yield (17.53 t/ha), net returns (Rs. 1,32,290/ ha) and B: C ratio (2.38) which remained at par with ICM practices. Organic practices incurred higher cost of cultivation, lesser tuber yield and net returns.

Table 1. Potato productivity and economics of cultivation under organic, integrated and conventional farming system in north-western Himalayas (Pooled mean of three years)

T. No.	Treatments	Potato tuber yield (t/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B: C ratio
T_1	FYM @ 25 t/ha	$13.40^b \pm 0.31$	106295	174573	68278	1.64
T_2	VC @10 t/ha	$14.65^b \pm 0.30$	103245	190720	87475	1.85
T_3	FYM @ 12.5 t/ha + VC @ 5 t/ha	$14.53^b \pm 0.26$	105120	189203	84083	1.80
T_4	FYM @ 9.375 t/ha + VC @ 3.75 t/ha + MC	$14.15^b \pm 0.30$	102095	184183	82088	1.80
T_5	50% NPK+FYM @ 12.5 t/ha	$16.53^c \pm 0.26$	99602	215147	115545	2.16
T_6	50% NPK + VC @ 5 t/ha	$17.10^c \pm 0.30$	98077	222590	124513	2.27
T_7	50% NPK + FYM @ 6.25 t/ha + VC @ 2.5 t/ha	$17.05^c \pm 0.24$	98752	221907	123155	2.25
T_8	50% NPK + FYM @ 3.125 t/ha + VC @ 1.25 t/ha+MC	$16.69^c \pm 0.28$	95902	217253	121351	2.27
T_9	100% NPK	$17.53^c \pm 0.18$	95760	228050	132290	2.38
T_{10}	Absolute control	$9.11^a \pm 0.31$	81695	117987	36292	1.44

Developing organic nutrition levels for potato crop in north- eastern Himalayas: Field study continued at Shillong Eight treatment combinations viz. control (0), 100% NPK through inorganic fertilizers+ FYM, 100% N through farmyard manure (FYM), 100% N through pig manure (PiM), 100% N through poultry manure (PM), 50% N through farmyard manure (FYM)+ 50% N through vermi-compost (VC), 50% N through pig manure (PiM))+ 50% N through vermi-compost (VC), 50% N through poultry manure (PoM))+ 50% N through vermi-compost (VC). FYM, pig manure, poultry manure and vermi-compost were applied at the rate of 30 t ha^{-1}, 17 t ha^{-1}, 12.5 t ha^{-1} and 10 t ha^{-1}, respectively for supplying 100% RDN (140 kg N ha^{-1}) to potato cv. Kufri Himalini. Significant variations were observed due amongst treatments and highest tuber yield (21.3 t ha^{-1}) was obtained with 100% NPK + FYM followed by 100 % N through poultry manure (17.3 ha^{-1}), 100% N through pig manure (16.0 ha^{-1}) and the lowest yield (4.5 ha^{-1}) was in control (**Fig.7**).

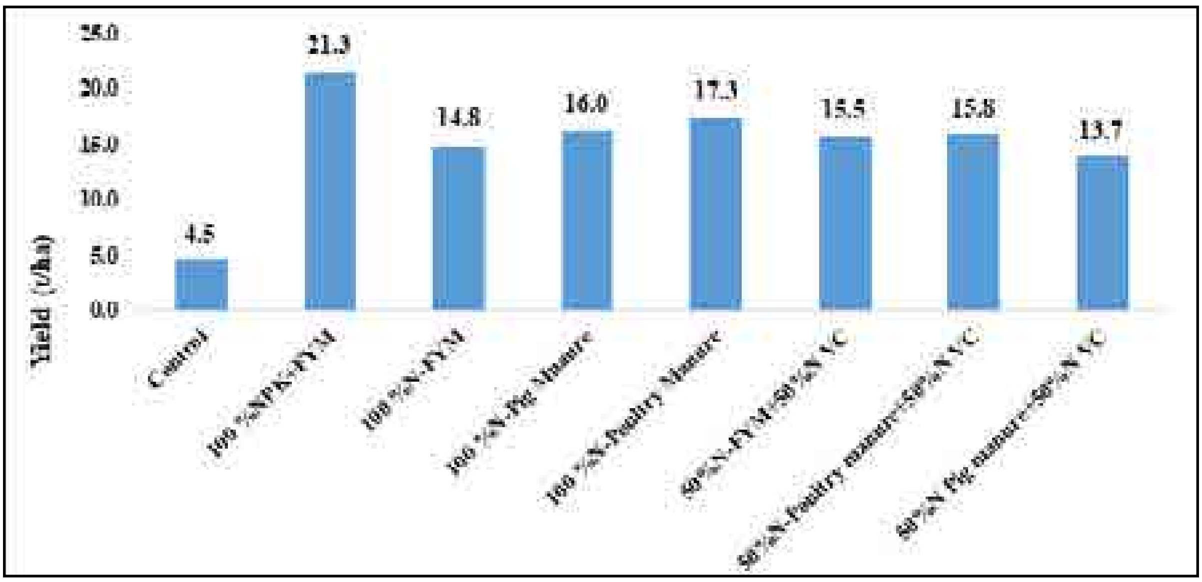


Fig.7: Effect of organic sources on tuber yield (t ha^{-1})

Refining organic potato protection technologies for sustainable yields

(PI: Mehi Lal; Co-PI: Anuj Bhatnagar, Sanjeev Sharma, Vinay Sagar, S Katare, Subhash S, P Janani)

Organic management of late blight of potato: Late blight disease of potato requires more attention in organic potato production. Copper-based products (restricted fungicides), *Neem* oil and *Neem*-based products, cow urine, and FYM were tested at Modipuram for their efficacy in a schedule-based spraying. Eleven treatments consisting of different product combinations were evaluated for disease incidence by applying four sprays during *Rabi* season of 22-23 on cvs. Kufri Bahar (susceptible) and Kufri Mohan (moderately resistant). All treatments recorded less disease severity in comparison to control. Mean lowest disease severity (24.56%) was recorded in treatment T4 (*Neem* oil @ 4.0%,copper hydroxide @ 0.3%-*Neem* oil @ 4.0%,copper hydroxide @ 0.3%) followed by T3 (*Neem* oil @ 4.0%-Copper oxychloride @ 0.25%-*Neem* oil @ 4.0%,copper oxychloride @ 0.25%), and T5 (fermented *Neem* kernel @ 2%-Copper hydroxide @ 0.3%- Fermented *Neem* kernel @ 2%- Copper hydroxide @ 0.3%) which recorded disease severity of 31.55% and 31.66%, respectively as compared to the control (75.56%) on cv. Kufri Mohan (**Fig. 8**). Treatments T3, T5, and T2 were on par with each other. These same treatments were also effective in cv. Kufri Bahar, but recorded higher disease severity. The results revealed that late blight disease of potato could be managed to a certain extent using a moderately resistant variety along with evaluated spraying schedules.

Organic managemnt of black scurf of potato: This is an important disease under the category of fungal soil and tuber-borne diseases. A study consisting 15 treatments of *Neem* kernel, cow urine, Jeevamrit, rotted buttermilk, waste decomposer, copper oxychloride, and standard check Pencycuron 22.9% SC was carried out at Modipuram for management of black scurf of potato during *Rabi season* of 2022-23 in cv. Kufri Bahar. All treatments reduced disease incidence and severity in comparison to control. Treatment consisting of *Neem* kernel @ 20 g/l (pure crushed powder) recorded the lowest disease incidence (26.33%) and severity (11.49%) followed by Jeevamrit @ 200 ml/l having disease incidence (31.82%) and severity (14.45%), cow urine @ pure (100%) dip treatment with disease incidence (36.95%) and severity (19.60%), and cow urine (1:10 ratio) dip treatment with disease incidence (37.03%) and severity (17.34%). Treatment consisting of waste decomposer+ *Neem* kernel @ 100 ml/l also recorded less disease in comparison to control (82.73% disease incidence and 39.70% disease severity)

Evaluation of bio-pesticides against whiteflies in potato crop: The experiment continued at Modipuram to assess the efficacy of various bio-pesticides in controlling whitefly populations on seed potatoes. Seven spray treatments: T1- *Neem* soap (7g/l), T2- Pongamia soap (7g/l), T3- Neemazal (3ml/l), T4- Neemastra (200l/acre), T5- *Beauveria bassiana* (@ 10g/l), T6- Imidacloprid 17.8 SL (0.4 ml/l), and T7- Control (no spray) were evaluated at 35 days after planting (DAP). Whitefly populations were monitored on ten randomly selected plants per replication one day before treatment (pre-count) and at 1, 3, 5, and 7 days after treatment (DAT). At 1 DAT, the *Neem* soap treatment exhibited a 39.08% reduction in whitefly populations as compared to the control, followed by Neemastra (32.40), *B. bassiana* (22.82) and Pongamia soap (22.75). The standard check Imidacloprid17.8 SL spray showed a reduction of 42.10%, while Neemazal had only a 3.25% reduction. At 3 DAT, Pongamia soap treatment resulted in the highest reduction of 67.19% over the control, followed by *Neem* soap (41.99) and Neemastra (31.24), while Imidacloprid showed a reduction of 42.58%. *B. bassiana* (17.49%) and Neemazal (8.32%) exhibited lower efficacy. After 5 DAT, *Neem* soap and Pongamia soap treatments had the highest population reduction of 86.32 and 81.53%, respectively among bio-pesticides. Neemastra achieved 73.01% reduction and Imidacloprid had 89.33%. Neemazal and *B. bassiana* again recorded lower reduction of 49.80 and 13.90%, respectively. However, at 7 DAT, the percentage reduction gradually decreased as compared to 5 DAT. Molecule Imidacloprid exhibited a population reduction of 60.76%, while *Neem* soap had 50.41% reduction. Rest of the treatments attained reduction of less than 35% (**Fig. 8**). Based on the results, *Neem* soap and Pongamia soap performed markedly better and were comparable to the standard molecule Imidacloprid until 5 DAT. These bio-pesticides can be considered as effective alternatives to synthetic insecticides for management of whitefly populations in organic seed potato production. Furthermore, they can be integrated into pest management strategies for sustainable seed potato cultivation.

Top of Form

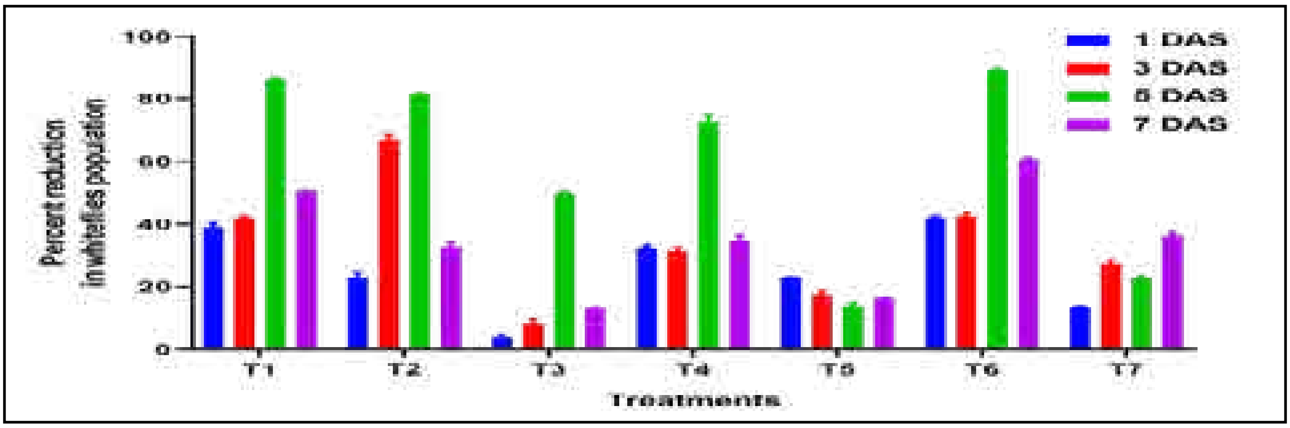


Fig. 8: Per cent reduction in whiteflies population in different treatments 1, 3, 5 and 7 days after spray

Evaluation of bio-pesticides for eco-friendly management of sucking pests in potato crop: A field experiment was conducted at Gwalior during *Rabi* season of 2021-22 on integrated management of sucking pests in potato cv. K Chandramukhi in RBD consisting eight treatments *viz*., T1- Azadirachtin 1500 ppm @ 5.0 ml/l, T2- *Verticillium lecanni* (2 x 10^8 c.f.u @3 g/l), T3- *Beaveria bassiana* (2 x 10^8c .f.u @5 g/l), T4-*Metarhizium anisopliae* @3 g/l, T5- Thiomethoxam 5% WG @0.5 g/l, T6- Farmer's practice (Imidacloprid 17.8 SL @0.5mlg/l) and T7- Untreated control, and three replications. Second year results showed that all the treatments were effective in controlling whitefly and thrips population 3 and 7 days after treatment (DAT) except T1-Azadirachtin 1500 ppm and T2- *Verticillium lecanni*. Treatment *Metarhizium anisopliae* @3g/l, was found most effective against whitefly and thrips population with reduction of 56.34 and 60.82%, respectively, over the control. This treatment also recorded higher tuber yield in comparison to control. Apart from bio-pesticides, Thiomethoxam 5% WG @0.5 g/l and Immidacloprid 17.8 SL @0.5mlg/l were also quite effective as standard check (**Fig. 9 & 10**).

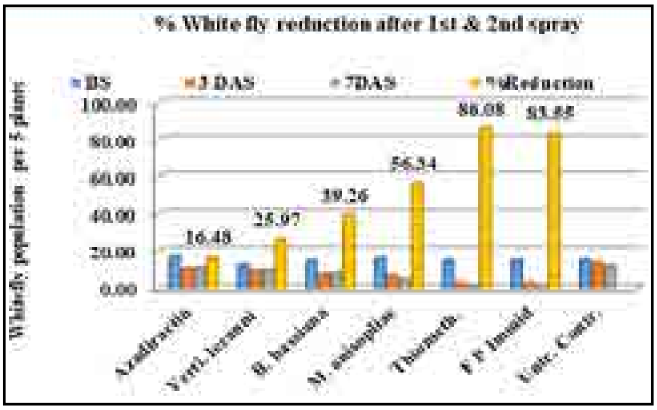


Fig. 9: Efficacy of bio-pesticides against white fly in potato crop

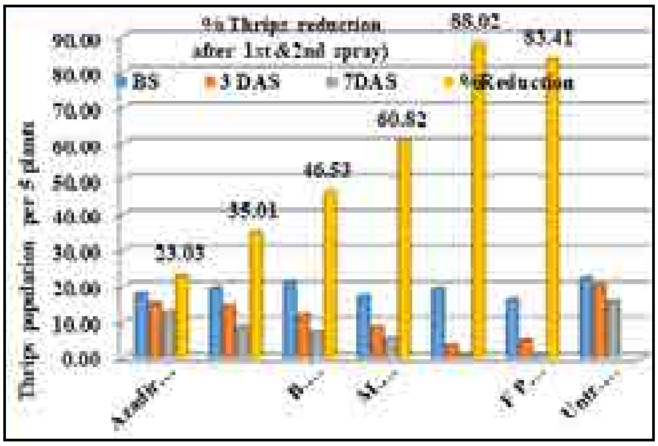


Fig. 10: Efficacy of bio-pesticides against thrips in potato crop

Development of potato based cropping systems for different agro-ecologies

(PI: SP Singh, Co-PI: VK Dua, Sanjay Rawal, Anil Sharma, Anil K Choudhary, RK Singh, Pooja Mankar, Janani P, Dharmendra Kumar, Kailash Chandra Naga, Bapidas, Yogesh Gautam)

Rice- potato- green manure (*Sesbania* species) crop sequence under natural farming crop production at Gwalior: During third year of a field study consisting four fertility levels (F1- 100% RDF of NPK; F2- Crop residue @ 25 t ha^{-1}+ *Azotobacter* @1.25 l ha^{-1}+ PSB + Jeevamrut @ 500 l ha^{-1}; F3- FYM @ 25 t ha^{-1}+ Jeevamrut @ 500 l $ha^{-1}$and F4- Control) and t mulch (no mulch and paddy straw mulch @ 5 t ha^{-1}) continued in third year significantly higher tuber yield was attained with paddy straw mulch (22.1 t ha^{-1}) compared to no mulch (19.9). Highest tuber yield (23.8 t ha^{-1}) was recorded under in treatment involving application of crop residues. Highest net return (2,67,000 ha^{-1}) was observed with paddy straw mulching when compared to no mulch (2,40,000 ha^{-1}). Highest net return (2,94,000 ha^{-1}) was harnessed with FYM @ 25 t ha^{-1} + Jeevamrut @ 500 l ha^{-1} over the other fertility treatments. Nutrient management practices significantly influenced the organic carbon content of soil. Organic carbon content varied in different treatments 0.23% in control to 0.39% in treatment invoving FYM after three crop cycles (**Fig. 11 & 12**).

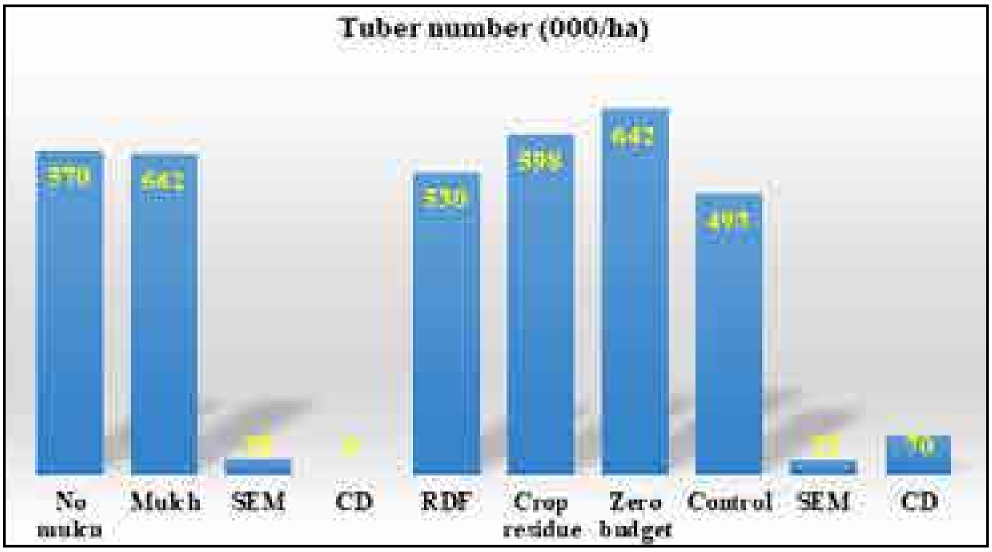


Fig. 11: Influence of nutritional sources and mulching on tuber number

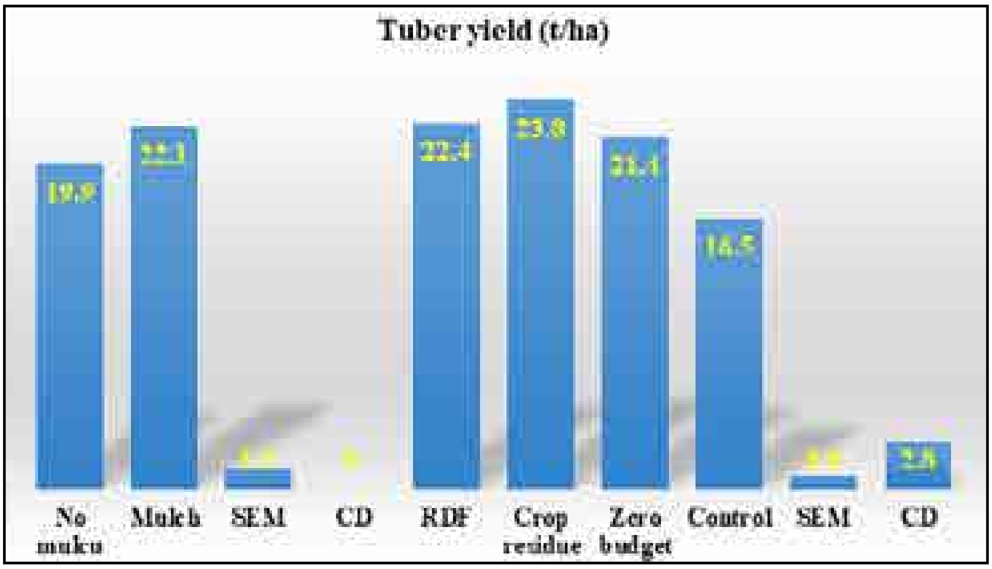


Fig. 12: Influence of nutritional sources and mulching on tuber productivity

Evaluation of diversified potato based cropping systems under integrated nutrient management in wet-temperate north-western Himalayas: A field study has been carried for three crop cycles during 2020-2023 at Shimla having four potato based cropping systems i.e. CS_1: potato-peas cropping system (PPCS); CS_2: potato-broccoli cropping system (PBCS); CS_3: Potato-garlic cropping system (PGCS); CS_4: potato-Matricaria cropping system (PMCS), and four integrated nutrient management (INM) schedules on system basis *viz.*, INM_1: 100% NPK both in Crop-I & II; INM_2: 75% NPK+ FYM @ 10 t/ha in Crop-I, and 75% NPK+ 25% NPK through FYM in Crop-II; INM_3: 75% NPK+ FYM @ 10 t/ha+ PSB+ AM-fungi (AMF) in Crop-I, and 50% NPK+ 50% NPK through FYM in Crop-II; INM_4: 100% NPK+ FYM @ 10 t/ha+ PSB+ AMF, and 75% NPK in Crop-II (**Photo. 1**) were evaluated during for the third crop cycle at Shimla during 2023. Balance P requirement after adding the required FYM in Crop-II was met through rock phosphate. The experiment was laid-out in split-plot design and replicated thrice. The bio-inoculant used were AM-fungi @ 12.5 kg/ha (*Glomus mosseae*) and PSB @ 500 g/ha (*Pseudomonas striata* & *Bacilluspolymyxa*, *10^8 cfu*).

Photo. 1: A pictorial view of potato based diversified cropping systems at Shimla

The results of final year revealed that total tuber yield of Kufri Himalini (Crop-I) was significantly higher under potato- peas (18.01 t ha^{-1}), which was followed by potato-*Matricaria* (17.75), potato-garlic (17.46), and potato-broccoli cropping system (17.04), respectively. Tuber yield trend was similar to as that of previous two year's findings. Among INM schedules, tuber yield was found to be significantly higher under INM_4 (18.88 t ha^{-1}), which was followed by INM_3 (17.80), INM_2 (16.89) and INM_1 (16.70), respectively. Application of 100% RDF + FYM @ 10 t ha^{-1} + PSB + AM-fungi in potato crop proved markedly beneficial to harness ~13.1, 11.8 and 6.1% higher yield over INM_1 (100% RDF), INM_2 and INM_3, respectively in 3rd crop cycle in all cropping systems. Among *Rabi* crops, INM_2 was best schedule as it exhibited significantly higher crop yields followed by INM_3, INM_4 and INM_1, respectively. Among cropping systems, potato-garlic sequence had highest and significantly better potato equivalent yield (79.27 t ha^{-1}), followed by potato- broccoli (51.19 t ha^{-1}), potato-*Matricaria* (47.50 t ha^{-1}) and potato-pea system (36.26 t ha^{-1}), respectively. Hence, PGCS, PBCS and PMCS exhibited 118, 38.2 and 26.1% higher system productivity, respectively over conventional potato-pea rotation. On overall system basis, INM_2, INM_3 and INM_4 registered ~15.3, 12.0 and 2.4% higher system productivity over conventional 100% RDF (INM_1). Over all, potato-garlic system and INM_2 schedule was best for wet-temperate north-western Himalayas (**Table 2**).

Table 2. Crop and potato equivalent yield (PEY) of system (t ha^{-1})

Treatments			Potato yield (t ha^{-1})	PEY* of Rabi crops (t ha^{-1})	System-PEY (t ha^{-1})	% increase in System-PEY
			Kharif 2022	Rabi 2022-23	2022-23	
Cropping systems						
CS_1	Potato-peas (PPCS)		18.01d	18.25a (10.95)	36.26a	-
CS_2	Potato-broccoli (PBCS)		17.04a	34.15c (13.66)	51.19b	38.2
CS_3	Potato-garlic (PGCS)		17.46b	61.81d (12.36)	79.27c	118.0
CS_4	Potato-*Matricaria* (PMCS)		17.75c	29.75b (1.79)	47.50b	26.1
Cropping system basis INM schedules						
	Crop-I (*Kharif* crop)	Crop-II (*Rabi* crop)				
INM_1	100% NPK @ 150:100:100 kg ha^{-1}	100 % NPK	16.70a	49.25a	49.25a	-
INM_2	75% NPK+ FYM @ 10 t ha^{-1}	75% NPK +25% NPK through FYM	16.89a	57.46c	57.46c	15.3
INM_3	75% NPK + FYM @ 10 t ha^{-1}+ PSB+AMF	50% NPK+50% NPK through FYM	17.80b	56.48c	56.48c	12.0
INM_4	100% NPK + FYM @ 10 t ha^{-1}+ PSB+AMF	75% NPK	18.88c	51.05b	51.05b	2.4

Potato-based intercropping system under rain-fed conditions in Meghalaya: Evaluation of Crop diversification studies involving were leafy green vegetable cropping system were carried out at Shillong to evaluate the system productivity and resource use efficiency. A total of seven potato-based cropping systems *viz.*, potato-cabbage, potato-kale, potato-bokchoy, potato-spinach, potato-leafy mustard and potato-lettuce were evaluated. Potato cultivar Kufri Giriraj was planted during the first week of March and vegetable crops were planted in autumn of 2023. Potato productivity did not differ significantly among different crop sequences.

Development of rapid seed potato production technologies

(PI: Sukhwinder Singh, Co-PI: Sugani Devi, Anil Sharma, Som Dutt, Brajesh Nare, Ratna Preeti Kaur)

Weight loss pattern of aeroponically produced mini-tubers: Aeroponically produced mini-tubers harvested in January of four varieties *viz.*, Kufri Pukhraj, Kufri Himalini, Kufri Khyati and Kufri Chandramukhi and three fresh weight (FW) categories of mini-tubers i.e. T1 (FW: 1-1.5g), T2 (FW: 2-3g) and T3 (FW: 3-5g) were used in this study. After recording fresh weight, mini-tubers were kept under constant artificial lights (18-20°C and 85-95% RH) for one week for greening followed by storage in cold store at 2-4°C and 85-90% RH. Weight loss was recorded separately after greening and after taking out from cold storage (**Fig. 15**). During greening maximum weight loss was recorded as 8.2% in T1, which was significantly higher than T3 (7.0%) and T2 (7.4). Amongst different varieties, maximum weight loss in mini-tubers during greening was in Kufri Chandramukhi (9.0%) and minimum was in Kufri Himalini (5.9%). During cold storage, weight loss was significantly influenced by mini-tubers grade, but differences between varieties were statistically non-significant. Maximum weight loss was recorded with treatment T1 (13.8%) followed by T2 (11.3%) and minimum in T3 (10.9%).

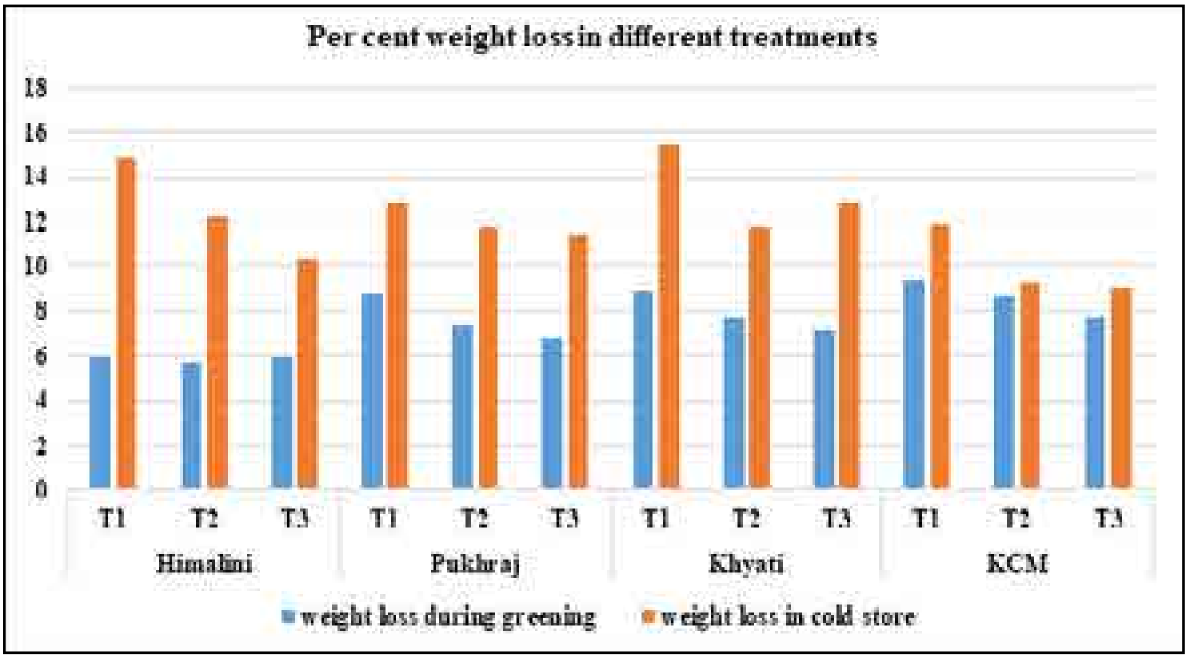


Fig. 15: Weight loss pattern of aeroponically produced mini-tubers

Performance of potato micro-plants at different plant densities in soilless system under insect proof net house: Hardened micro-plants of K Himalini and K Pukhraj were planted in soilless beds i.e. coco-peat based media at three plant densities of 22 plants m^{-2} (D$_1$), 44 plants m^{-2} (D$_2$) and 66 plants m^{-2} (D$_3$) in an insect proof net-house for producing mini-tubers. Average number of mini-tuber recorded was 446 per m^2 in variety Kufri Pukhraj and it was significantly higher than Kufri Himalini (260 tubers per m^2). Highest tuber number per m^2 was obtained with plant density D3 (482.4) followed by D2 (354.4) and D1 (222.4) as depicted in **Fig. 16**.

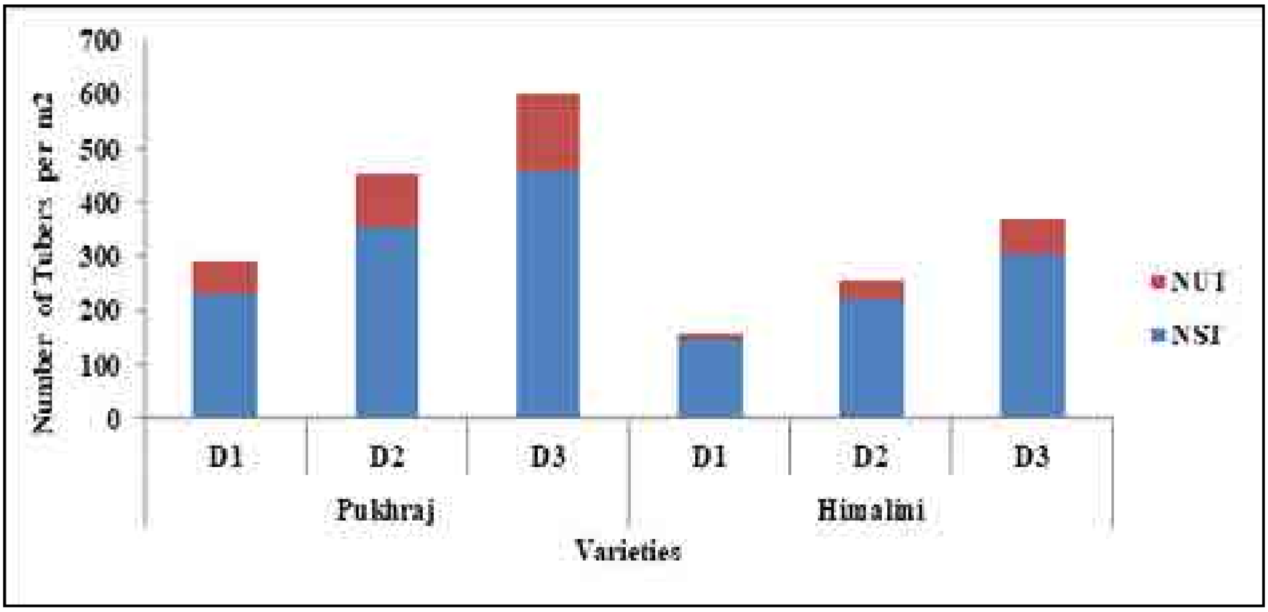


Fig. 16: Total, seed size (NST) and undersize (NUT) tuber number

Engineering technologies for potato production and utilization

(PI: Sukhwinder Singh, Co-PI: Brajesh Nare, Prince Kumar)

Development of potato mini-tuber planter: Area under mini-tuber crop is on the rise annually especially in the states of Punjab and Haryana. \For precise planting of costly mini tubers, a prototype of four row semi-automatic mini-tuber planter has been developed keeping in view the requirement of seed potato growers (**Photograph 2**). It consists of a seed box, seed metering and precise placement mechanism, power transmission system, seating arrangement, ridger and furrow closer. Four person are required to feed the seed material into the metering unit. Initially, mini-tubers are poured in the seed box. Ridger tines make ridges of 15-17 cm height and 66 cm base width. Mini-tubers are than placed manually into cavities present in the metering unit, which is further placed in the furrows at a depth of 5-7 cm through seed delivery tube. After mini-tuber placement, soil covering device covers the placed tubers with 5 cm thick soil cover. The capacity of the system is 1.6-2.0/ ha per day.

Photo. 2: Tractor operated potato mini-tuber planter

Refinement of hand tool for potato mini-tuber planting: Design of pull type marking tool has been optimized for planting of aeroponically produced mini-tubers. In this tool, two wheels are installed with a frame at a distance of 66 cm and 12 pegs of 3.2 cm diameter and 7.5 cm height, which are fixed around periphery of the wheel. A handle is provided to move the tool in standing posture. Tool is operated manually on the formed ridges to make impressions and mini-tubers are than placed into the marked holes of approximately 5 cm depth and covered with soil (**Photograph 3**).

Photo. 3: Hand tool for potato mini-tuber planting

Mechatronics in potato production

(PI: Er. Brajesh Nare, Co-PI: Sukhwinder Singh, Anil Sharma, Ratna Preeti Kaur**)**

Development of unmanned robotic ground vehicle for safe spray application of agrochemicals: The aim of this research project is to develop a remotely controlled unmanned ground vehicle (UGV) for precise and targeted application of agro-chemicals under field crops. This UGV will eliminate the exposure of harmful chemicals to the operator and reduce the environmental degradation by precise and targeted application of agro-chemicals as per the canopy cover and crop requirement. It includes electric powered propelling unit, controlled agro-chemical application systems and remotely operated GPS based auto-navigation and control systems, mounted on a four-wheel drive high clearance robotic vehicle. The design and development of the UGV system is in process.

DIVISION OF PLANT PROTECTION

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

Disease Monitoring and Pathogens Profile

In most of the locations in the sub-tropical plains, late blight appeared during first-second week of January, 2023 in rabi 2022 planted crop; however, it appeared very early in most of the potato growing regions in rabi 2023 planted crop. Blight appeared during last week of November in Punjab, in first week of December in Meerut region of western Uttar Pradesh and in second week of December in Haryana, most districts of Uttar Pradesh and West Bengal. The crop was completely wiped out by the late blight in Hoshiarpur and Macchiwara regions of Punjab (**Fig. 1**). However, disease could not assume epiphytotic status in western Uttar Pradesh due to unfavourable weather conditions (low temperatures). But blight has impacted some pockets of central Uttar Pradesh viz., Unnao, Fateh Pur and Farrukhabad districts. In Shimla hills, it appeared on 9th July, 2023 and intensity of the disease was up to 100%.

Fig.1*: View of late blight infected crop*

At Ooty, the incidence of common scab was recorded > 80% in Kufri Girdhari, Kufri Himalini, Kufri Jyoti and Kufri Swarna, moderate infestation (~65%) was in Kufri Sahyadri while, Kufri Karan exhibited lower level of infestation (52%, **Fig. 2**). The intensity of scab infestation was found very high (>20 lesions/ tuber) in two cultivars (Kufri Girdhari & Kufri Himalini); however, the lower infestation (<5 lesions/ tuber) was observed in Kufri Karan and Kufri Swarna. Sporadic incidence of Sclerotium wilt and Sclerotinia rot was also observed in western Uttar Pradesh with low disease incidence (< 4%).

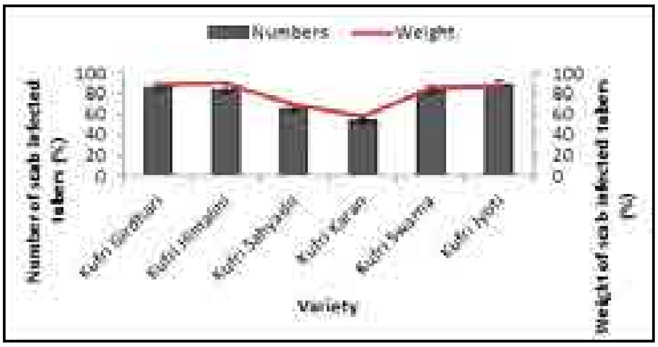


Fig. 2: Scab infestation in different potato varieties

Comparative Genomics of Potato Pathogens

Characterization of *Phytophthora infestans*

The population of *P. infestans* collected from different potato agro-ecologies during the crop season of 2022-23 was monitored for mating types and sensitivity to fungicides. Last year, we reported the occurrence of self-fertile (homothallic) isolates from West Bengal, Punjab, Maharashtra and Himachal Pradesh belonging to both A1 and A2 mating types. This year also the isolates were characterized for mating types and results revealed that 76.19% isolates from West Bengal and 13% from Himachal Pradesh were self-fertile. This information is important for planning strategies for the effective management of late blight in India.

A sub-set of isolates of *Phytophthora infestans* was also phenotyped for fungicide / oomycide (metalaxyl / mefenoxam, cymoxanil, dimethomorph, fenamidone) sensitivity. All tested isolates were observed to be intermediate resistant/resistant to metalaxyl / mefenoxam. This year isolates have shown insensitivity towards cymoxanil and tolerance up to 125 ppm (**Fig. 3**) has been observed. This indicates that *P. infestans* is acquiring resistance towards cymoxanil based fungicides which is cause of concern to all potato stakeholders. However, the isolates were found sensitive to dimethomorph and fenamidone fungicides.

Fig. 3: Common scab infestation on different potato varieties

Characterization of Streptomyces species

The infected potato tubers showing characteristic scab symptoms collected from various potato growing regions of Punjab, Haryana, Rajasthan, Gujarat, Uttar Pradesh, Bihar, West Bengal, Odisha, Jharkhand, Telangana, and Arunachal Pradesh during 2021-22 were characterized molecularly this year. DNA extraction of all the isolates was done by using a versatile quick-prep method for genomic DNA of Gram-positive bacteria. The 16s rRNA gene was amplified using the primers 16S-1F (5'-CAT TCACGGAGAGTTTGATCC-3') and 16S-1R (5'-AGAAAGGAGGTGATCCAGCC-3'. The sequences of the 16S rRNA genes of *Streptomyces* were compared with other *Streptomyces* from the GenBank databases of NCBI and results revealed the presence of diverse species of *Streptomyces* viz., *Streptomyces scabiei*, *S. caniscabiei*, *S. bottropensis*, *S. glaucescens*, *S. griseorubens*, *S. galilaeus*, *S. achromogenes*, *S. bobili*, *S. europaescabiei*, *S. actuosus*, *S. coelicolor*, *S. minutiscleroticus*, *S. caviscabies*, *S. canus* and *S. griseotuber*.

Sensitivity of fungicide against Fusarium species

Dry rot of potato is emerging as a major biotic threat to processing industries. Therefore, a subset of collected isolates of *Fusarium* spp. was evaluated against Azoxystrobin 23% SC at 5, 10 & 15 ppm by poisoned food technique *in-vitro*. Results revealed that 65, 45 and 40% isolates were resistant at 5, 10 and 15 ppm respectively; whereas 35, 55 and 55% isolates were intermediate sensitive at 5, 10 and 15 ppm respectively.

Diagnostics and Detection of Potato Pathogens

One-Step Reverse Transcription Recombinase Polymerase Amplification Method for Real-Time Detection of Potato Virus A

We successfully developed a robust one-step Reverse Transcription Recombinase Polymerase Amplification (RT-RPA) assay for detection of Potato virus A (PVA). This assay enables detection in 30 minutes, eliminating the need for a thermal cycler. Four recently reported simple RNA extraction methods with the Spectrum™ Plant Total RNA kit from Sigma-Aldrich, Missouri, USA, were compared. Among these methods, a modified cellular disc paper-based RNA preparation method was found highly effective for identifying PVA in potato leaves but not in tubers. High-quality RNA was not recovered from tubers due to excessive polyphenols and polysaccharides. To overcome this issue, Lithium chloride (LiCl) was evaluated at 8 M by coupling with a modified cellular disc paper-based RNA preparation method. RT-PCR and RT-RPA were used to detect PVA using this modified method and purified RNA obtained from the Spectrum™ Plant Total RNA kit.

Optimization of one-step RT-RPA for the detection of PVA with selected primer

The two steps RT-RPA and one-step RT-RPA were conducted at three temperatures (38, 40 & 42 °C) under the heating block/water bath. All tested temperatures (38, 40 & 42 °C) under the heating block/water bath worked well for one step/two steps RT-RPA and PVA was amplified when cDNA/RNA was taken as a template. No amplification was inspected in healthy and negative control. These results exhibited that accessible amplification of PVA by RT-RPA can be achieved within 30 min at a temperature ranging from 38-42 °C through cDNA in two steps RT-RPA and through RNA in one-step RT-RPA. In the next step, 40 °C was selected for further RT-RPA experiments and the incubation time (10, 20, 30, 40, and 50 min) was evaluated in one and two steps RT-RPA reactions. In these experiments, 10 min incubation time (**Fig. 4A & B**) was found sufficient for PVA detection in case of two steps RT-RPA in both thermal cycler and heating block/water bath incubation conditions, while 30 min incubation time (**Fig. 4C & D**) was found better under one-step RT-RPA in both the incubation conditions (thermal cycler and heating block/water bath). The results indicated that RT-RPA could detect PVA within 10 min when cDNA is used as a template, while it took a minimum of 20-30 min for successful detection of PVA in one-step RT-RPA.

Further, 30 min incubation time was used for the optimization of one-step RT-RPA with optimum concentration of magnesium acetate. Five concentrations (12, 14, 16, 18 & 20 mM) of magnesium acetate were tested and results indicated that14 mM (**Fig. 4E & F**) was optimum for better performance in a water bath/heating block condition.

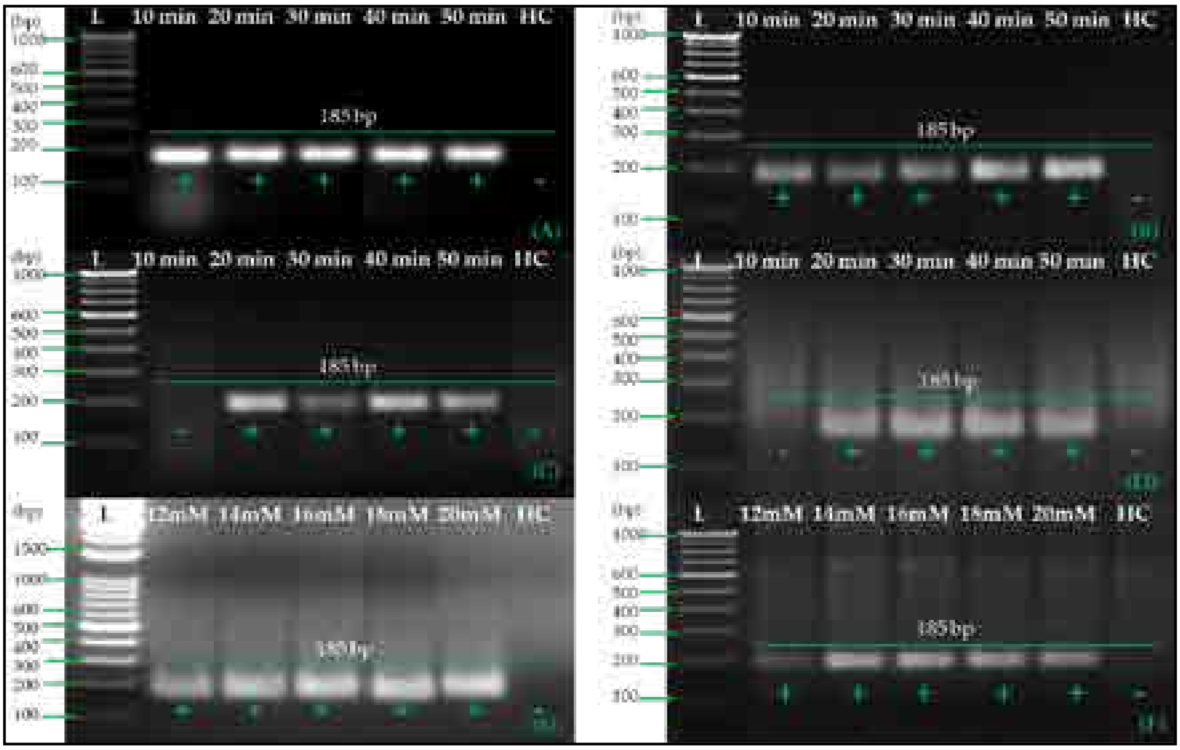


Fig.4: Optimizing the RT-RPA reaction for the detection of PVA with primer pair A (PVARPAF1/R1). In (A) cDNA is used as a template in a thermal cycler. In (B) cDNA is used as template in the water bath/ heating block. In (C), using RNA as a template, under a thermal cycler. (D) Using RNA as a template and a water bath/heating block. Under thermal cycler, RNA was used as a template for determining the optimum concentration of magnesium acetate (E). Under water bath/heating block, RNA was used as a template for determining the optimum concentration of magnesium acetate (F). Lane L-1Kb or 100 bp ladder, lane HC-healthy control (cDNA/RNA).

Sensitivity and specificity analysis for the specific detection of PVA in leaves and tubers

The sensitivity of the one-step RT-RPA method was determined using a 10-fold serial dilution (10^{-0} to 10^{-8} dilutions) of 1 µg total RNA from potato leaves and tubers which were compared with earlier reported RT-PCR. The sensitivity was also checked with 10^{-0} to 10^{-8} dilutions of 1 µl RNA extract from the cellular disc paper-based RNA preparation method. The 1 µl of dilution of simple RNA extract was taken as a template for one-step RT-RPA. The one-step RT-RPA and RT-PCR detection limit was confirmed by electrophoresis on 2.5 and 1.0% agarose gel, respectively. Results showed that when total RNA dilution was evaluated with selected primer set A and compared with earlier reported primers under one-step RT-PCR, primers set A showed 10 times higher sensitivity in the leaves and equally sensitivity in the tubers (**Fig. 5A, B, C, D**). Similarly, no difference was observed in RT-RPA sensitivity using simple RNA extract compared to purified RNA dilutions. The results indicated (**Fig. 5E, F, G & H**) that the detection limit of one-step RT-RPA using simple RNA extract was equal to that of RT-RPA and RT-PCR using purified RNA. The specificity of the primers was also checked through one-step RT-RPA assay for other viruses' viz., ToLCNDV, PLRV, PVY, PVS, PVV, PVX, and PVM. The primer set A detected only PVA and no cross-reaction was observed with other potato viruses in this study.

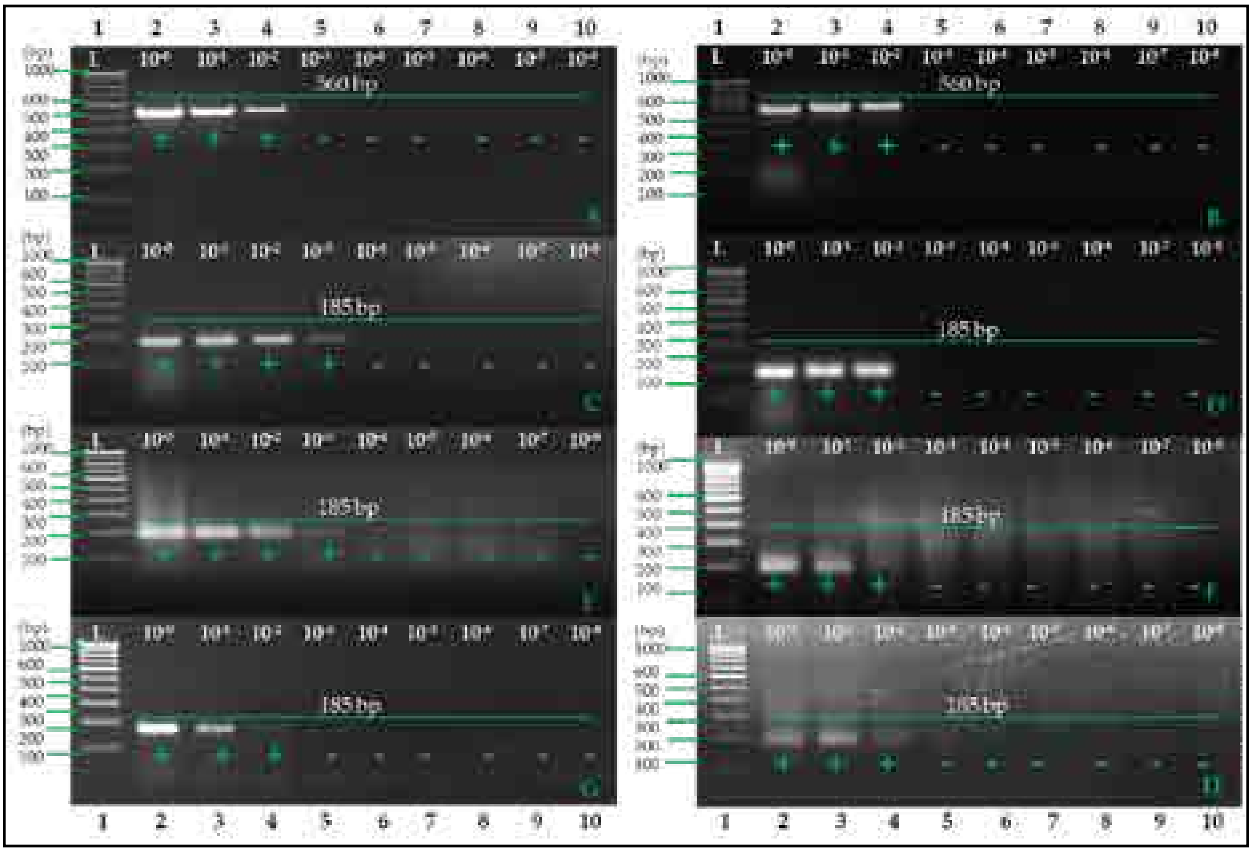


Fig. 5: One-step RT-PCR and RT-RPA sensitivity for detecting Potato virus A (PVA) A. One-step RT-PCR with existing protocol using purified RNA (leaf), B. One-step RT-PCR with existing protocol using purified RNA (tuber), C. One-step RT-PCR with primer pair A (PVARPAF1/R1) using purified RNA (leaf), D. One-step RT-PCR with primer pair A (PVARPAF1/R1) using purified RNA (tuber), E. One-step RT-RPA with primer pair A (PVARPAF1/R1) using purified RNA (leaf), F. One-step RT-RPA with primer pair A (PVARPAF1/R1) using purified RNA (tuber), G. One-step RT-RPA with primer pair A (PVARPAF1/R1) using cellular disc paper-based RNA extract (leaf), H. One-step RT-RPA with primer pair A (PVARPAF1/R1) using 8 M LiCl with cellular disc paper-based RNA extract (tuber). Lane L-1Kb or 100 bp ladder; Lanes 2 to10- RT-RPA/RT-PCR products obtained with total RNA dilutions from 10-0–10-8 (A, B, C, D, E, F) and cellular disc-based RNA preparation (G, H).

Validation of the one-step RT-RPA results by one-step RT-PCR and DAS-ELISA using field samples

The assay was validated using 300 PVA suspected (150 each for leaves and tubers from the same plants) field samples along with virus-free tissue culture-raised mother plants/mini tubers as healthy controls. These samples were initially checked by DAS-ELISA followed by further validation with one-step RT-PCR and one-step RT-RPA. A total of 15 samples were randomly chosen from 150 samples of leaves where 14 samples were detected positive in one-step RT-PCR using earlier reported primers (**Fig. 6A**). Similarly, 13 samples were found positive in the case of one-step RT-PCR and 11 samples in RT-RPA with RPA primer set A using purified RNA (**Fig. 6B & C**). Similar results were noticed in one-step RT-RPA with primer set A when cellular disk paper-based RNA extract was taken as a template (**Fig. 6D**).

Similarly, out of 15 samples randomly selected from 150 samples of tubers (dormant and stored), all 15 samples were detected positive in one-step RT-PCR (**Fig. 7A**), while 14 samples were found positive in the one-step RT-PCR (**Fig. 7B**) and 12 samples in case of RT-RPA with primer set A using purified RNA (**Fig. 7C**). Similarly, 12 samples were detected positive in one-step RT-RPA with primer set A when cellular disk paper-based RNA extract coupled with 8 M LiCl was used as a template (**Fig. 7D**).

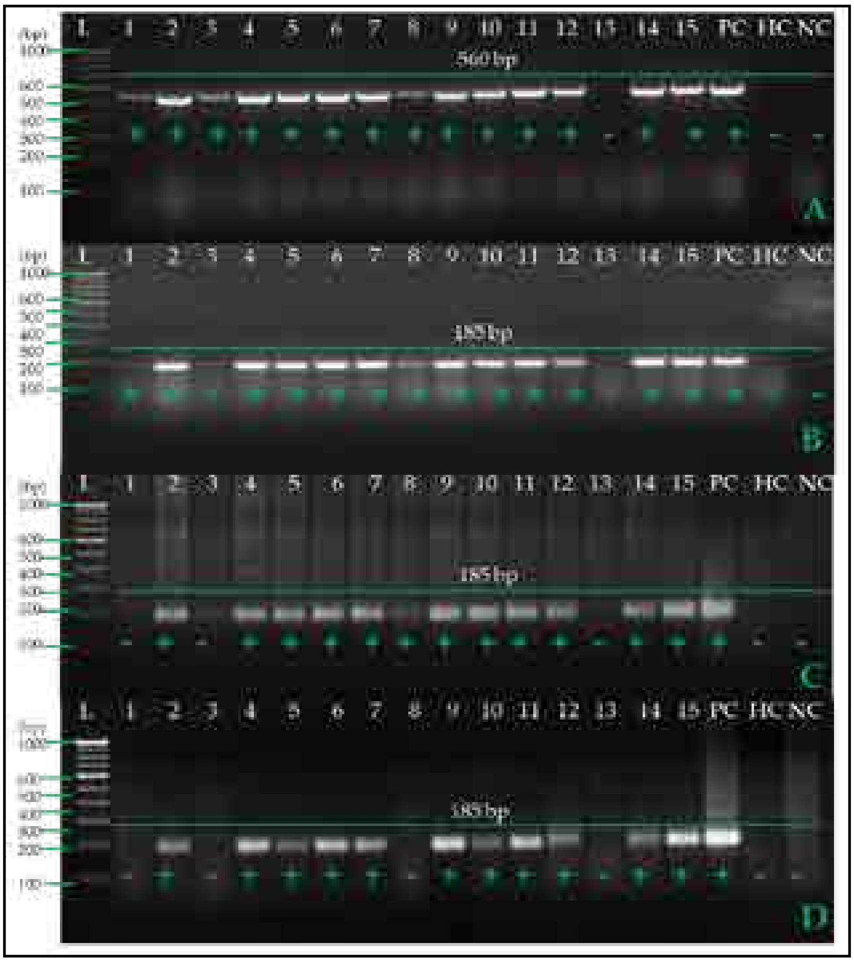


Fig. 6: Detection of PVA in field samples of potato (leaves) by one-step RT-RPA and RT-PCR. A. One-step RT-PCR with existing protocol using purified RNA, B. One-step RT-PCR with primer pair A (PVARPAF1/R1) using purified RNA, C. One-step RT-RPA with primer pair A (PVARPAF1/R1) using purified RNA, D. One-step RT-RPA with primer pair A (PVARPAF1/R1) using cellular disc paper-based RNA extract. Lane L-1Kb or 100 bp ladder, Lane 1-15 shows different samples of potato leaves, PC- known positive leaf sample of potato, HC-healthy potato leaf sample, NC-Negative (water) control.

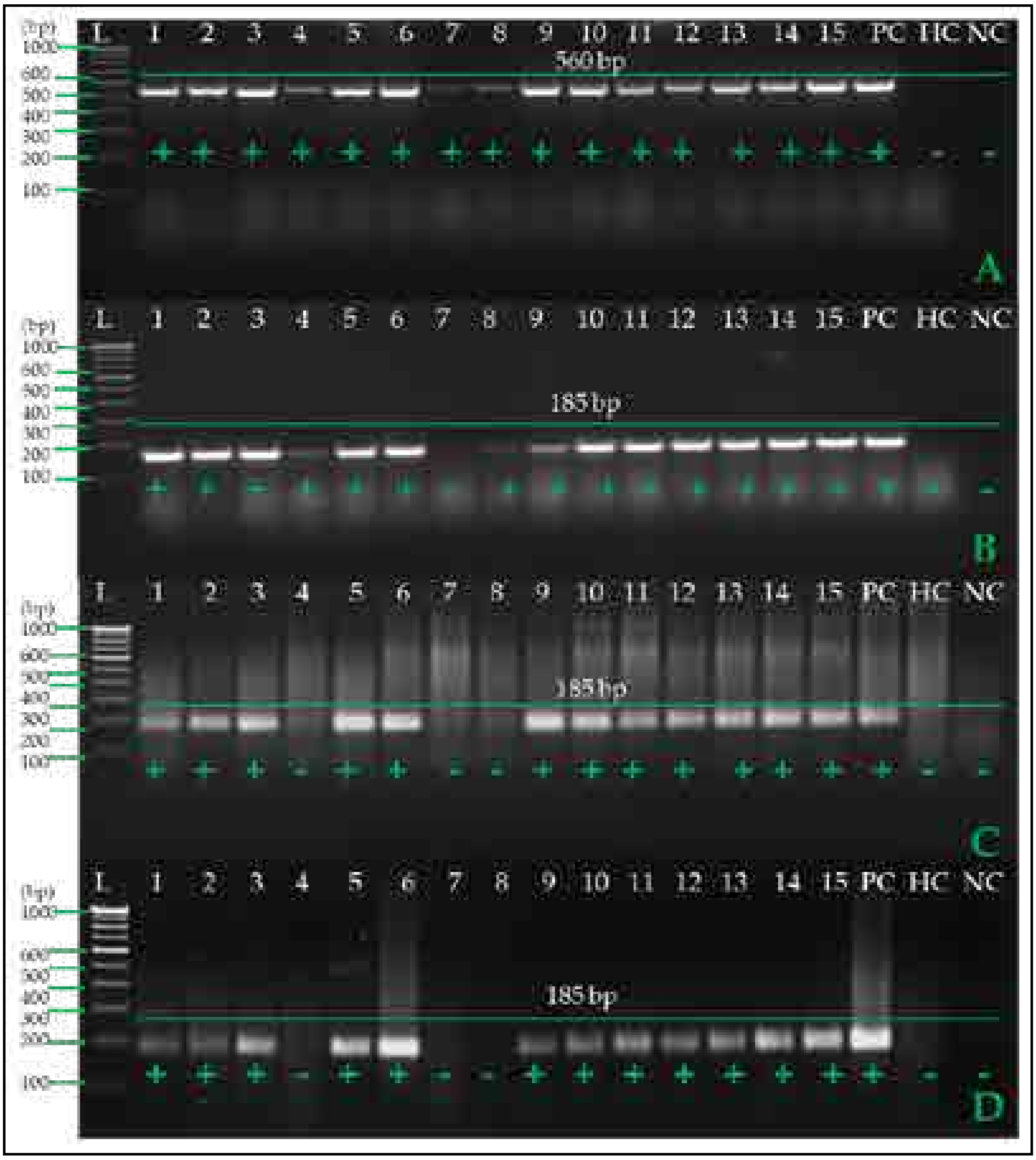


Fig.7: Detection of PVA in field samples of potato (tubers) by one-step RT-RPA and RT-PCR. A. One-step RT-PCR with existing protocol [25] using purified RNA, B. One-step RT-PCR with primer pair A (PVARPAF1/R1) using purified RNA, C. One-step RT-RPA with primer pair A (PVARPAF1/R1) using purified RNA, D. One-step RT-RPA with primer pair A (PVARPAF1/R1) using cellular disc paper-based RNA extract with 8 M LiCl. Lane L-1Kb or 100 bp ladder, Lane 1-15 shows different samples of potato leaves, PC- known positive leaf sample of potato, HC-healthy potato leaf sample, NC-Negative (water) control.

Epidemiology and Forecasting of Potato Pathogens

Forecasting of late blight

Indo-Blightcast model was used to predict appearance of late blight across the agro-ecologies during *kharif* 2023 and *rabi* 2023-24 and the model predicted late blight accurately at each location (**Table 1**). Accordingly, the agro-advisories were issued to respective regions through print and electronic media to protect the crop from the onslaught of late blight.

Table 1: Performance of Indo-Blightcast model during *kharif* 2023 and *rabi* 2023-24

Location	Prediction date of late blight	Actual date of late blight appearance
Bhubaneswar (Odisha)	Did not predict	Did not appear
Dholi (Bihar)	14.12.2023	27.12.2023
Patna (Bihar)	24.12.2023	04.01.2024
Faizabad (UP)	18.12.2023	24.12.2023
Hisar (Haryana)	05.12.2023	09.12.2023
Jorhat (Assam)	19.12.2023	22.12.2023
Kanpur (UP)	11.12.2023	15.12.2023
Kota (Rajasthan)	10.12.2023	14.12.2023
Modipuram (UP)	19.11.2023	02.12.2023
Pantnagar (Uttarakhand)	05.12.2023	18.12.2023
Jalandhar (Punjab)	17.11.2023	22.11.2023
Bankura (WB)	16.12.2023	28.12.2023
Burdwan (WB)	20.12.2023	02.01.2024
Hooghly (WB)	18.12.2023	31.12.2023
Jalpaiguri (WB)	11.01.2024	14.01.2024
West Mednapur	31.12.2023	10.01.2024
Shimla (HP)	02.07.2023	09.07.2022

Comparative epidemiological studies of self-fertile (SF), A1 and A2 mating type isolates of P. infestans

Fifteen selected (five each A1, A2 & SF) isolates of *P. infestans* were compared for their mycelia growth grown on rye B medium at 18±1 °C for weeks. Mycelial plugs (5 mm dia) from each isolate were obtained from actively growing cultures transferred to test plates and incubated at 12, 15, 18, 20, 22, 25 and 28 °C. Diametric growth was observed from 4th day to 14th day and mean values calculated. Results showed that temperature ranging from 12 to 28 °C greatly affected mycelial growth. Mycelial growth was observed in the range of 12–25 °C with the optimum temperatures being 15–20 °C. At 12^{0}C, maximum mycelial growth (26.47 cm) was exhibited by A1 followed by SF (23.30 cm) and A2 (17.28 cm). Same trend was observed at 15, 18 and 20 °C. However at 22°C, highest mycelial growth (22.03 cm) was observed in self-fertile isolates followed by A1 (19.55 cm) and A2 (16.59 cm). Same trend was observed at 25 °C but growth was relatively less. At 28 °C, only few isolates (two each) of A1 and self-fertile could grow with little mycelial growth (**Fig. 8**).

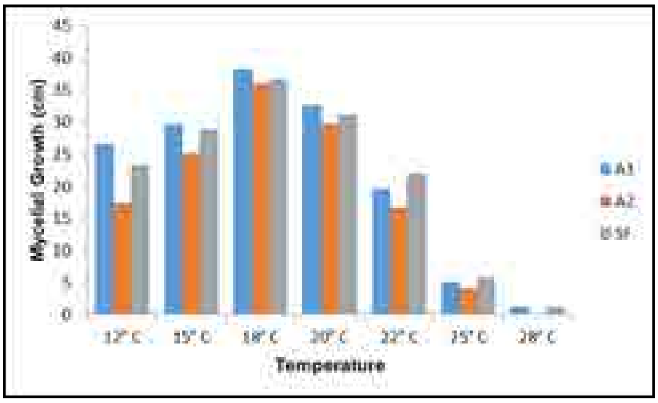


Fig. 8: Effect of temperature on growth of Phytophthora infestans

Same set of isolates was used to study comparative aggressiveness using detached leaf of cv Kufri Bahar. Five leaflets were used for each isolate and inoculated with zoospore suspension @ 6 × 10^4 zoospores/ml and incubated in specifically designed plastic trays at 18 °C and assessed for lesion area (LA) and sporulation. Results revealed that more lesion areas (**Fig. 9**) were incited by A1 (11.36 cm^2) and self-fertile (11.27 cm^2) than A2 mating type (8.92 cm^2). Highest sporulation (11.2 x 10^3) was observed in A2 followed by A1 (10.5 x 10^3) and self-fertile (9.8 x 10^3) isolates (**Fig. 10**).

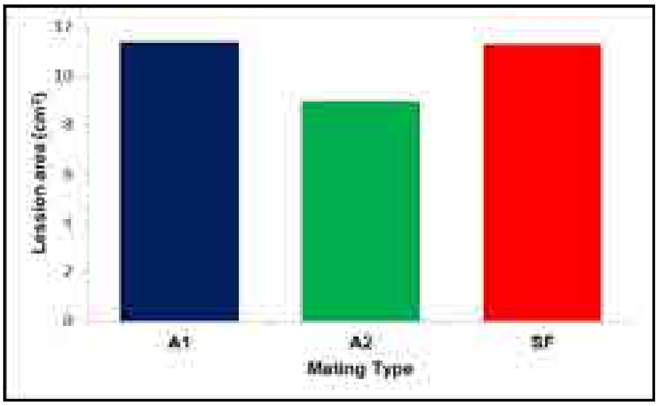


Fig. 9: *Lesion area development by different mating types*

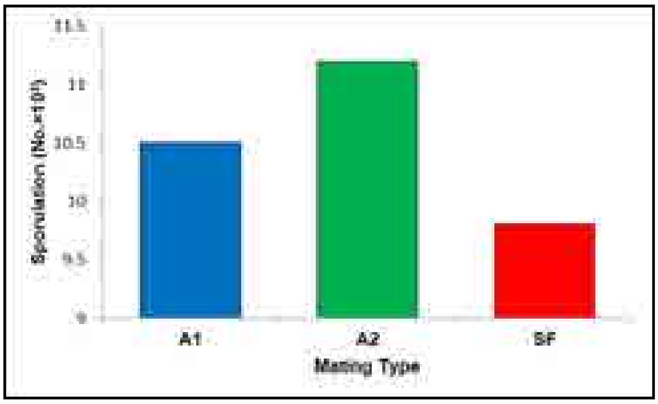


Fig.10: Spore production by different mating types

Management of Potato Pathogens

Evaluation of new chemicals for late blight management

It is essential to test new fungicides on regular basis for their efficacy and subsequently for their inclusion in spray schedules for management of late blight. Seven treatments consisting of existing and new fungicides (Kresoxim-methyl 15% + chlorothalonil 56% WG, Amisulbrom 20% SC, and Valifenalate 6% + Mancozeb 60% WG) were evaluated by applying three sprays against late blight of potato during Rabi season 2022-23. Amongst the tested fungicides, Valifenalate 6% + Mancozeb 60% WG @ 0.5% (7.50% DS) followed by Fenamidon10 + mancozeb50%WG @ 0.3% (9.50% DS) and Dimethomorph 50% WP @ 0.1% (10.00% DS) exhibited less disease severity as against control (75.00%, **Fig. 11)**.

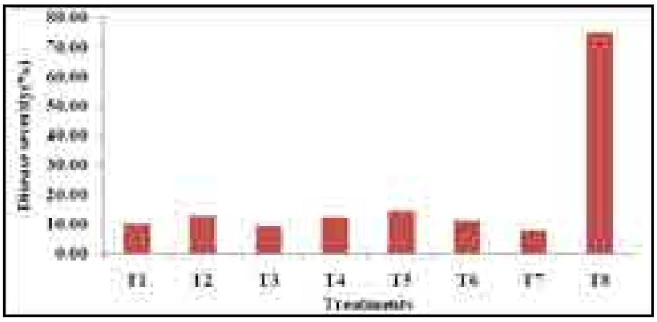


Fig. 11: Efficacy of new chemicals against late blight of potato

[T1: Dimethomorph 50% WP @ 0.1%, T2: Cymoxanil 8+ mancozeb 64% WP @ 0.3%, T3: Fenamidon10 + mancozeb50% WG @ 0.3%, T4: Kresoxim-methyle 15% + chlorothalonil 56% WG @ 0.2%, T5: Amisulbrom 20% SC @ 0.1%, T6: Valifenalate 6% + Mancozeb 60% WG @ 0.4%, T7: Valifenalate 6% + Mancozeb 60% WG @ 0.5%, T8: Control]

Chemical management of black scurf of potato

Efficacy of 12 different fungicides (Penflufen 22.43%FS, Pencycuron 22.9%SC, Boric Acid, Tebuconazole 15% + Zineb 57% WDG, Fluxapyroxad 333FS, Kasugamycin 6 + Thifluzamide 26% SC, Thifluzamide 24%SC, Azoxystrobin 2.5% + Thiophanate Methyl 11.25% + Thiamethoxam 25% FS and Imidacloprid 17.8 SL + Penflufen 22.43% FS) was evaluated as potato tuber seed treatment by spray method at the time of planting during *Rabi* 2022-23. All the treatments were effective in reducing the disease incidence and severity in comparison to control treatment. Lowest disease incidence (1.33%) and disease severity (0.33%) was observed in Imidacloprid 17.8 SL @ 0.04% + Penflufen 22.43% FS @0.1% (T12) followed by Pencycuron 22.9% SC (T1) with disease incidence (1.97%) and disease severity (0.49%) and Thifluzamide 24% SC @ 0.5% (T8) against control (T13) **(Fig.12)**. These treatments were statistically at par with each other.

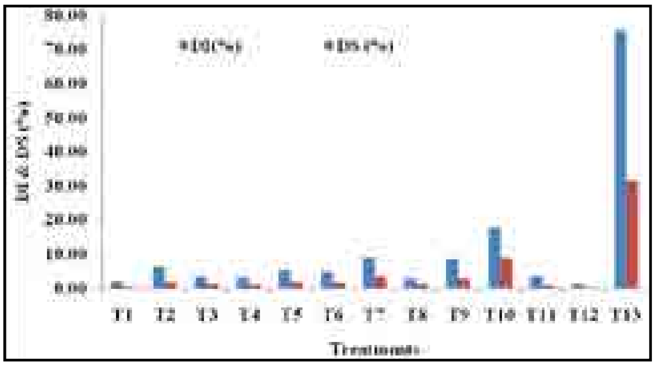


Fig.12: Evaluation of new chemicals against black scurf of potato

Management of common scab

Effect of pH: In a glass house, pots (6" dia) were filled with mixture of autoclaved coco-peat and vermi-compost (2:1 ratio) and arranged in CRBD to accomodate 6 levels of pH (4.0, 5.0, 6.0, 7.0, 8.0, and 9.0); under each level 12 pots were maintained totalling to 72 pots. The pots under each pH level were irrigated with water adjusted to respective pH (using 0.1N NaOH and 0.1N HCl) to saturation on alternate days for two weeks. Then under each pH level, inoculum of 04 species of *Streptomyces* (*S. gallilaeus, S. scabiei, S. bottropensis* and *S. canniscabiei*) was added separately @ one culture plate (7-10 days old grown on oat meal agar at 28±1°C) per pot maintaining 03 pots per species. One healthy tuber of potato variety 'Kufri Jyoti' was planted per pot. Afterwards, the pots under different pH levels were irrigated with respective pH adjusted water as and when required till harvesting. The results revealed that *S. gallilaeus, S. scabiei,* and *S. canniscabiei* caused scab on tubers in soil pH ranging from 4.0 to 9.0 and *S. bottropensis* in soil pH from 5.0 to 9.0. A gradual increase in common scab severity by all the four *Streptomyces* spp. was also observed with an increase in soil pH **(Fig. 13)**.

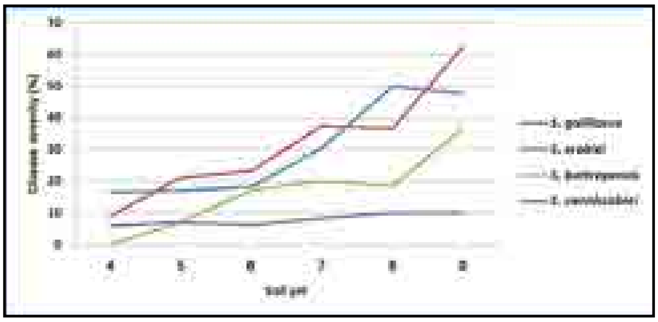


Fig. 13: Effect of soil pH regimes on potato scab severity

Effect of irrigation regimes: A pot experiment was conducted to see the effect of irrigation regimes (alternate days, once a week and 10 days interval) on potato scab. Pots (6" dia) were filled with mixture of autoclaved coco-peat and vermi-compost (2:1 ratio) and arranged in CRBD maintaining 03 replications per treatment in glass house. Pathogenic culture of *S scabiei* grown on oat meal agar in Petri plates for 07-10 days at 28±1°C was mixed in pots @ one culture plate per pot. Healthy tubers of Kufri Jyoti variety were planted to these pots (one tuber per pot) and irrigated on alternate days with 200 ml water per pot until 30 DAP. Afterwards, with the initiation of tuberization, the irrigation regimes were initiated till harvesting. At harvest, no significant difference in common scab severity on tubers was observed in all the three irrigation regimes.

***In-vitro* evaluation of fungicides/ chemicals:** Boric acid (2.0%, 3.0%, NaOCl (0.5%, 1.0%) and ClO_2 (0.2%, 0.3%) were evaluated *in-vitro* through agar diffusion method for their efficacy in inhibiting the growth of *Streptomyces scabies*. ClO_2 (0.3%) was most effective and almost completely inhibited the growth of *S. scabiei*, NaOCl formed a clear inhibition zone of about 1.5 cm dia., whereas boric acid was least effective compared to control **(Fig. 14; left)**.

Fig. 14: *In*-vitro evaluation of boric acid, ClO_2, and NaOCl to inhibit S. scabiei growth (left); evaluation of tuber dip treatment in NaOCl and boric acid on germinating sprouts and in reducing tuber borne inoculum of S. scabiei (right)

Common scab infected tubers (with severe and moderate symptoms) and healthy sprouted tubers were given dip treatment in Boric acid (3.0%) and NaOCl (2.0%) for 30 minutes separately to see their effect in reducing the seed borne inoculum of *S. scabies* and on sprout injury. Isolations made from the treated tubers revealed that NaOCl

(2.0%) was more effective in reducing the tuber borne inoculum (**Fig. 14**; right: cfu count is less in NaOCl treated tubers) than boric acid (3.0%). Both the treatments resulted in slight tip burning of the sprouts but did not affect their growth (observed up to two weeks after dip treatment).

***In-vivo* evaluation of fungicides/ chemicals:** A pot experiment was conducted to see the effect of seed tuber treatment with copper-oxychloride 50WP (0.3%), mancozeb 72WP (0.3%), ClO_2 (0.3%), $ZnSO_4$ (0.05%) alone and in combination of tuber treatment followed by drenching of root zone with respective chemical/ fungicide 30 days after planting (DAP), on common scab disease. Pots (6" dia) were filled with mixture of autoclaved coco-peat and vermi-compost (2:1 ratio) and arranged in CRBD maintaining 03 replications per treatment in glass house. Pathogenic culture of *S. scabiei* grown on oat meal agar in Petri plates for 07-10 days at 28±1°C was mixed in pots @ one culture plate per pot. The treated tubers (dipped for 20 minutes in respective chemical/ fungicide) were planted in the pots (01 tuber/ pot). In control, tubers dipped in water were planted in pathogen inoculated pots. The pots were irrigated as and when required till harvesting. Results revealed that all treatments reduced common scab severity (13.3 to 41.11%) compared to control (55.0%) Minimum disease severity of 13.3% (T-7) was observed in tuber treatment (at planting) + drenching (30DAP) with ClO_2 (0.3%) followed by 17.8% (T-6) in tuber treatment (at planting) + drenching (30DAP) with mancozeb (0.3%) and 20.0% (T-8) in tuber treatment (at planting) + drenching (30DAP) with $ZnSO_4$ (0.05%) **(Fig. 15)**.

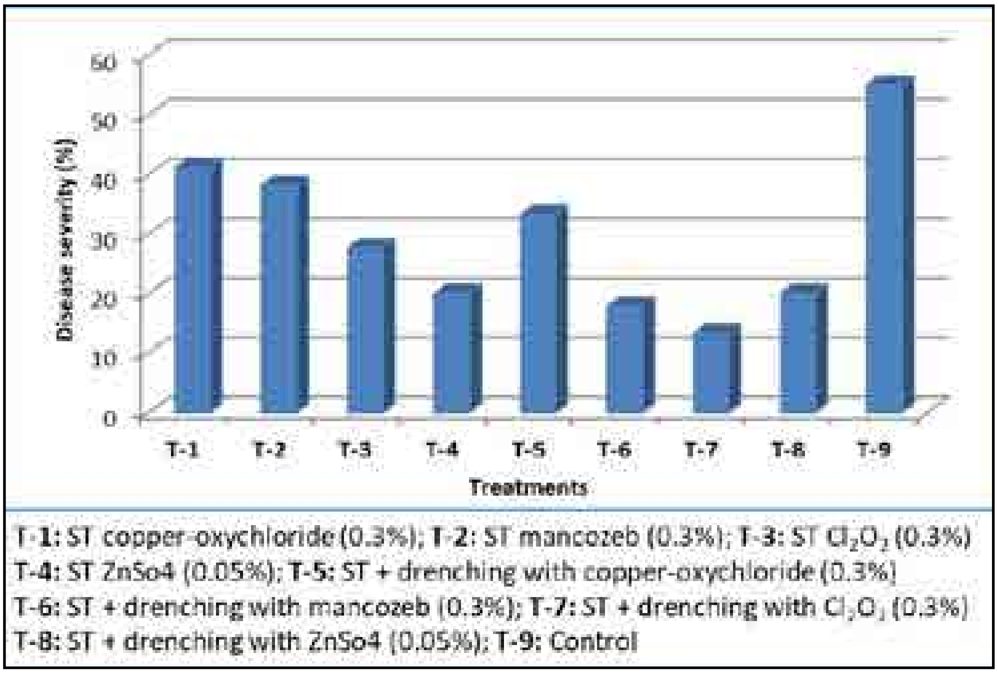


Fig. 15: *Effect tuber treatment (at planting) alone and in combination with drenching (30DAP) with fungicides/ chemicals on common scab disease*

Field screening of potato varieties for resistance to *Ralstonia solanacearum*

Three potato lines/ collections namely, SM/11-93, SM/ 92-338 and PAP 2-4 having shown resistance to *R. solanacearum* in earlier *in-vitro* screening tests, in a pot experiment under controlled conditions and in bacterial wilt sick field experiment were again tested under replicated field experiment in a bacterial wilt sick field at lower lab farm of ICAR-CPRI, Shimla to confirm the reproducibility of the last year results. Variety 'Kufri Jyoti' was planted in every alternate row as susceptible check.

The potato line SM/92-338 did not show any wilt symptoms till harvesting. The bacterial wilt incidence in SM/11-93, PAP 2-4 and Kufri

Jyoti was 20.0, 20.0 and 100.0%, respectively. The brown rot incidence in SM/92-338, SM/03-23 and PAP 2-4 was 2.0, 20.0 and 20.0%, respectively, compared to 100.0% in Kufri Jyoti **(Fig. 16)**.

Fig. 16: Screening of potato lines for resistance to R. solanacearum in a bacterial wilt sick field

Screening of potato varieties for resistance to *Streptomyces scabiei*

Glass house screening: Five potato varieties/ lines namely, K. Jyoti, K. Khyati, K. Bahar, K. Pukhraj, K. Sindhuri, and 04 lines (found tolerant to thaxtomin A toxin in tuber slice assay) namely CP 2110, CP 1012, CP 2171 and J/A-197 were tested for resistance to *Streptomyces scabiei* in a pot experiment. All the varieties/ lines were found susceptible with common scab incidence ranging from 50.0 to 100.0% and severity from12.0 to 46.7% **(Fig. 17)**.

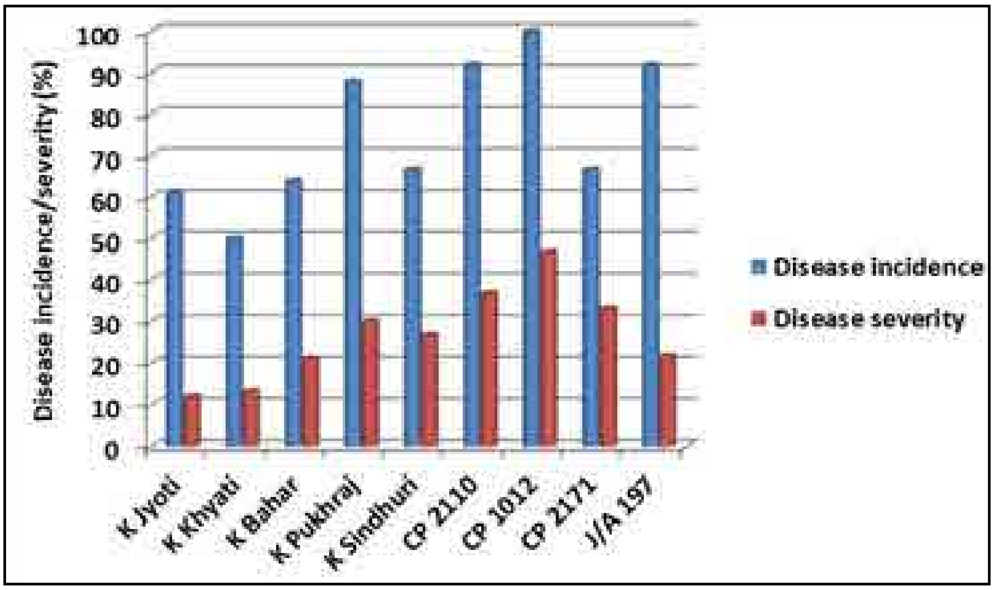


Fig. 17: Screening of potato varieties/ lines for resistance to S. scabiei in pots

***In-vitro* screening:** A novel tissue culture based method was developed for *in-vitro* screening of potato germplasm against common scab disease. The method is quick, simple and feasible in lab and the symptoms on micro-tubers develop within 7-10 days of inoculation.

In this method, micro-tubers produced in tissue culture were used for pathogenicity test/ screening against *S. scabiei.* Inoculum was prepared by dissolving powdery growth of *S. scabiei* (7-10 days old culture grown on oat meal agar) in distilled sterilised water and adjusted to a concentration of $1x10^8$ cfu approximately. Under aseptic conditions, 1-2 loops full of inoculum were gently smeared on to the surface of intact micro-tubers growing in test tubes. The inoculated test tubes were then placed back in dark at 20-25°C and observed regularly for symptom development. Following this method, 27 potato varieties namely, K. Kiran, K. Karan, K. Sangam, K. Thar-1, K. Thar-2, K. Thar-3, K. Chandarmukhi, K. Girdhari,, K. Surya, K. Jyoti, K. Sindhuri, K Chipsona-3, K. Chipsona-4, K Chipsona-5, K. Khyati, K. Himalini, K. Mohan, K. Gaurav, K. Sukhyati, K. Ganga, K. Pukhraj, K. Sahyadri, K. Neelkanth, K. FryoM, K. Uday, K. Lauvkar and K. Bahar were screened for resistance to *S. scabiei*. All the 27 varieties were found susceptible as the symptoms developed on micro-tubers within 7-10 days **(Fig. 18)**.

Fig.18: *In*-vitro screening of potato lines for resistance to S. scabies

Biosafety Evaluation of Late Blight Resistant GE Potato KJ66 as per Regulatory Requirements for Environmental Release

The institute has developed GE potato KJ66 having high resistance to late blight by using both genetic engineering and traditional breeding approaches. This work was started in the year 2005 and now we have reached to the stage of its environmental release after thorough field evaluation. Environmental release of a GE plant requires submission of a biosafety dossier to Genetic Engineering Approval Committee (GEAC) consisting of data from three years of field trials (two years of BRL-I and one year of BRL-II) and safety studies as per the prescribed guidelines for food and environmental safety assessment. We submitted our application to Review Committee on Genetic Manipulation (RCGM), Department of Biotechnology for conduct of BRL-1 trials of KJ66. The Genetic Engineering Appraisal Committee (GEAC) approved our application vide Permit No.: BT/IBKP/081/2020 dated 24.02.2023. The BRL-I 1st year trial was conducted during *kharif* 2023 at Kufri farm with four entries which include the KJ66 test line, the two parental cultivars, Kufri Jyoti and Katahdin, and a national check with moderate resistance to late blight, Kufri Himalini. Plot layouts include two treatments; fungicide sprayed and unsprayed, each consisting of three blocks arranged in a randomized complete block design (RCBD). Observations on various parameters *viz.*, agronomic and phenotypic characteristics, efficacy for late blight resistance, susceptibility to insects and other diseases, monitoring for predators and other beneficial insects, were recorded at regular intervals. The values for late blight severity (**Fig. 19**) revealed significant difference among the genotypes under both sprayed and un-sprayed conditions.

Fig. 19: View of BRL-I 1st year trial of GE potato KJ66

No blight was observed in KJ66 under both the situations i.e. sprayed and un-sprayed conditions. Under sprayed plots, the severity of late blight was 15% (Kufri Jyoti), 10% (Katahdin) and 11% (Kufri Himalini) as against of zero in KJ66. Under un-sprayed plots, late blight severity reached to 100% (Kufri Jyoti), 36% (Katahdin) and 70% (Kufri Himalini) as against of zero in KJ66. Observance of no blight in KJ 66 indicates its high efficacy (high resistance) against late blight which is the trait of the interest in this study (**Fig. 20**). The data on pests and disease incidence suggest that susceptibility level of GE potato KJ66 was similar to all other tested conventional non-transgenic counterparts and checks and did not show any enhanced or lowered incidence of pests and diseases.

Fig.20: Efficacy of KJ66 under un-sprayed plots

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

This year also the two transgenic lines (GTLC2-127 and KPLC2-53) were evaluated under containment facility for resistance and other agronomic parameters. The results of the screening showed that these two transgenic lines did not exhibit any symptoms of ToLCNDV infection, in contrast to the control plants. Besides, six other transgenic lines (GTLC2-90, GTLC2-127, KPLC2-13, KPLC2-37, KPLC2-53, and KPLC2-54) were also maintained and multiplied under tissue culture conditions.

Post entry quarantine testing of imported germplasm

A total of 70 *in-vitro* cultures imported by Head, CI &ST (24 *in-vitro* lines from Peru CIP), M/s Technico Agri-sciences Pvt Ltd (14 lines), M/s Pepsico India Holdings Pvt Ltd (17 lines), Mahindra HZPC (02 lines), M/s Siddhi Vinayak Agri Processing Pvt. Ltd (08 lines) and M/s Merino Industries Pvt Ltd (05 lines) were tested for post entry quarantined pathogens and all were found free from quarantined pathogens.

Facilitation of potato export

Facilitated export of potato minitubers (seed) by monitoring, inspecting and testing the potato crops raised by the seed producers as per the requirements of the importing countries (**Fig. 21**). After testing, Phytosanitary Certificates were issued which could lead to the export of 41,98, 130 minitubers to Egypt, Saudi Arabia, Senegal, Tanzania and Turkey by M/s Mahindra HZPC Pvt Ltd, M/s Pepsico India Holdings Ltd. and M/s Technico Agri-Sciences Pvt. Ltd.

Fig.21: Monitoring of potato crops for export purposes

PROGRAMME: BIOLOGY, ECOLOGY AND MANAGEMENT OF INSECTS AND NEMATODE PESTS OF POTATO

Project 1. Biology, epidemiology and management of insect pests of potato

I. Biology, Population Dynamics and Diversity of Insect Pests of Potato

Monitoring aphid flight activity in potato crop fields

The study aimed to monitor aphid flight activity in potato crop fields throughout the growth season to assess timing, intensity, and peak periods of activity. Yellow pan water traps were deployed from October to February, with weekly aphid counts recorded. Results showed notable fluctuations in trap catches, ranging from 2.5 to 81 aphids per week, indicating variable aphid activity. Peaks were observed during the 2nd week of November (47 aphids) and the 2nd week of February (81 aphids), highlighting critical periods of intensified activity (**Fig. 1**). Increased activity in November and February underscores the need for vigilance and potential implementation of pest management strategies during these months. The mean trap catch of 22.39 aphids with a standard deviation of 19.56 emphasizes the dynamic nature of aphid flight activity, necessitating monitoring to inform timely interventions and mitigate crop damage.

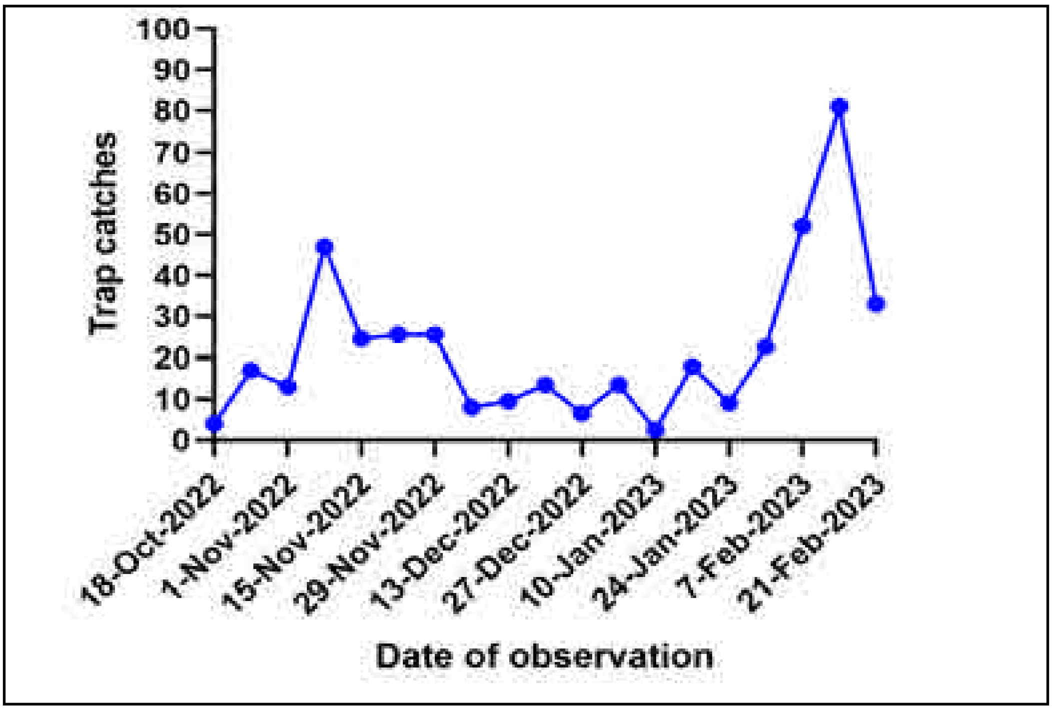


Fig. 1: Trap catches of alate aphids recorded throughout the crop growth season at weekly intervals

Influence of different planting dates on the incidence of sucking insect pests in potato

The objective of this experiment was to evaluate the impact of different planting dates on the incidence of sucking insect pests, including alate and non-alate morphs of aphids, whiteflies, and leaf hoppers, in K. Phukraj potato variety. Seven treatments were used, consisting of different planting dates: 30th September, 15th October, 30th October, 15th November, 30th November, 15th December, and 30th December.

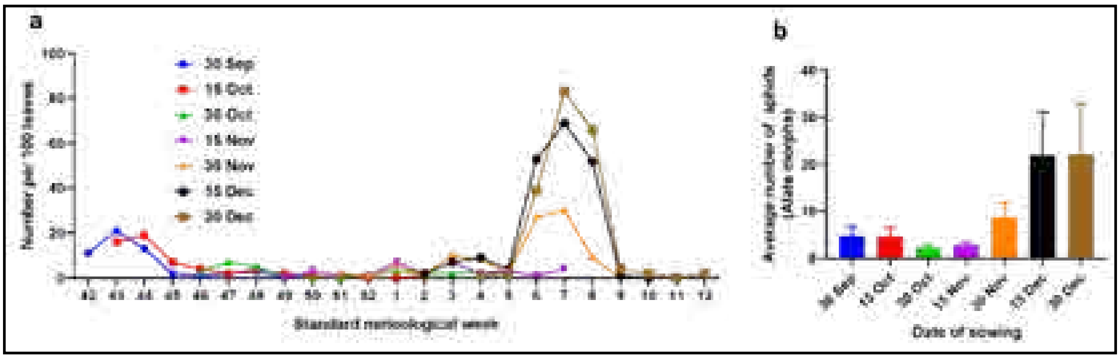


Fig. 2: a. Aphid (Alate morphs) population dynamics across Standard Meteorological Weeks (SMWs) and b. Average number of aphids across different sowing dates

The analysis revealed significant impacts of planting dates on the incidence of alate and non-alate morphs of aphids ($p < 0.05$), indicating distinct variations in pest infestation levels. The analysis of mean number of alate aphids across different planting dates revealed notable variations in infestation levels. The average number of alate morphs ranged from 2.33 to 22.11, showing differences in pest populations during the standard meteorological weeks (**Fig. 2**). The analysis of mean numbers for non-alate aphids across different planting dates revealed variations in their population levels. The average number of non-alate aphids ranged from 2.63 to 18.00, indicating differences in their abundance during the specified dates (**Fig. 3**).

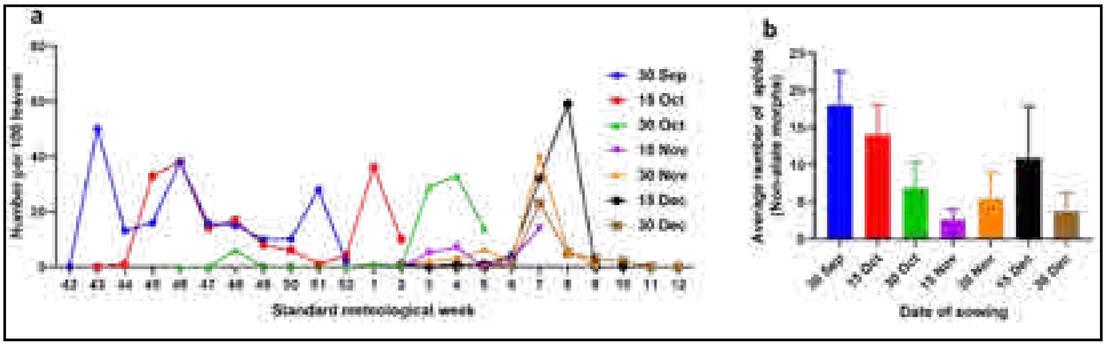


Fig. 3: a. Aphid (Non-alate morphs) population dynamics across Standard Meteorological Weeks (SMWs) and b. Average number of aphids (non-alate morphs) across different planting dates

However, whiteflies showed no significant difference in incidence based on planting dates ($p > 0.05$). The average number of whiteflies ranged from 0.728 to 0.971, indicating fluctuations in population densities during the specified dates (**Fig. 4**).

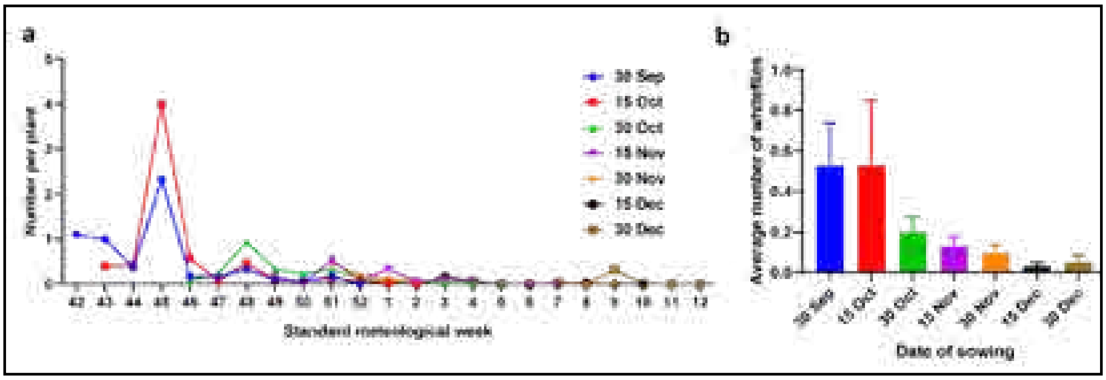


Fig. 4: *a.* Whiteflies population dynamics across Standard Meteorological Weeks (SMWs) and b. average number of Whiteflies across different sowing dates

Notably, the timing of planting exhibited a significant effect on the presence of leafhoppers, with considerable variations observed across different planting times ($p < 0.0001$). The analysis of mean values for leafhoppers across different planting dates revealed variations in their population levels. The average number of leafhoppers ranged from 0.121 to 4.162, indicating differences in their abundance during the specified dates (**Fig. 5**).

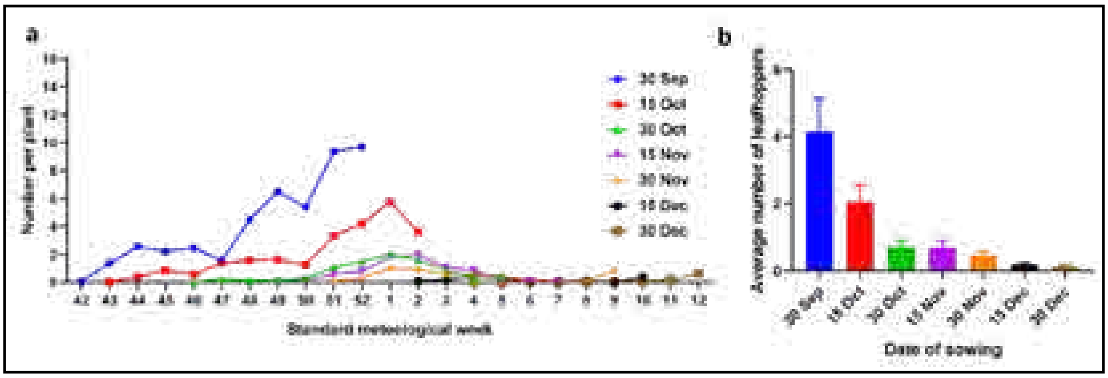
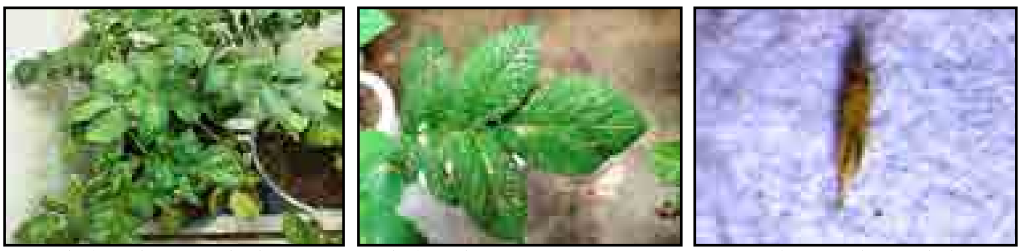


Fig. 5: a. Leafhopper population dynamics across Standard Meteorological Weeks (SMWs) and b. average number of Leafhopper s across different sowing dates

In conclusion, mean insect counts across various planting dates exhibited notable variations, emphasizing the dynamic nature of pest populations during different periods. Peaks and fluctuations in infestation levels underscored the critical role of planting timing in influencing insect incidence on potato plants. These findings highlight the importance of strategic planting practices for effective pest management in potato cultivation.

Identification of thrips species infesting potato under glasshouse conditions at Shimla

The potato plants cultivated in glasshouses in Shimla suffered significant damage from thrips. Damage begins at the midrib and extends to the entire leaf blade in cases of severe infestation (**Fig. 6**). Individuals' thrips DNA was isolated using DNeasy Blood & Tissue Kits (Qiagen, Germany) by following manufacturer guidelines. The mitochondrial cytochrome oxidase subunit I gene (*mtCOI*) was amplified through polymerase chain reaction (PCR) by using LCO (5'GGT CAACA AATCA TAAAGATATTGG3') and HCO (5'TAA ACTT CAG GGTG ACCA AAA AA TCA3') primers. The PCR reaction included 10 µl of 2x EmeraldAmp GT PCR Master Mix (Takara, India), 1 µl of each forward and reverse primers (10 pmol/ µl), 20 ng of DNA template and the nuclease free water was added to make the final reaction volume 20 µl. The PCR conditions were as followed: A four min initial denaturation at 94°C then 35 cycles of 94°C for 30 sec, 50°C for 30 sec and 72°C for 45 sec as denaturation, annealing and extension and also a final extension was also given at 72°C for 7 min. The PCR products were visualized on 1% agarose gel stained with ethidium bromide. The DNA bands of ~ 650 bp appeared on gel which were excised and purified using GeneJET PCR Purification Kit (Thermo Scientific) by following the manufacture manual. A 624 bp clean sequence was then used for BLAST analysis and the mtCOI sequence had 100% identity with *Thrips tabaci* sequences available at genbank (Accession no. MN036456.1, OR136282.1, JX403009.1 and KY674342.1). The thrips species was identified as *Thrips tabaci.*



Thrips damaged plant **Thrips damage symptoms** ***Thrips tabaci* adult**

Fig. 6: Damage symptoms by Thrips tabaci and adult specimen

Comparative trends in aphid and coccinellid beetle populations in early and main potato crop

Two species of Coccinellid beetles namely *Coccinella septempunctata* and *Paranaemia vittigera* were observed on the potato crop. Observations on their population on September (Early) and October (Main) planted crops were done along with grubs and other unidentified coccinellid beetles (**Fig.7**). Their populations fluctuated over time. Additionally, we also observed fluctuations in the populations of grubs and other coccinellid beetles during the monitoring period (**Fig.8**).

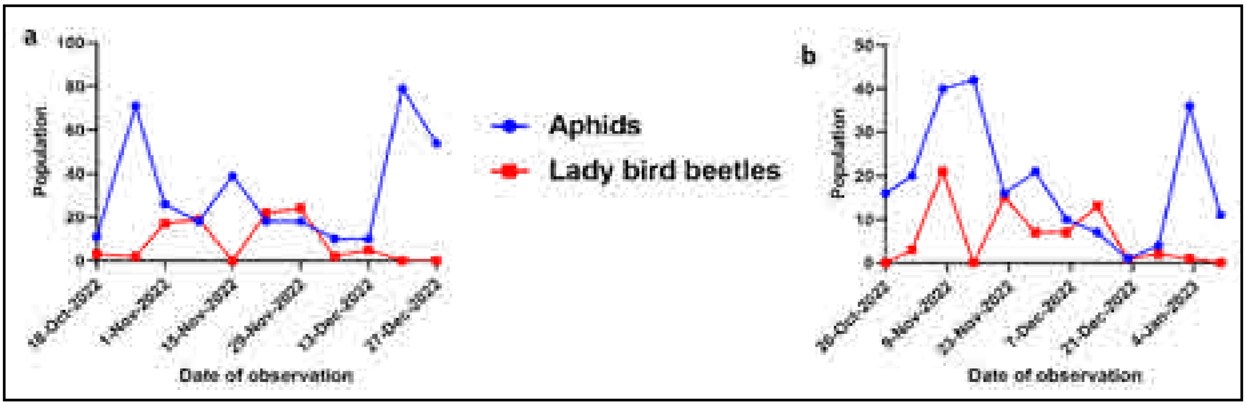


Fig. 7: Comparative trends in aphids and coccinellids population on a) September and b) October planted potato crop

Correlation has been worked out between aphid population and coccinellid beetle population. For the crop planted in September, the correlation analysis revealed a correlation coefficient (Pearson's r) of -0.4780, indicating a moderate negative relationship between the aphid population and coccinellid beetle population. The correlation analysis showed a weak positive correlation between the aphid population and coccinellid beetle population, with a Pearson's correlation coefficient (r) of 0.1743 ($p = 0.5881$) for the October planted crop.

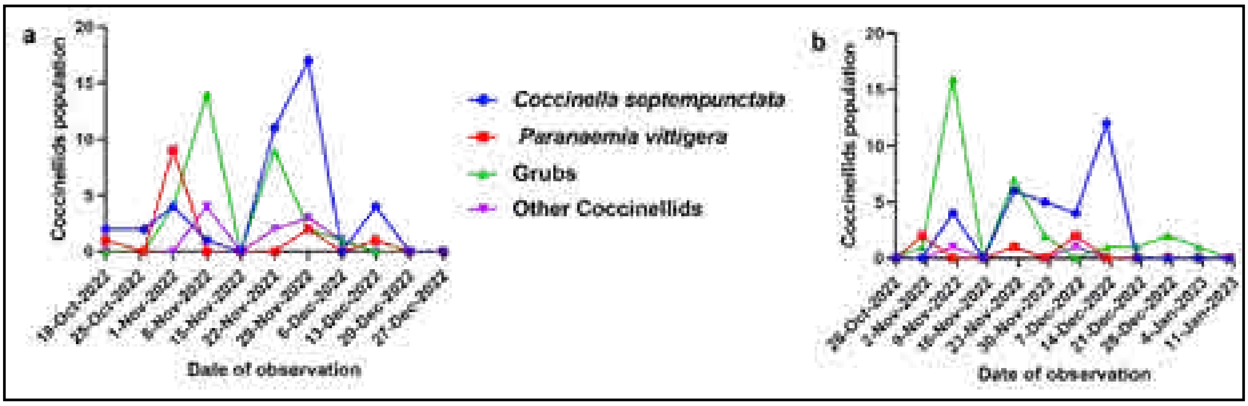


Fig. 8: Coccinellids population on a) September and b) October planted potato crop

II. Studies on Phyto-semio Chemicals Involved in Insect-plant Interactions of Major Potato Pests –PTM

Co-occurrence and correlation analysis of aphids, whiteflies, and leafhoppers on potato crop

The objective of this study was to investigate the occurrence of aphids, whiteflies, and leafhoppers on potato crops, with a focus on their co-existence on the same plant. The study aimed to analyze relationship between the populations of these three sucking insect pests to understand their potential interactions.

Aphids vs. Whiteflies: The correlation between aphids and whiteflies was weak and not statistically significant (r = 0.07650, p = 0.1266). The linear regression analysis showed a non-significant relationship between the two pests (Y = 0.03197*X + 0.1903). The coefficient of determination (R^2) was 0.005852, suggesting only 0.59% of the variation in whiteflies could be explained by aphids (**Fig. 9**).

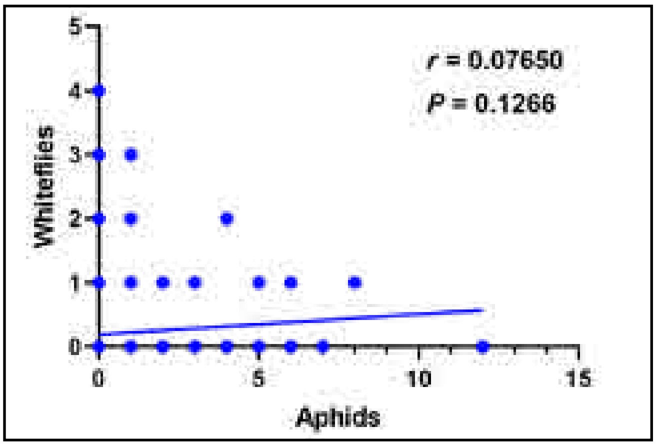


Fig. 9: *T*emporal Dynamics of Aphids and Whiteflies: Illustrating Non-Correlative trends through Scatter Plots

Aphids vs. Leafhoppers: There was a very weak and non-significant negative correlation between aphids and leafhoppers (r = -0.02236, p = 0.6557). The linear regression analysis indicated a non-meaningful relationship (Y = -0.04638*X + 2.220). The coefficient of determination (R^2) was 0.0005000, suggesting only 0.05% of the variation in leafhoppers could be explained by aphids (**Fig. 10**).

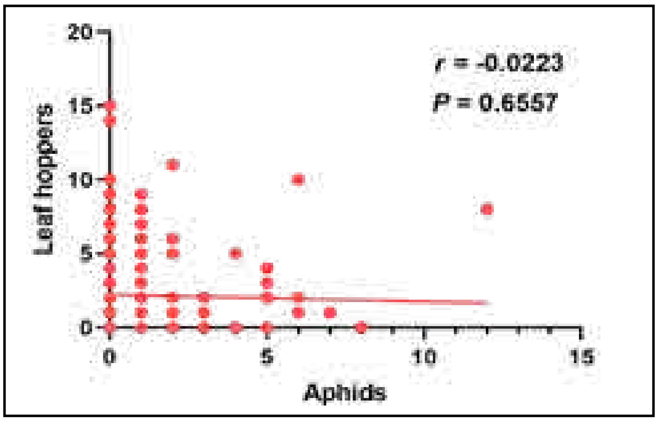


Fig. 10: Temporal dynamics of aphids and leafhoppers: Illustrating non-correlative trends through Scatter Plots

Whiteflies vs. Leafhoppers: The correlation between whiteflies and leafhoppers was weak and not statistically significant (r = -0.09807, p = 0.0500). The linear regression analysis showed a non-significant relationship (Y = -0.4867*X + 2.296). The coefficient of determination (R^2) was 0.009617, indicating only 0.96% of the variation in whiteflies could be explained by leafhoppers (**Fig. 11**).

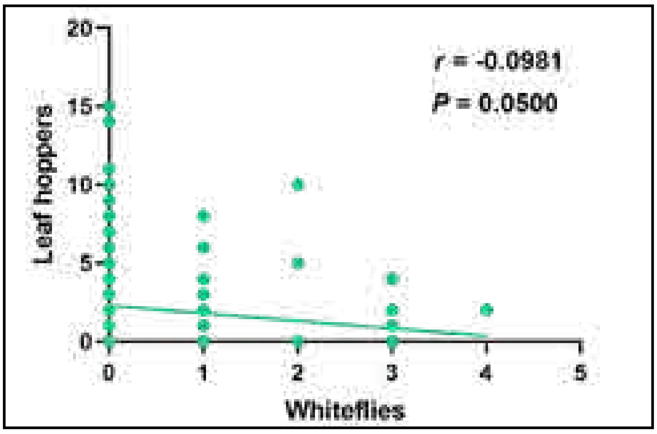


Fig. 11: Temporal dynamics of whiteflies and leafhoppers: Illustrating non-correlative trends through Scatter Plots

In summary, there were weak and non-significant correlations between aphids and whiteflies, aphids and leafhoppers, as well as whiteflies and leafhoppers on the potato crop. The linear regression analyses did not reveal meaningful relationships between these pest populations.

Evaluation of aphid and whitefly incidence on different varieties of potato

Ten potato varieties were used as treatments, including K. Kiran, K. Sangam, K. Chipsona 1, K. Frysona, K. Khyathi, K. Mohan, K. Lohit, K. Lima, K. Surya, and K. Bahar.

Aphids: The analysis revealed that the effect of different potato varieties on the aphid population was not statistically significant (F = 2.459, p = 0.1087), indicating that the choice of potato variety did not significantly impact the aphid population. However, the matching of weekly mean aphid population across different potato varieties was highly effective (F = 21.31, p < 0.0001), suggesting successful subject matching. The mean aphid counts varied among the different varieties, ranging from 1.848 to 5.878. "K. Frysona" had the highest mean aphid count, while "K. Lohit" had the lowest mean aphid count (**Fig. 12**).

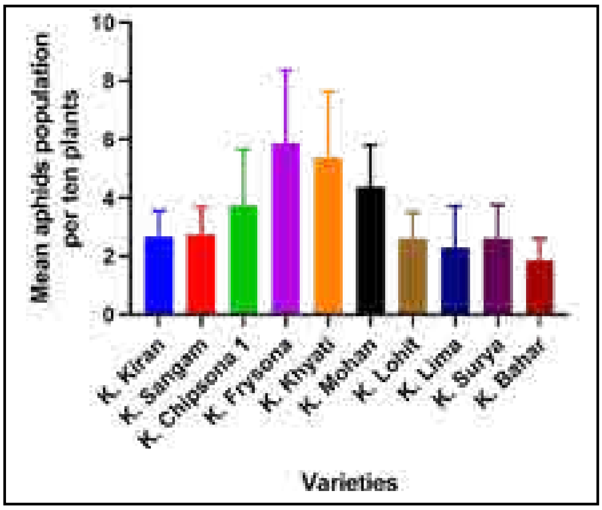


Fig. 12: Mean aphid incidence across different potato varieties

Whiteflies: The analysis revealed that the effect of different potato varieties on the whitefly population was not statistically significant ($F = 2.552$, $p = 0.0822$), indicating that the choice of potato variety did not significantly impact the whitefly population. However, the matching of weekly mean whitefly population across different potato varieties was highly effective ($F = 64.69$, $p < 0.0001$), indicating successful subject matching. The mean whitefly counts varied among the different varieties, ranging from 3.485 to 5.819. "K. Kiran" had the highest mean whitefly count, while "K. Lohit" had the lowest mean whitefly count (**Fig. 13**).

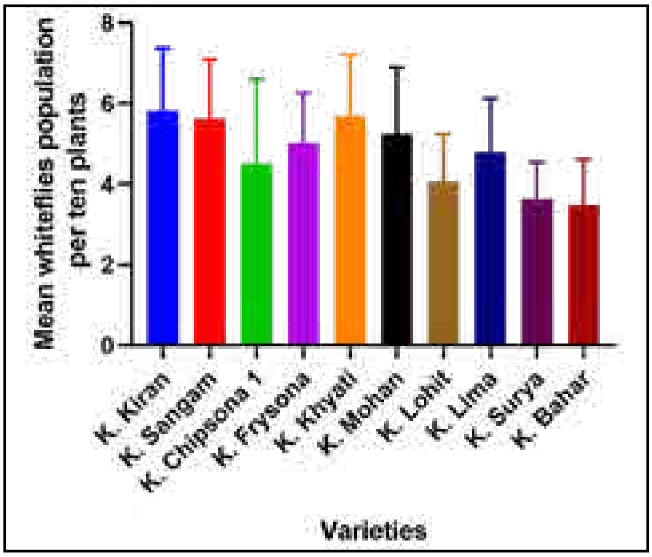


Fig. 13: Mean whiteflies incidence across different potato varieties

The analysis of aphid and whitefly populations in relation to different potato varieties did not show statistically significant differences. The choice of variety did not significantly impact the infestation levels of these pests. Additional research may be needed to explore other factors influencing aphid and whitefly populations in potato crops and to develop effective pest management strategies.

Influence of *Bemisia tabaci* on *Tuta absoluta* host choice

In this study, we discovered that *Tuta absoluta*, a co-existing pest of potato, exhibited significant attraction towards potato plants damaged by *Bemisia tabaci*. Through olfactometer assays and Electroantennogram (EAG) studies, we determined that this attraction was mediated by the volatile compounds emitted by *B. tabaci*-induced potato plants (**Fig. 14**). Gas Chromatography-Mass Spectrometry (GC-MS) analysis further unveiled notable alterations in the volatile composition between *B. tabaci* - induced and uninfested potato plants. Moreover, Gas Chromatography coupled with Electroantennogram Detector (GC-EAD) analysis elucidated that *T. absoluta* responded to four specific compounds present in the volatiles emitted by *B. tabaci*-infested potato plants. Collectively, our findings highlight that damage caused by *B. tabaci* induces changes in the volatile profile of potato plants, rendering them more appealing to *T. absoluta*.

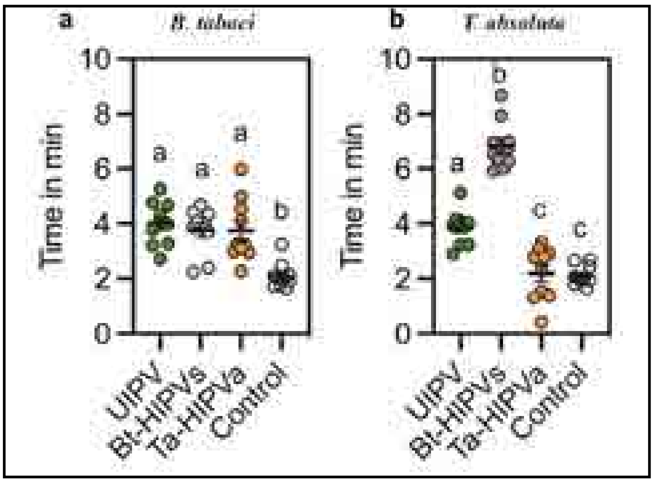


Fig. 14: Olfactometer response of a. B. tabaci and T. absoluta to UIPV- Uninfested Potato volatile; Bt-HIPVs- B. tabaci infested potato volatile; Ta-HIPVa-T. absoluta infested potato volatile

Effect of intercropping and border cropping on whitefly incidence in potato plants

The objective of this study was to assess the impact of intercropping with garlic and border cropping with mustard on whitefly incidence in potato plants, comparing the results with a control plot containing only potato. The analysis revealed no significant difference in whitefly incidence between T1 (Intercropping and Border Cropping) and T2 (Control) during the 50-day crop growth period (P = 0.5971). Intercropping with garlic and border cropping with mustard did not significantly affect whitefly incidence in potato plants compared to the control plot.

III. Conventional and Novel Strategies for the Management of Insect Pests of Potato

Seasonal evaluation of insect pest incidence on potato crop with IPM and without IPM practices

The study aimed to assess the effectiveness of IPM practices in reducing insect pest populations and minimizing the occurrence of viral diseases in the potato crop. In the IPM plots, the potato crop was bordered with two rows of mustard and two rows of maize. Both IPM and non-IPM plots received treatments of neem soap (7 g per litre of water) at 30 days after sowing (DAS) and pongamia soap (7 g per litre of water) at 50 DAS. Yellow sticky traps were installed in the IPM plots to monitor flying insect populations. The IPM plots were also rogued for diseased plants, similar to the non-IPM plots. Imidacloprid (0.04%) was used as a seed treatment in both IPM and non-IPM plots.

Aphids: The unpaired t-test revealed no significant difference (p = 0.3817) in the average number of aphids between the IPM and non-IPM treatment groups. The descriptive statistics show that IPM treatment group had a lower average aphid incidence (mean = 6.481) compared to the non-IPM treatment group (mean = 11.11). The aphid incidences in the IPM group ranged from 0 to 35, while in the non-IPM group, they ranged from 2.67 to 34 (**Fig. 15**).

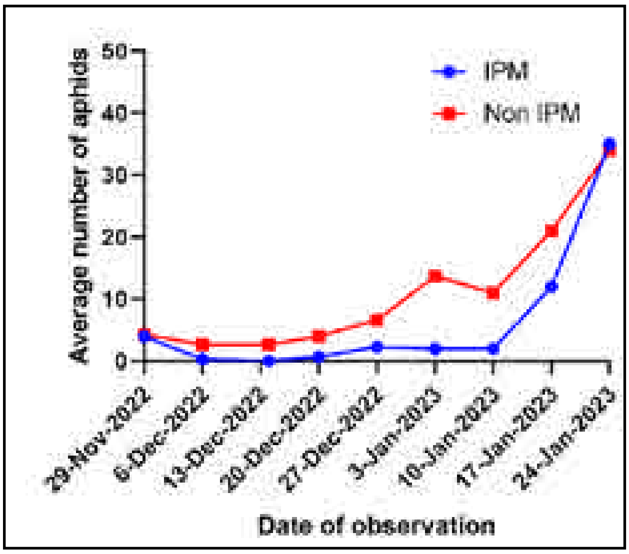


Fig. 15: Aphid's population dynamics at weekly intervals in IPM and non IPM plots

Whiteflies: The unpaired t-test results for whiteflies indicate no significant difference (p = 0.1196) in the average number of whiteflies between the IPM and non-IPM treatment groups. The descriptive statistics reveal that, on average, the IPM treatment had a mean of 6.073 insects, while the non-IPM treatment had a slightly higher mean of 8.702 insects (**Fig. 16**).

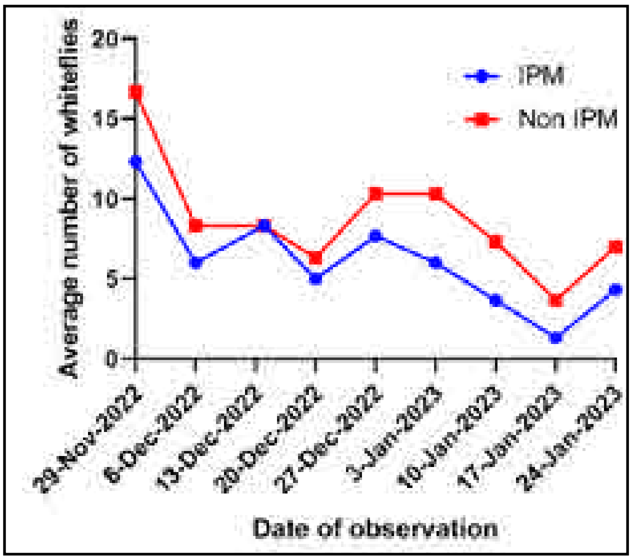


Fig. 16: Whiteflies population dynamics at weekly intervals in IPM and non IPM plots

Leafhoppers: The unpaired t-test results for leafhoppers show a significant difference (p = 0.0405) in the average number of leafhoppers between the IPM and non-IPM treatment groups. The descriptive statistics reveal that the IPM treatment group had a lower average number of leafhoppers (mean = 2.260) compared to the non-IPM treatment group (mean = 5.223). The data further demonstrates that the range of leafhopper incidences was narrower in the IPM group (0.000 to 3.000) compared to the non-IPM group (0.670 to 12.000) (**Fig. 17**).

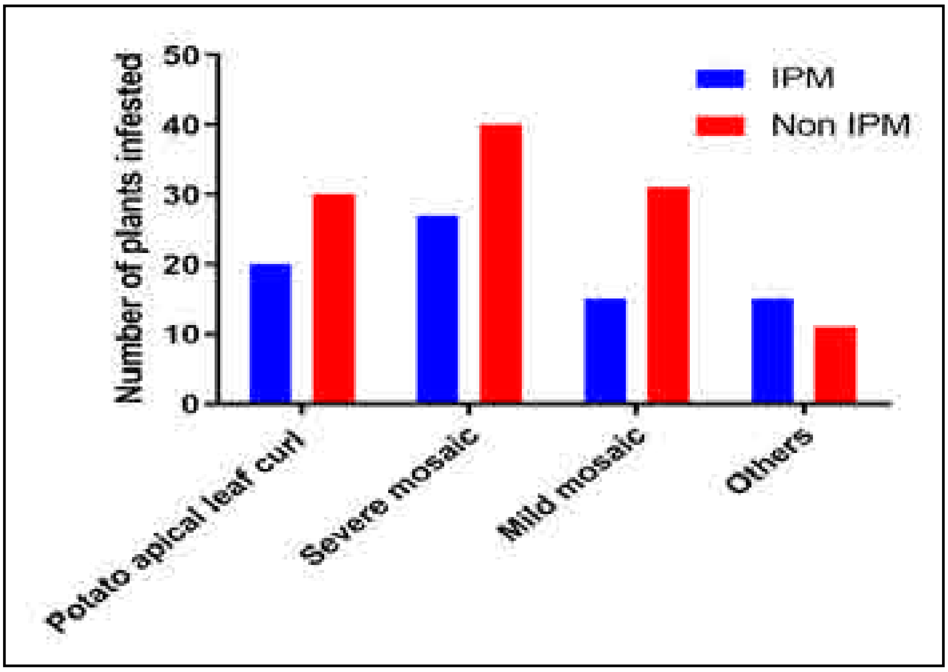


Fig. 17: Leafhopper population dynamics at weekly intervals in IPM and non IPM plots

Diseases: Based on the data provided, the IPM treatment group had fewer diseased plants compared to the non-IPM treatment group for Potato Apical Leaf Curl (20 vs. 30) and severe mosaic (27 vs. 40). However, for mild mosaic and others, the non-IPM treatment group had slightly higher numbers (31 vs. 15 and 11 vs. 15, respectively) (**Fig. 18**).

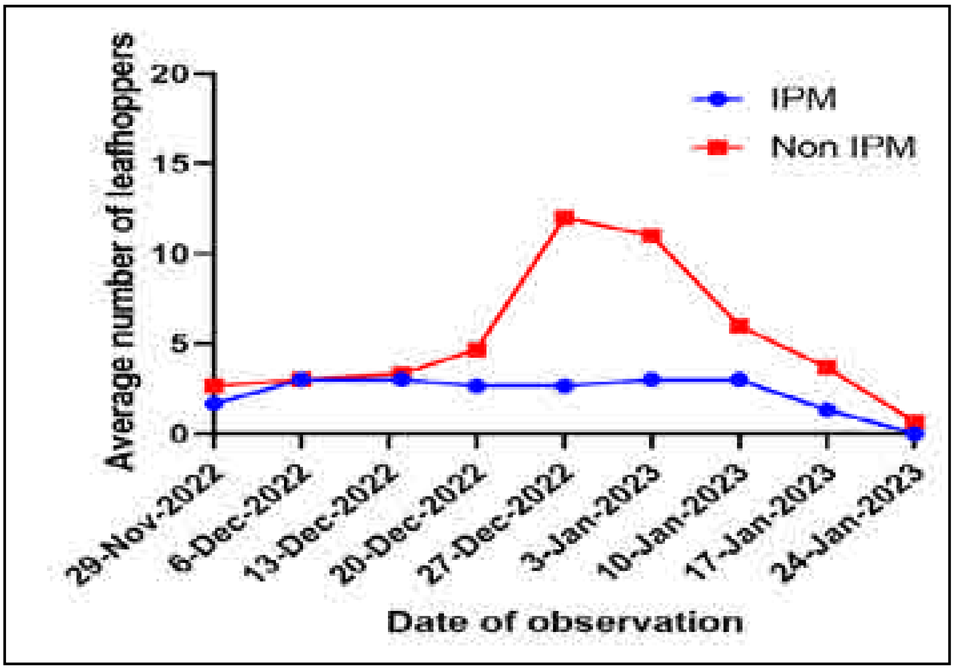


Fig. 18: Number of diseased plants in IPM and non IPM plots

Effect of soil application of granular insecticides at planting on whitefly populations in potato crop

The objective of this study was to investigate the impact of soil application of granular insecticides at the time of planting on whitefly populations over a 50-day period after planting or treatment. The data analysis revealed no statistically significant differences in whitefly populations among the five treatments at any specific time point. Additionally, the repeated measures one-way ANOVA showed no significant effect of treatments on whitefly populations over the entire 50-day period (F = 0.2469, P = 0.7822).

Evaluation of insecticides against white grub at Fagu, Shimla

Seven insecticides were tested against white grub, at Kufri-Fagu (Shimla) from May – September 2023. Every treatment was administered in two doses, the first being administered during planting and the second during earthing up. The percentage of tuber damage (df=7, F=11.91, p=0.001) and weight loss (df=7, F=12.42, p<0.001) varied significantly between the treatments. While the percentage of weight loss varied from 1.72±0.62% to 43.11±6.40%, the percentage of tuber damage ranged from 0.93±0.44% to 36.67±6.55%. While the control group recorded the greatest weight loss and tuber damage, treatment T4 (Clothianidin 50WDG) showed the least amount of both. Nonetheless, it was observed that treatments T7 (chlorpyrifos 20EC) was equally effective as treatment T4 in preventing tuber damage and causing weight reduction (**Fig. 19**). When it comes to managing white grub damage in potato cultivation in hilly terrain, the Clothianidin 50WDG has a lot of potential.

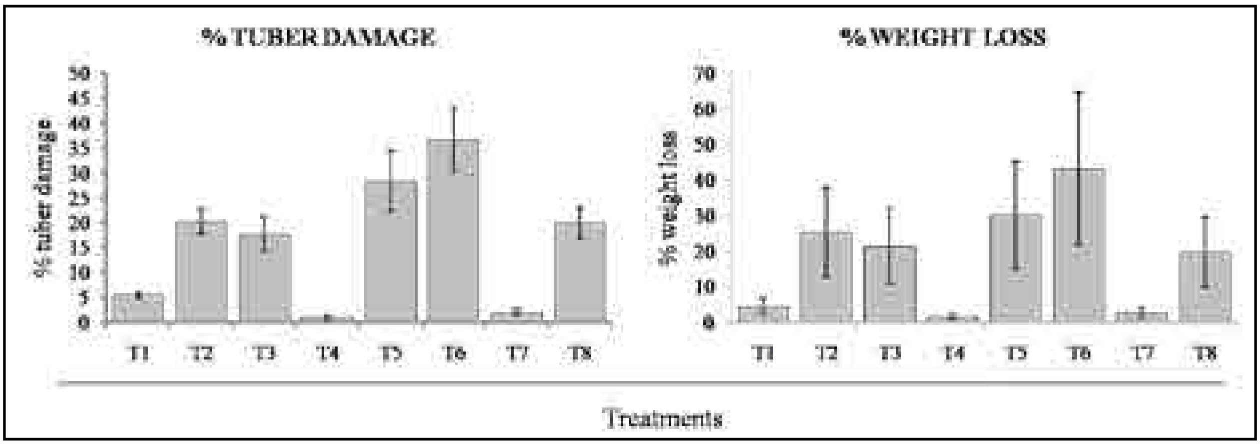


Fig. 19: Percent tuber damage and percent weight loss observed among the treatments evaluated. (T1: Fipronil + Imidacloprid 40WG @ 500g/ha, T2: Cartap Hydrochloride @18.7 kg/ha, T3: Cartap Hydrochloride @25 kg/ha, T4: Clothianidin 50WDG @250 g /ha, T5: Fipronil 00.30 % GR @33 kg/ha, T6: Fipronil 00.30 % GR @25 kg/ha, T7: Chlorpyrifos 20 % EC @2.5 lt/ha), T8: Control)

Isolation, pathogenicity and identification of entomopathogenic fungi infecting Myzus persicae

Aphids collected from Pantnagar were checked for the entomopathogenic fungi and suspected aphids having entomopathogenic infections were directly transferred over potato dextrose agar plates supplemented with streptomycin @ 10µg/ml and chloramphenicol @ 25mg/ml. The isolated fungi were sub-cultured and purified. Spore of the fungal cultures were harvested by flooding the Petri plates with water and the spore suspension (~10^5 spores / ml) was applied over the *Myzus persicae* aphids to confirm its pathogenicity. The Chinese cabbage plants with *M. persicae* treated with fungal spore were covered by 5 liter transparent cello jars to maintain humidity and kept in a glasshouse with temperature ranging from 24±4°C. The infection of the entomopathogenic fungus was noted after 3rd day of inoculation and the aphid's body was completely covered with mycelia after 5- 6 days of inoculation (**Fig. 20**). Identification of the fungus was done by amplification and sequencing of two regions viz., nuclear ribosomal internal transcribed spacer (ITS) region and large-subunit rRNA (**LSU**) gene. One primers pair targeting internal transcribed spacer (ITS) region (ITS-1 5'-TCCGTAGGTGAACCTGCGG-3'ITS-4 5'-TCCTCCGCTTAT TGATATGC-3') was used for amplification of genomic DNA. Whereas LSU gene was amplified using forward primer LROR 5'-ACCCGCTGAACTTAAGC-3' and reverse primer LR5 5'-TCCTGAGGGAAACTTCG-3'. The fungus was identified as *Akanthomyces dipterigenus*. Initial screening suggests that this fungus has a potential to be used as bio- control agent against *M. persicae*.

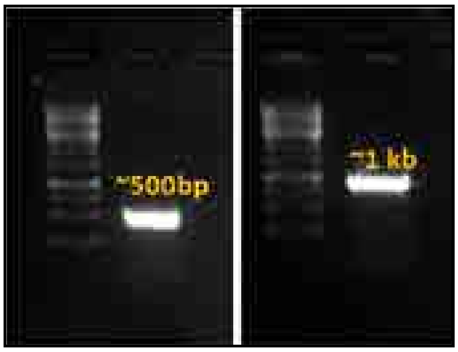
Mummified aphid collected from field

Isolated fungi on PDA

Mycelial growth of fungi after 3rd day of infection

Mummified *M. persicae* after 6th day of infection

Fungal spores



Amplification of 500bp ITS region and 1kb region of LSU

Fig. 20: Isolation pathogenicity and spore morphology of entomopathogenic fungus collected from Pantnagar (Uttarakhand)

Mechanism of resistance to neonicotinoids in Myzus persicae

As per the last year's information, some populations have shown moderate level of resistance, while a few numbers have developed a high level of resistance. To comprehend the mechanism of resistance, two mechanisms were investigated. First, a point mutation (R81T) was found in the nicotinic acetylcholine receptor (nAChR) D-loop region. This mutation has the potential to cause *M. persicae* to become highly resistant to imidacloprid. In a high-throughput TaqMan PCR assay, over 270 individuals from 18 geographically distinct *M. persicae* populations were examined for the R81T point mutation using a protocol previously developed by Puinean et al (2013). Based on our findings, every individual who underwent testing for the R81T mutation discovered a recessive wild-type allele. When the cytochrome p-450 gene, CYP6CY3, was examined for expression in the *M. persicae* populations, it was found to have a substantial positive connection with the neonicotinoids' LC50 value. We silenced the CYP6CY3 gene by directly administering 501 bp dsRNA of CYP6CY3 gene to the aphid abdomen in order to confirm the gene's involvement in neonicotinoid resistance. In this manner, the CYP6CY3 gene was silenced, and aphid mortality rose markedly when such aphids were exposed to LC50 levels of neonicotinoids. These results provide compelling evidence that the CYP6CY3 gene contributes to neonicotinoids resistance.

Project 2. Biology, Ecology and Management of Nematodes Pests of Potato

Studies on potato cyst nematode (*Globodera* spp.) management strategies

Different potato cyst nematode management strategies as detailed in **Table 1, 2 and 3** were followed at PCN sick fields of Kufri Farm to see their effect on PCN population dynamics (Three years pooled data w.e.f. 2021-2023). Among the treatments (**Table 1**), significantly less nematode reproduction factor (Rf = Fp/Ip) was recorded in the treatment **T_7**: Application of *Bacillus cereus* SGL6 @ 30 kg/ha with Trap crop (35 DAP) followed by non-host crop (Mustard) followed by Fallow (**Rf: 0.26**). The next best treatments were **T_2:** Trap crop (35 DAP) followed by antagonistic crop (Marigold) followed by fallow (**Rf: 0.29**), **T_4:** Application of ARL @ 5 lit/m^2 followed by non-host crop (Mustard) followed by fallow (**Rf: 0.32**) and **T_6:** Application of Nimitiz @ 50kg/ha, 50% at the time of planting of trap crop and 50% Nimitiz at the time of planting of non-host crop (Mustard) followed by fallow (**Rf: 0.32**) treatments by giving 58.9% (T_7), 54.6% (T_2) and 50.4% (T_4 & T_6) reduction of cyst population over the fallow treatment (**T_8**) (**Fig. 21**).

Table 1: Effect of soil treatments in combination with trap crop on PCN population

T_1 :	Trap crop (35 DAP) followed by non-host crop (Mustard) followed by fallow
T_2 :	Trap crop (35 DAP) followed by antagonistic crop (Marigold) followed by fallow
T_3 :	Trap crop (35 DAP) followed by application of Dazomet (Basamid 95G) @ 5q/ha (50 gm/m^2) for 10 days followed by non-host crop (Mustard) followed by fallow
T_4 :	Application of ARL @ 5 lit/m^2 followed by non-host crop (Mustard) followed by fallow
T_5 :	Application of Nimitiz @ 50 kg/ha (100% dose) with trap crop (35 DAP) at the time of planting followed by non-host crop (Mustard) followed by fallow
T_6 :	Application of Nimitiz @ 50 kg/ha, 50% at the time of planting of trap crop and 50% Nimitiz at the time of planting of non-host crop (Mustard) followed by fallow
T_7 :	Application of *Bacillus cereus* SGL6 @ 30 kg/ha with Trap crop (35 DAP) followed by non-host crop (Mustard) followed by fallow
T_8 :	Fallow

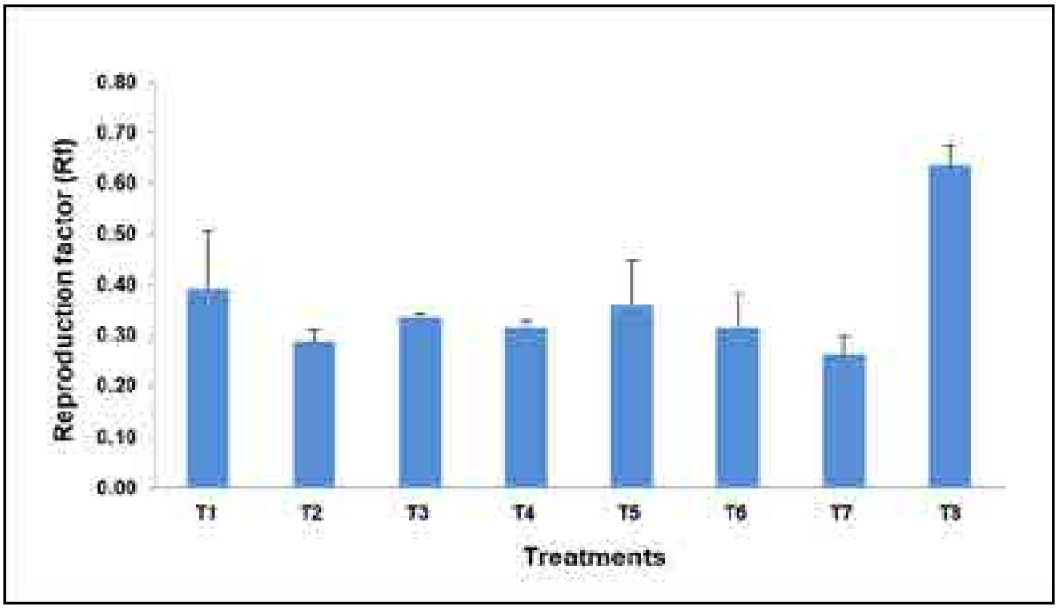


Fig. 21: Effect of soil treatments in combination with trap crop on PCN population

Out of ten treatments evaluated (**Table 2**), T3: Planting of resistant hybrid (SM/11-120) followed by fallow, recorded significantly less PCN reproduction factor (Rf: 0.40) followed by T9: Application of *Bacillus cereus* SGL6 @ 30 kg/ha with moderately resistant variety (Kufri Karan) at the time of planting followed by fallow (Rf: 0.61) and T8: Application of *Bacillus cereus* SGL6 @ 30 kg/ha with susceptible variety (Kufri Jyoti) at the time of planting followed by fallow (Rf: 0.63) by giving 77.4% (T_3), 65.8% (T_9) 63.1% (T_8) reduction of cyst populations over the T_2 treatment (**Fig. 22**).

Table 2: Evaluation of genotypes along with nematicides and bioagent against PCN

T_1 :	Alone planting of moderately resistant variety (Kufri Karan) followed by fallow
T_2 :	Alone planting of susceptible variety (Kufri Jyoti) followed by fallow
T_3 :	Alone planting of resistant advance hybrid (SM/11-120) followed by fallow
T_4 :	Application of Nimitiz @ 50kg/ha, 100% at the time of planting of moderately resistant variety (Kufri Karan) followed by fallow
T_5 :	Application of Nimitiz @ 50kg/ha, 50% at the time of planting of moderately resistant variety (Kufri Karan) and 50% during earthing up followed by fallow
T_6 :	Application of Nimitiz @ 50kg/ha, 100% at the time of planting of susceptible variety (Kufri Jyoti) followed by fallow
T_7 :	Application of Nimitiz @ 50kg/ha, 50% at the time of planting of susceptible variety (Kufri Jyoti) and 50% during earthing up followed by fallow
T_8 :	Application of *Bacillus cereus* SGL6 @ 30 kg/ha with susceptible variety (Kufri Jyoti) at the time planting followed by fallow
T_9 :	Application of *Bacillus cereus* SGL6 @ 30 kg/ha with moderately resistant variety (Kufri Karan) at the time planting followed by fallow
T_{10} :	Fallow

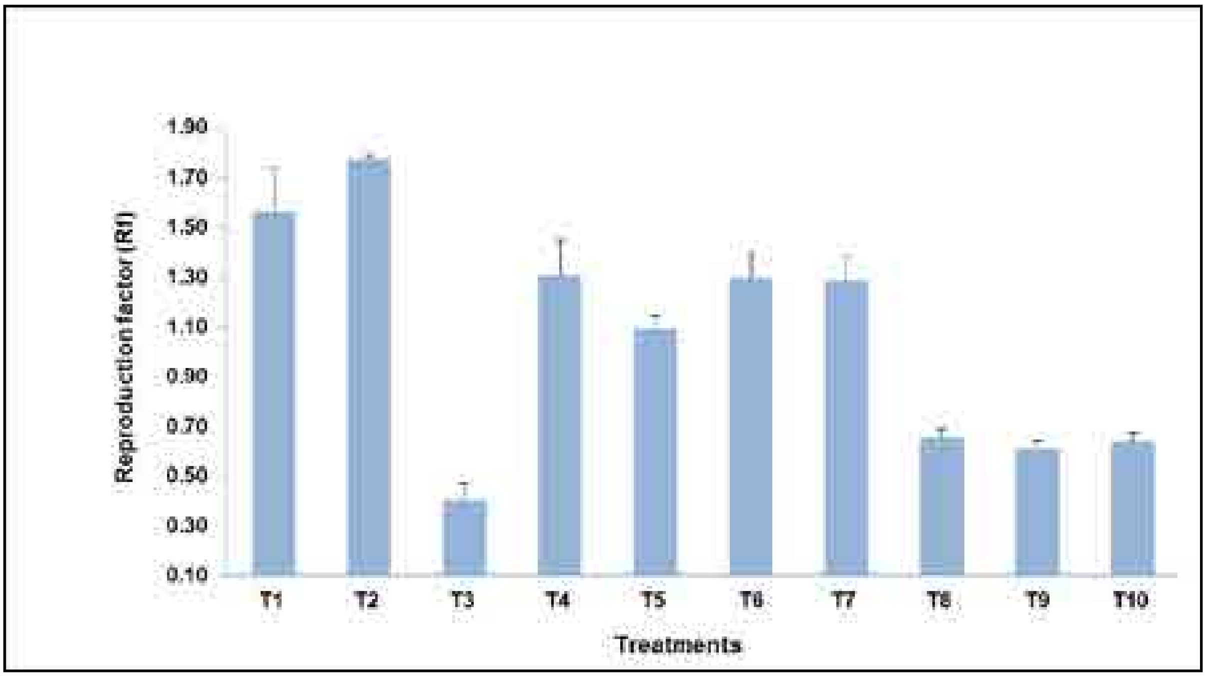


Fig. 22*:* Evaluation of genotypes along with nematicides and bio agent against PCN

Out of eight treatments evaluated (**Table 3**), significantly less nematode reproduction factor (Rf) was recorded in the treatment T_5: Application of bleaching powder @ 40kg/ha followed by fallow (Rf: 0.26) followed by T_6: Application of bleaching powder @ 40 kg/ha followed by non-host crop (Rajmash) followed by fallow (Rf: 0.29), and T_7: Application of bleaching powder @ 40kg/ha followed by non-host crop (Oat) followed by fallow (Rf: 0.31) by giving 58.5% (T_5), 55.2% (T_6) and 51.5% (T_7) reduction of cyst population over the untreated fallow treatment (T_8) (**Fig. 23**).

Table 3: Evaluation of bleaching powder along with host and non-host crop against PCN population

T_1 :	Application of bleaching powder @ 40kg/ha with moderately resistant variety (Kufri Karan) at the time planting followed by fallow
T_2 :	Application of bleaching powder @ 40kg/ha with susceptible variety (Kufri Jyoti) at the time planting followed by fallow
T_3 :	Trap crop (35 DAP) followed by application of bleaching powder @ 40kg/ha by fallow
T_4 :	Application of bleaching powder @ 40kg/ha with trap crop (35DAP) followed by fallow
T_5 :	Application of bleaching powder @ 40kg/ha followed by fallow
T_6 :	Application of bleaching powder @ 40kg/ha followed by non host crop (Rajmash) followed by fallow
T_7 :	Application of bleaching powder @ 40kg/ha followed by non host crop (Oat) followed by fallow
T_8 :	Fallow

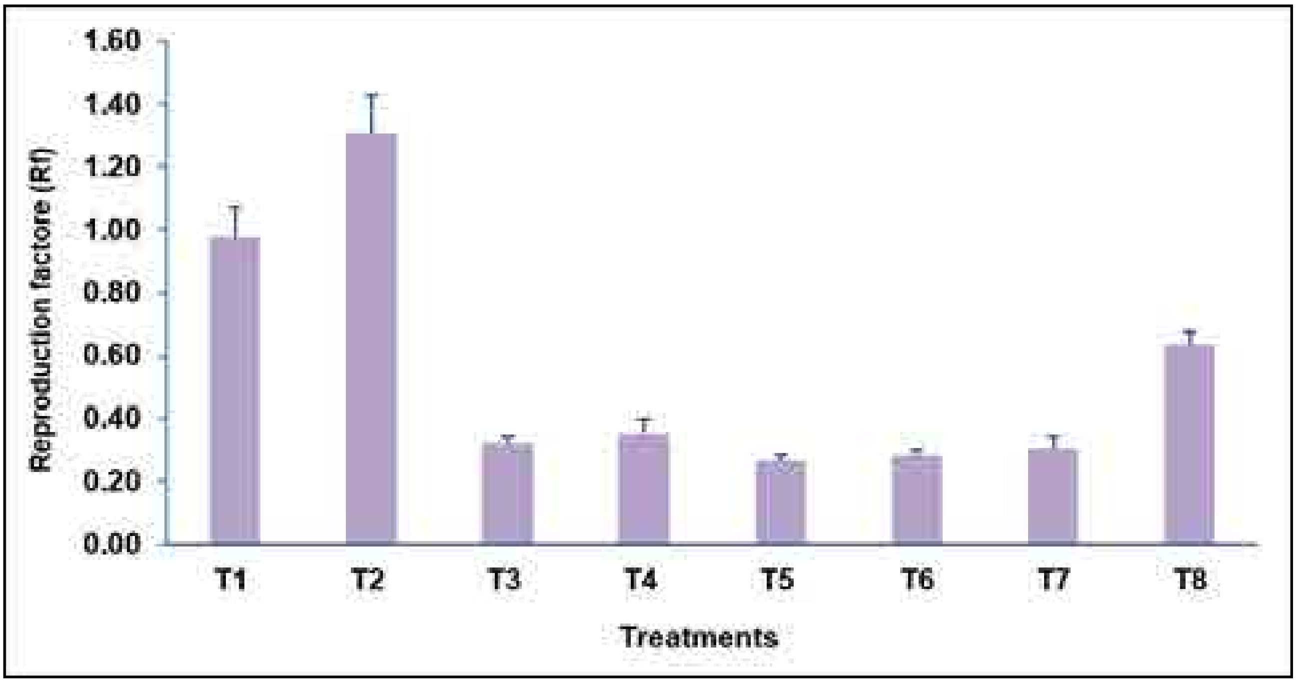


Fig 23: Evaluation of bleaching powder along with host and non-host crop on PCN population

Effect of different cropping systems on PCN population dynamics

After following four years (2019-2022) of management strategies at Kufri Farm, growing Oat-Mustard- Mustard-Trap cropping system resulted in maximum reduction (74.3%) of PCN population followed by Mustard-Rajmash-Trap-Rajmash (73.5%) and Potato-Oat-Trap-Mustard (55.9%). In Fagu farm, Mustard-Rajmash-Trap-Rajmash cropping system resulted in maximum reduction (77.7%) followed by Oat-Mustard-Mustard-Trap (70.4%) and Trap-Trap-Potato-Oat (68.8%) cropping systems (**Table 4**).

Table 4: Effect of different cropping systems on PCN population dynamics

Block	Kufri Farm				
	Year / Crop				Decrease (%) in PCN population
	2019	**2020**	**2021**	**2022**	
1	Trap	Potato	Oat	Trap	-44.3
2	Trap	Trap	Potato	Oat	-43.7
3	Rajmash	Trap	Rajmash	Potato	-18.6
4	Mustard	Rajmash	Trap	Rajmash	-73.5
5	Oat	Mustard	Mustard	Trap	-74.3
6	Potato	Oat	Trap	Mustard	-55.9
	Fagu farm				
1	Potato	Oat	Trap	Mustard	-47.3
2	Trap	Potato	Oat	Trap	-65.9
3	Trap	Trap	Potato	Oat	-68.8
4	Rajmash	Trap	Rajamsh	Potato	-34.6
5	Mustard	Rajmash	Trap	Rajmash	-77.0
6	Oat	Mustard	Mustard	Trap	-70.4

Root leachates of millets and cereals as a new hatching factor for potato cyst nematodes (PCNs)

In the present study, we found that some millets and cereals also support the hatching in PCNs. Under *in vitro* conditions, cysts of *Globodera* spp. were incubated in the root leachates of sorghum, oats, pearl millet, little millet, brown top, barnyard millet, kodo millet, foxtail millet and finger millet (collected from the 10, 20, 30, 40, 50, 60, 70 and 80 days old plant) along with potato aeroponic root leachate (ARL) collected at 30 DAP (30 days after planting) and water. Each treatment was incubated with ten cysts and replicated four times. The experiment was kept at 20 °C temperature. Initiation of PCNs hatching was observed after six days in the potato ARL, cereals as well as millet root leachates successfully (**Fig. 24**). In the case of cereals and millets, the root leachates of pearl millet (885 Nos.), sorghum (461 Nos.) and little millet (223 Nos.), produced the highest number of hatched J2s, followed by brown top millet (134 Nos.) (**Fig. 25**). It was found that the root leachates taken from the crop when it had been grown for 50, 60 and 70 days were more effective in inducing hatching. No hatching was observed in foxtail millet leachates. This is the first report globally indicating the role of millet root exudates supporting the hatching of PCNs. Current research is focused on identifying the chemical compounds that cause the hatching of PCNs.

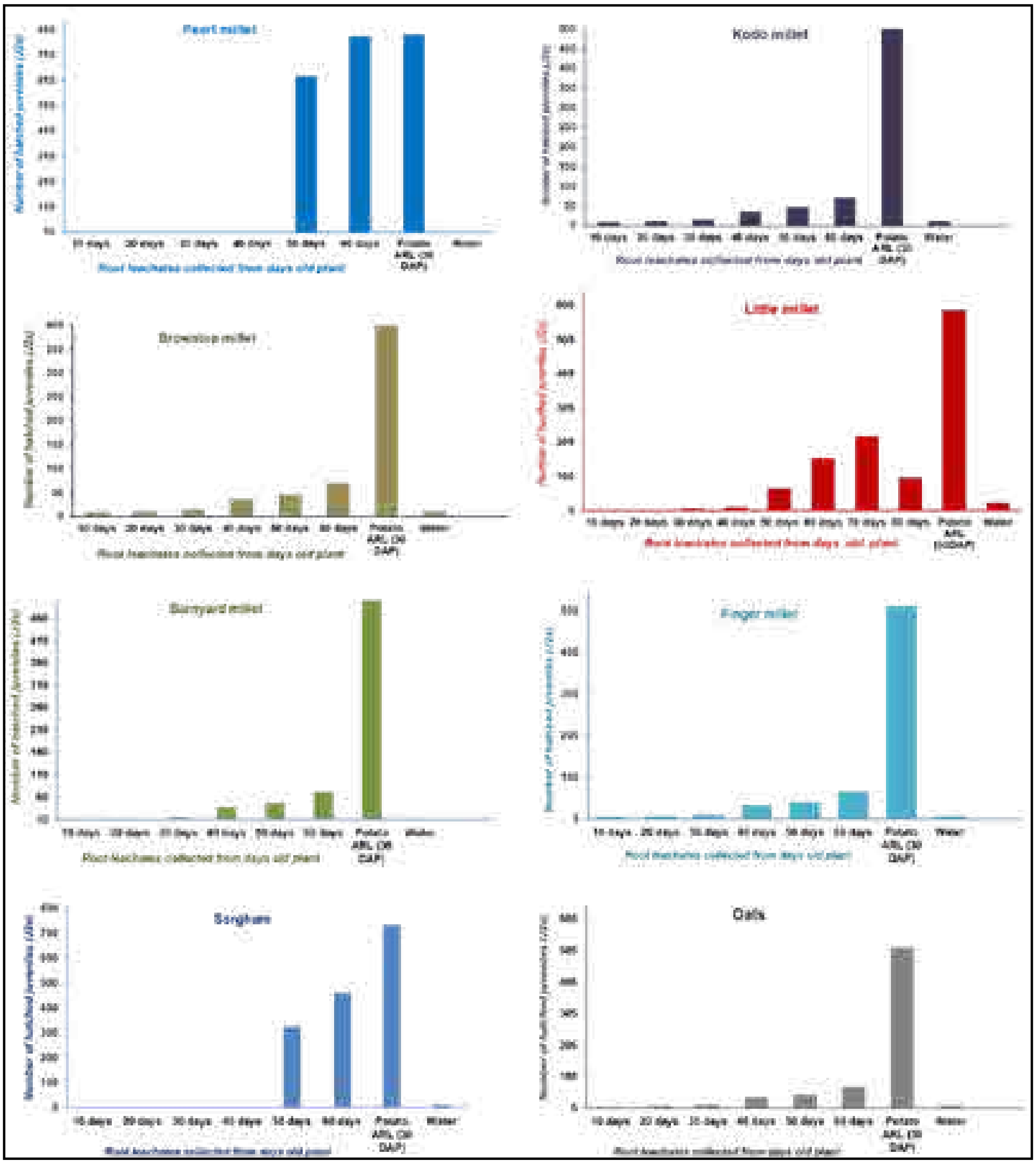


Fig. 24: Effect of different millets and cereals root exudates on PCN hatching under in vitro condition

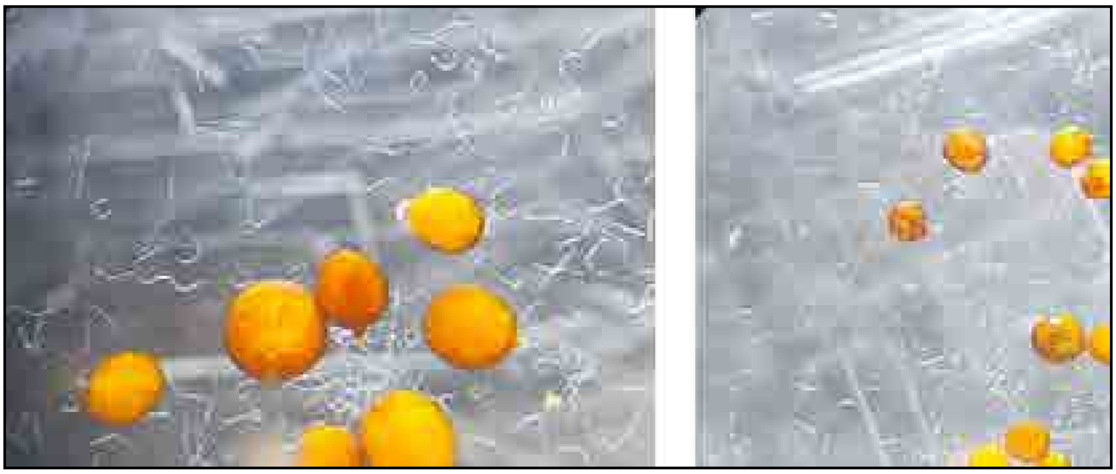


Fig. 25: *Hatched juveniles (J2s) in the root exudates, (a). Pearl millet (60 DAP); (b). Potato ARL (30 DAP)*

DIVISION OF CROP PHYSIOLOGY, BIOCHEMISTRY & POST-HARVEST TECHNOLOGY

PROGRAMME: POST-HARVEST MANAGEMENT AND NUTRITIONAL ENHANCEMENT OF POTATOES

Project 1: Developing management systems for handling and storage of potatoes for minimization of losses

Use of sprout suppressant for enhancing the storage life of potatoes (volatiles, new molecules, water based formulations and organic compounds)

Identification of promising plant based sprout suppressants

This year 7 natural oils/compounds were tested in preliminary trials in assortment of eight combinations. Efficacy of each combination was tested on 2 kg potatoes of *Kufri Chandramukhi* in PET jars stored at 10-12°C and 95% RH during April to November 2023. After adequate dilution in alcoholic solvent, each combination was applied on tubers in the form of fine mist and tested in duplicate. For comparisons one blank control in PET Jar and one in leno bag and CIPC treated samples were kept in separate chambers. At a regular interval of 15 days, lid of the jars was opened for exchange of gases. Monthly observations on sprouting (%), sprouting index, percent rotting tubers, change in skin colour, and stiffness were made throughout storage. Four combinations An, Bn, En and Hn were found highly effective. For these combinations throughout the 250 days of storage, sprouted and rotten tubers were nil, tuber eyes were remained black and there was no change in skin colour. However, in case of control samples (both PET jar and leno bags) sprouting started after 30 days of storage and reached to 100% after 90 days of storage. For other combinations (Cn, Dn, Fn, and Gn) sprouting started after 30 days of storage (Figure-1). From the texture analysis of tubers after 200 days of storage (Table-1), it was found that for CPRI formulation treated tubers, hardness, peel toughness, travel at F-max and stiffness of the tubers were similar to fresh potatoes. Likewise, tuber firmness of the CPRI formulation treated tubers and CIPC treated tubers were similar. These results indicates that the efficacy of the CPRI formulations were comparable to the CIPC.

Table 1: Texture analysis of oil treated as well as control tubers after 200 days of storage at 10-12°C

Parameters	0 Day	After 200 Days		
		Control	CIPC	CPRI Formulation (An)
Hardness (N)	42.37±4.69	65.3±6.07	53.58±4.14	42.96±4.35
Peel Toughness (N.mm)	62.63±0.34	178.93±48.36	99.41±18.23	68.97±8.86
Travel at F-max (mm)	3.09±0.39	10.62±1.73	4.38±0.64	3.47±0.18
Initial Hardness/Stiffness (N/mm)	6.5±0.69	0.9±0.37	4.36±0.9	5.6±0.57
Firmness (N/mm)	14.05±3.83	6.22±0.8	12.31±1.21	12.31±0.64

Fig. 1: Sprout suppression effect of selected ICAR-CPRI formulations on K Chandramukhi after 100 days of storage at 10-12°C (in PET jars)

Confirmatory trial of natural ingredient-based formulations on different potato varieties

During the year 2022 seven naturally occurring compounds were evaluated in different combination for their efficacy against sprout suppression in potatoes stored at 10-12°C and the best combination (Combination–A) was selected for bulk storage studies in the year 2023. The Combination A was applied on 16 varieties for sprout suppression efficacy at 10-12°C. The combination was found effective for 120 days with single application as compared to untreated control and the check of CIPC. The skin colour and firmness of the CPRI formulation (Combination-A) treated tubers remained unaltered throughout storage. Likewise, CIPC-treated tubers remained unsprouted throughout storage. (Plate 1 & 2)

Fig. 2: Effect of natural ingredient-based formulation (Combination-A) application on potato sprouting during storage at 10-12°C after 120 days of storage.

Project 2: Establishing Nutritional Significance of Potatoes

Effect of processing on Ascorbic acid and Carotenoid content of potatoes

Most bioactive compounds undergo changes during the thermal treatment of potatoes, and these changes may be determined by the process time, temperature duration and presence of water. Few varieties were cooked through boiling and microwave cooking to study the content of ascorbic acid and carotenoid, the results shown higher content in oven cooked potatoes as compared to boiled one, which could be partially contributed by evaporation of water. The cooking with and without peel also led to difference in values, with higher values in with peel cooking. Among the varieties studied, Kufri Surya had the highest ascorbic acid and carotenoid content (Fig. 3 to 6).

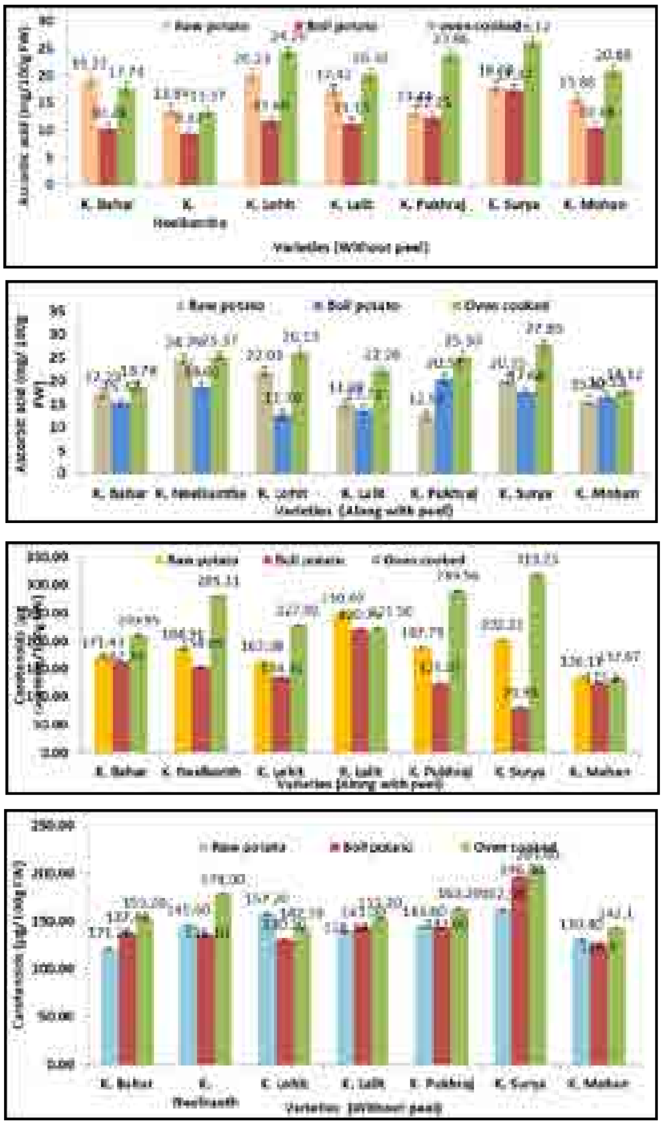


Fig. 3-6: Changes in ascorbic acid and carotenoids by different methods of cooking

Project 3: Developing custom made potato products

Potato-Bengal Gram Based boondi for raita

Boondi are tiny crunchy deep fried snack balls generally made with gram flour. After blending with the curd, ground spices and herbs these boondi's can be served as a side meal. It is usually served with *Biryani* or *pulao* but can also be served with paratha or any other flatbreads. ICAR-CPRI developed potato and black gram based boondi by replacing Bengal gram flour. Out of the several combinations evaluated, combination F was found best for *Raita* (Fig. 7). It was found that up to 75.5% of Bengal gram flour can be replaced with the blend of potato flour, arrowroot starch and black gram flour. The unique combination of ingredients makes these boondi to hold more amount of curd without any deterioration or structural deformation and long-lasting crunchiness. Besides these boondi's can be prepared from any type of potatoes. Under inert gaseous storage and absence of light and moisture conditions these boondi can be preserved up to 3 months.

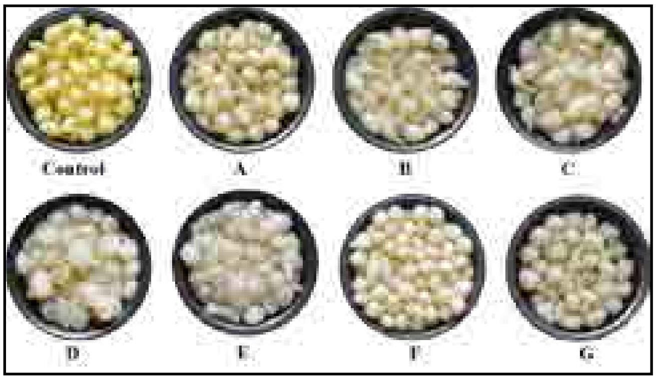


Fig. 7: Different combinations of the potato-based boondi for raita; Control-100% Bengal gram; A -36% potato flour, B-40% potato flour; C-50% potato flour; D-60% potato flour; E-70% potato flour; F-75.5% potato flour; G-80% potato flour.

Gluten-free Potato-Kodo Cookies

Millets are a type of grain with small seeds that have been cultivated and consumed by humans for thousands of years. Because of their high nutritional value and potential health benefits, these grains have sparked renewed interest in recent years. Moreover, millets are high in a variety of nutrients, including dietary fiber, protein, fat, carbohydrates, polyphenols, calcium, iron, and zinc. ICAR-CPRI has developed potato and millet (Kodo) based cookies by blending them with each other (Fig.-8). These cookies contain 37.5% part of total flour as Kodo flour and remaining part is potato flour. Developed cookies are rich in dietary fiber (~6.7%), calcium (~39 mg/100g), and potassium (~270 mg/100g). This technology has the potential to reduce the percentage of post-harvest losses by converting them into flour, which can be utilized for the production of bakery products along with the benefits of underutilized millets. The unique formulation of Potato-Kodo cookies makes them fit for celiac and wheat allergic population also. The technology is applicable to potatoes of any shape, size, and variety, whether fresh or cold-stored. To our knowledge, there are currently no potato-based cookies available in the Indian market. These cookies can be preserved up to 4 months under dark and dry conditions.

Fig. 8: Gluten-free potato kodo cookies

Potato swirls

Potato swirls are similar to south Indian snack Murukku/chakli. Murukku is a deep-fried snack traditionally prepared from rice flour and black gram flour along with added spices and salt. To explore the possibility of utilizing potatoes for the development of murukku like salty snacks this year trials were conducted some initial trials using whole potato flour along with tapioca starch as base ingredients. Among the different combinations tried combination containing 80% of potato flour was found satisfactory (Fig.-9). Textural properties of selected combination were evaluated and compared with commercially available Murukku. Texture analysis was performed using cutting test and bulk compression in Ottawa cell (Table 2). It was found that hardness of the potato swirls (27.9 N) was lower than commercial sample (40.3 N). Similarly, the toughness and crispiness of the potato swirls was better than commercial samples. Based on the selected combination the product will be further standardized in the upcoming year.

Table 2: Texture analysis of potato swirls and commercially available murukku

Sample	Hardness (N)	Work of shear (N. Sec)	Crispiness
Potato Swirls	27.9±8.5	7.26±2.7	51
Commercial Murukku	40.3±4.7	19.94±6.7	31

Fig. 9: Potato and tapioca starch-based potato swirls

Anthocyanin rich Potato Idli (Premix)

Idli is a popular and traditional South Indian cuisine that has spread throughout India and abroad. Idli is famous for its light and fluffy texture and is frequently eaten with sambar and coconut chutney. Looking at the present market trend, we can see that the food processing sectors are concentrating on the inclusion of functional ingredients, adding vitamins, minerals, and other bioactive substances. ICAR-CPRI recently developed some nutrient-rich (Anthocyanins) potato types. However, due to the limited shelf life of potatoes and an insufficient supply chain, these nutrient-rich potatoes are out of reach for all customers. As a result, ICAR-CPRI has conducted trials to transform these into shelf stable product-Idli premix, which may enhance the availability of these potatoes throughout India. This one-of-a-kind Idli premix comprises anthocyanin-rich potato flour, black gram flour, salt, and chemical leaveners. This idli premix can be cooked like conventional idlis by adding curd and water. Furthermore, due to the presence of anthocyanins, these idli can change colour according on the pH and have a shelf-life of 9 months at room temperature.

(This product was developed using nutrient rich tubers under the project "Breeding trait specific varieties for productivity, quality and resistance to biotic and abiotic stresses-HORTCPRISIL202000400143).

Fig. 10: Potato based anthocyanin rich *Idli*

Production of glucose syrup from potato starch

Potato starch is of considerable significance across various industries and research domains due to its versatile properties and wide-ranging applications. In industrial settings, it plays a pivotal role in the production of various goods such as food, textiles, and pharmaceuticals. Additionally, potato starch is utilized in the production of sweeteners and syrups. Research at ICAR-CPRI involved initial trials aimed at enhancing the glucose concentration in the production of glucose syrup from potato starch. Following the extraction of potato starch, we subjected it to a series of enzymatic processes, primarily utilizing alpha-amylase and glucoamylase enzymes. In particular, we varied the contact time with glucoamylase from 24 to 120 hours to investigate its impact on glucose concentration. Regular sampling at 24-hour intervals allowed us to monitor the glucose concentration during the hydrolysis process (Figure 11). Our findings indicated that a 3-hour hydrolysis period in the presence of alpha-amylase, followed by a subsequent 48-hour hydrolysis at 55°C with glucoamylase, yielded optimal scarification of potato starch, resulting in a glucose concentration of 115g/l. This transformative process holds promise, particularly in the food and beverage industry, as it offers an alternative sweetener with diverse applications. From an academic standpoint, our study contributes to the understanding of carbohydrate biochemistry and the industrial applications of sweeteners derived from potato starch. The enzymatic conversion of potato starch into glucose syrup represents an area of research that has implications for both industry and scientific knowledge in the field.

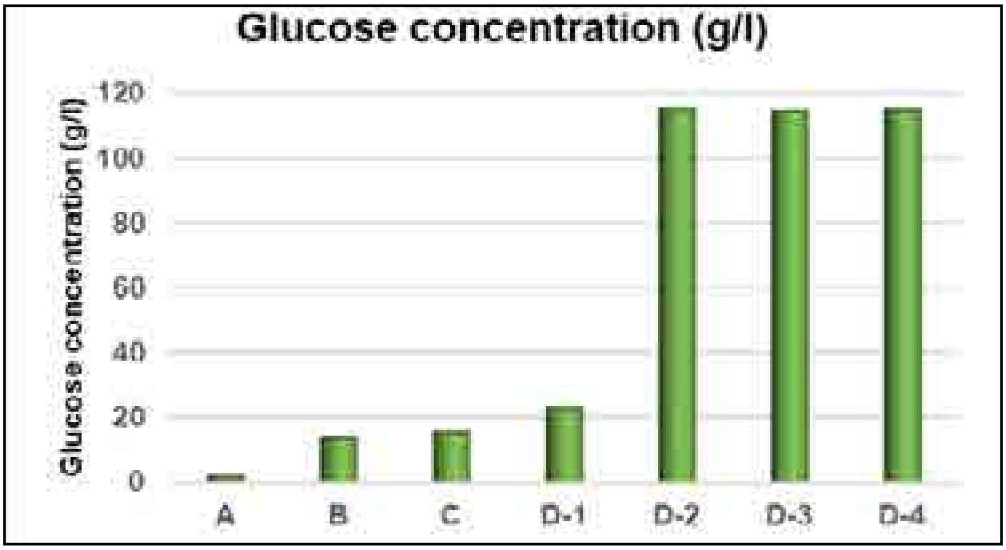


Fig. 11: Glucose concentration in the samples collected during enzymatic hydrolysis. A- Starch slurry, B- After 3h of steaming, C- 12h incubation with alpha-amylase, D-1- 24 h incubation with glucoamylase, D-2- 48h incubation with glucoamylase, D-3- 72h incubation with glucoamylase, D-4- 120h incubation with glucoamylase

Project 4: Potato Waste Management

Potato Synbiotics

Probiotics derived from potatoes offer unique benefits stemming from the inherent properties of this versatile tuber. Firstly, potatoes contain resistant starch, a type of prebiotic fibre that acts as food for probiotic bacteria, promoting their growth and activity in the gut. This synergy between probiotics and resistant starch contributes to improved gut health by enhancing the balance of beneficial bacteria in the microbiome, which is linked to various aspects of overall health, including digestion, immunity, and even mental well-being. Isolating probiotic microbes from various sources like cheese, curd, vegetables, and fruits was tried and strains with maximum potential were isolated and characterized at molecular level using 16S rRNA sequencing (Table 3)

Table 3. Nucleotide identity % of isolates to the closest phylogenetic neighbour and classification of the isolates

Strain Number	Identity	% Similarity	Classification
IP-3	*Lactobacillus curvatus*	100 %	Gram-positive bacteria
IP-5	*Lactobacillus curvatus*	97.4%	Gram-positive bacteria
IP-13	*Lactobacillus fermentum*	99.5%	Gram-positive bacteria
IP-15	*Bacillus proteolyticus*	99.97%	Gram-positive bacteria
IP-22	*Lactobacillus curvatus* strain 1633	99.85%	Gram-positive bacteria
IP-29	*Lactobacillus curvatus* strain 1123	99.85%	Gram-positive bacteria
CP-5	*Lactobacillus curvatus* CBA3617	100%	Gram-positive bacteria
CP-11	*Lactobacillus curvatus* strain 609	99.85%	Gram-positive bacteria
CP-20	*Lactobacillus curvatus* strain 8951	99.85%	Gram-positive bacteria
CP-33	*Bacillus toyonensis*	100%	Gram-positive bacteria

DIVISION OF SOCIAL SCIENCES

PROGRAMME: TRANSFER OF POTATO TECHNOLOGIES TO STAKEHOLDERS AND ASSESSMENT OF THEIR IMPACTS

Economic Analysis of Potato Production in Bihar

A survey for assessing the cost and income of potato production was conducted by randomly interviewing 120 potato growers in Bihar (60 each from Vaishali and Nalanda districts). The study revealed that the total cost of potato cultivation (Cost C) in Nalanda was ₹1,69,030/- which was higher than that of the Vaishali district with ₹1,28,314/- (Table 1). The overall cost C was ₹1,48,611/-. The findings also revealed that overall, the highest cost contribution was that of seeds which account for about 34% of the total cost of cultivation (Figure 1). Other major cost components were hired human labor (18%), fertilizers and micronutrients (10.4%), imputed family labor (9.6%) and machine labor (6.6%). It is evident that the production cost of Nalanda (₹515/-) is lower than that of Vaishali (₹658/-) due to low productivity in the Vaishali district. Overall, the gross income and net income were ₹224343/- and ₹75732/-, respectively and the B:C ratio is 1.51. Table 1 provides information on other cost components and economic parameters.

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

Cost components (Rs. /Ha)	Vaishali (n=60)	Nalanda (n=60)	Overall (N=120)
Hired Human Labor	22920	30455	26688
Machine Labor	6499	13106	9802
Seeds	35143	65207	50175
FYM	6278	6010	6144
Fertilizers + micronutrients	12194	18623	15409
Plant protection	3268	3918	3593
Irrigation	3865	4183	4024
Total working capital	90167	141502	115835
Interest on working capital	1559	2447	2003
Depreciation	1304	1944	1625
Cost A1	93030	145893	119462
Rental value of leased in land	2830	2195	2526
Cost A2	95860	148087	121988
Interests on value of owned fixed assets	4321	6092	5206
Cost B1	100181	154179	127194
Rental value of owned land	6681	7805	7168
Cost B2	106862	161984	134362
Imputed value of family labour (FL)	21452	7046	14249
Cost A2+FL	117312	155133	136237
Cost C (Total Cost)	**128314**	**169030**	**148611**
Cost of production (over Cost C)	658	515	581
Cost of production (over Cost A2+FL)	601	472	532
Yield (q/Ha)	195	328	256
Price (Rs. /q)	864	889	877

Cost components (Rs. /Ha)	Vaishali (n=60)	Nalanda (n=60)	Overall (N=120)
Gross Income (Rs. /Ha)	168615	292030	224343
Net Income (over Cost C) (Rs. /Ha)	40302	123000	75732
B:C Ratio (over Cost C)	**1.31**	**1.73**	**1.51**
B:C Ratio (over Cost A2+FL)	1.44	1.88	1.65

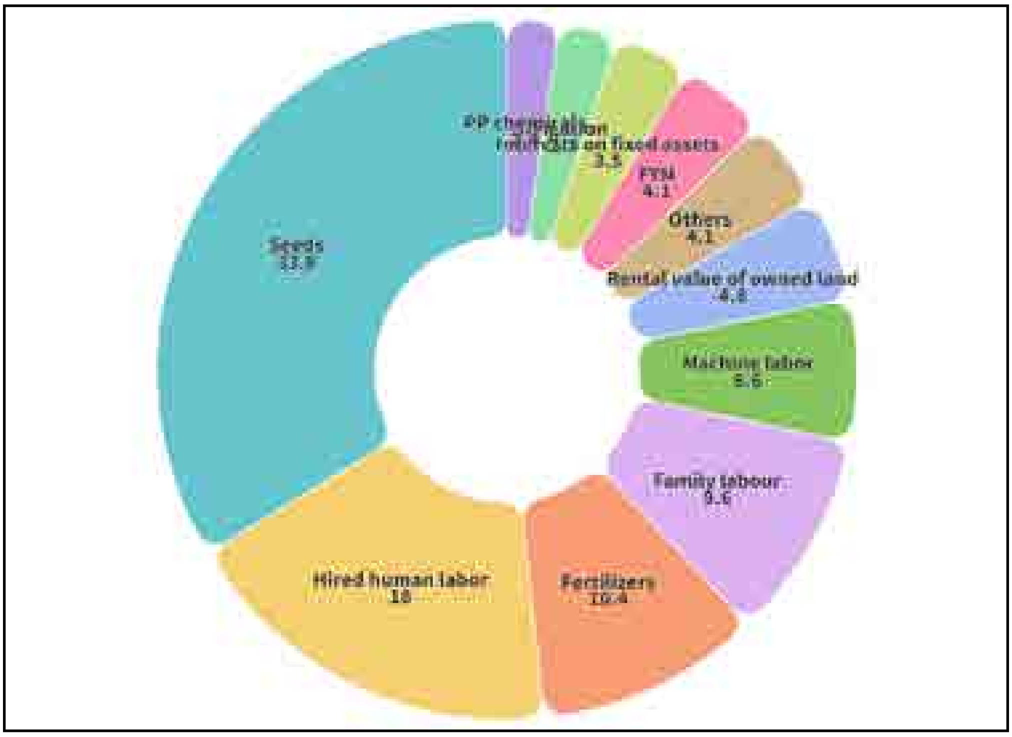


Fig.1: Percentage contribution of different cost components in potato cultivation in Bihar

Assessment of varietal adoption patterns in Bihar and Uttar Pradesh

Surveys were conducted for 120 farmers in Bihar, 60 each from Vaishali and Nalanda districts, and 140 farmers in Uttar Pradesh (70 each from Agra and Kannauj districts) to assess the varietal adoption patterns. In Vaishali, the most popular variety among the farmers was Kufri Sindhuri, accounting for about 24% of the total potato area (Figure 2), which was followed by Kufri Jyoti (~22%) and Kufri Pukhraj (~13%). In Nalanda, Kufri Pukhraj is the most popular variety, as it alone covers about 94% of the total potato area. Overall, Kufri Pukhraj contributed about 57% of the potato area, followed by Kufri Sindhuri (~11%) and Kufri Jyoti (~10%). Local varieties like C-1 and Lal Gulab also cover a significant area and are mainly cultivated for home consumption.

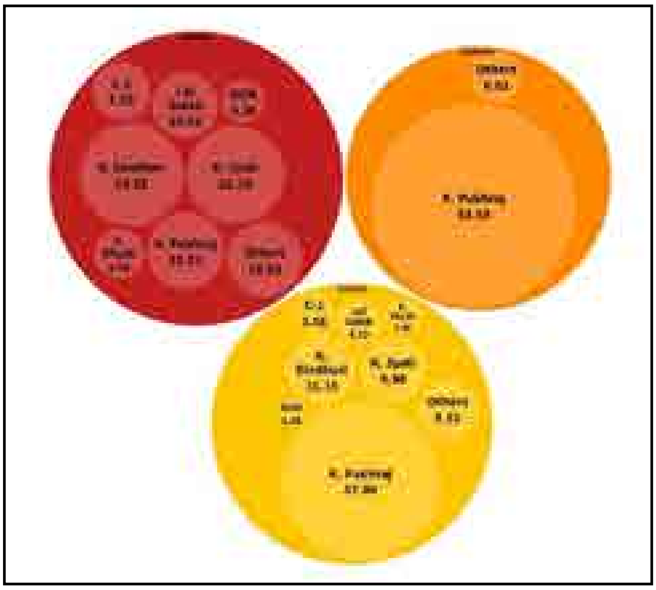


Fig 2. Varietal adoption pattern in Vaishali and Nalanda Bihar

In Uttar Pradesh, Kufri Bahar, which covers about 64% of the potato area, is the most popular variety in Agra district, followed by Kufri Mohan and Kufri Khyati, which each cover about 10% of the potato area in Agra (Figure 3). In Kannauj district, Kufri Chipsona-1, a processing variety developed by the institute, covers about 47% of the potato area. Red varieties like Kufri Sindhuri (~15%), Kufri Kanchan (11%), and Holland/ New Holland (9%) are also popular among the farmers.

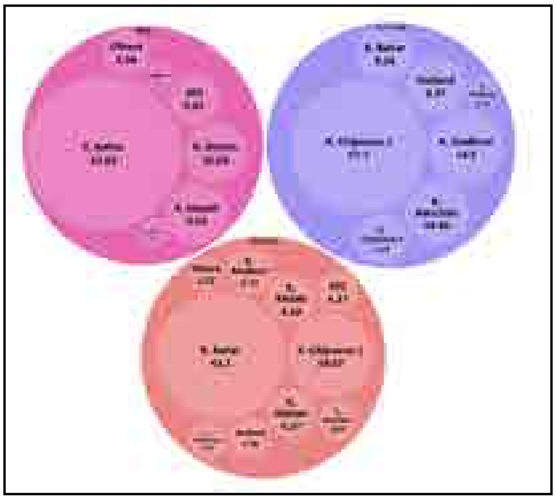


Fig 3. Varietal adoption pattern in Agra and Kannauj districts of Uttar Pradesh

Garrett ranking analysis of constraints in adoption of quality/ certified seeds of improved varieties

The study attempted to identify the constraints faced by farmers in adoption of quality/ certified potato seeds by interviewing 120 randomly selected farmers in Bihar and 140 farmers in Uttar Pradesh. Garrett's Ranking Technique was used to identify and rank the constraints. Garrett's formula for converting ranks into percent was given by

$$\text{Percent Position} = \frac{100(R_{ij}-0.5)}{N_j}$$

, where $\mathbf{R}_{ij}$ = Rank given for the i[th] variable by j[th] respondents and $\mathbf{N}_j$ = Number of variables ranked by j[th] respondents. With the help of Garrett's table, the estimated percent position is converted into scores.

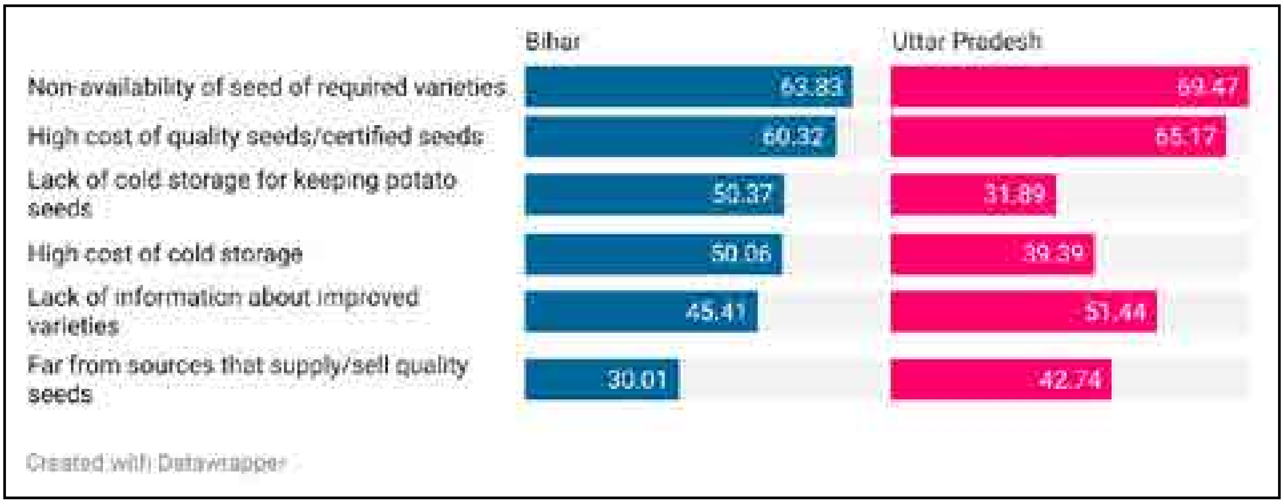


Fig. 4: Garrett's mean score of constraints in adoption of quality/certified seeds in Bihar and Uttar Pradesh

The study indicated that the first major constraint ranked by potato growers in Bihar was non-availability of seeds of required varieties (score=63.83, Rank I), subsequently followed by high cost of quality/certified seed (score= 60.32, rank II) and lack of cold storage (score=50.37, rank III). A similar finding was also observed in Uttar Pradesh. Non-availability of seeds of required varieties (score=69.47, Rank I) was the first major constraint, followed by high cost of quality/certified seed (score= 65.17, rank II) and lack of information about improved varieties (score=51.44, rank III). The findings may be useful for state governments, policymakers and researchers in formulating plans, policies and research related to the diffusion and adoption of quality/certified seeds of improved potato varieties.

Analysis of export performance of potato and its products

The total export of potatoes, seed potatoes and their products from India has increased over the years (Table 2). Based on the data collected from APEDA and the World Bank, the total export of potato and its products was about 5.59 lakh tons during the triennium average ending (TE) 2022–23, which is about 1.05% of the total potato production (~530 lakh tons) during the same TE period. While India's potato export share in the world market may be disappointing, the growth rate at a CAGR of 14.1% from 2003 to 2022 in the world makes the whole scenario optimistic. There are increasing trends in the export quantity of potatoes and its products, except for potato seeds and frozen steamed or boiled potatoes, which have negative growth rates. The export value of India's total export of potatoes and potato products was about ₹14.56 billion during the TE 2022–23. India reaches a record high of over ₹20 billion in the total export value in the year 2022–23.

Table 2. Exports of potatoes, seed potatoes and processed potato products

Items with ITC-HS codes in brackets	TE 2005–06		TE 2022-23		CAGR of export volume (2003-22)
	Quantity (tons)	Value (Million ₹)	Quantity (tons)	Value (Million ₹)	
Potatoes, fresh/chilled (07019000)	69423.47 (84.71)	327.89 (68.66)	401801.88 (71.92)	6528.15 (44.82)	11.8
Potato seeds, fresh/chilled (07011000)	5233.71 (6.39)	42.03 (8.80)	351.15 (0.06)	51.90 (0.36)	-15.2
Prepared/preserved potatoes, frozen (20041000)	483.08 (0.59)	19.78 (4.14)	67770.56 (12.13)	5336.37 (36.64)	35.7
Potatoes, dried (07129060)	683.22 (0.83)	11.81 (2.47)	48977.65 (8.77)	586.39 (4.03)	17.1
Potatoes, uncooked/cooked by steaming/ boiling in water, frozen (07101000)	4565.85 (5.57)	35.26 (7.38)	24164.65 (4.33)	426.71 (2.93)	-0.9
Flakes, granules and pellets of potatoes (11052000)	93.80 (0.11)	3.19 (0.67)	10583.05 (1.89)	1213.30 (8.33)	27.8
Potato starch (11081300)	71.89 (0.09)	1.96 (0.41)	2161.81 (0.39)	122.15 (0.84)	17.6
Flour, meal and powder of potatoes (11051000)	950.27 (1.16)	14.60 (3.06)	2049.62 (0.37)	97.27 (0.67)	6.4
Prepared/preserved potatoes, not frozen (20052000)	446.88 (0.55)	21.05 (4.41)	799.03 (0.14)	202.97 (1.39)	12.4
Exports of processed products	7295.00 (8.90)	107.65 (22.54)	156506.36 (28.01)	7985.16 (54.82)	15.4
Overall exports	81952.18 (100.00)	477.57 (100.00)	558659.39 (100)	14565.22 (100)	12.1

Note: ITC-HS Code=Indian Trade Classification's harmonized system codes; the figures in parentheses are the percentages of the total export volume and value of the respective items; TE= triennium average ending; CAGR=Compounded Annual Growth Rates for the period 2003-22; **Data Sources:** APEDA, World Bank

India exports about 4.02 lakh tons of fresh potatoes, which account for about 72% of the overall export volume (Table 2). However, this only represents 0.76% of the total potato production during TE 2022–23. The export of potatoes generates approximately ₹6.53 billion, accounting for approximately 44.82% of the overall value of exports. The volume of exports has grown at a healthy CAGR of 11.8% during the last two decades.

Potato seed export performance is quite disappointing, with a negative CAGR of -15.2%. Two decades ago, India used to export about 5233.71 tons of seed potatoes, which has now declined to only about 351.15 tons. India should consider the preferences of destination countries when developing and exporting potato varieties.

India is emerging as a prominent player in the global export of potato products, with its industry experiencing rapid growth. During TE 2005–06, the total export volume of potato products was only 7295.00 tons, but presently (TE 2022-23) it has risen to about 1.56 lakh tons, accounting for about 54.82% of the total export value. The overall CAGR of the export volume of potato products is growing at 15.4% from 2003 to 2022. The export of frozen prepared/preserved potatoes (mostly French fries) is growing at the fastest rate with a CAGR of 35.7% and is expected to expand in the future. This is followed by the exports of flakes, granules, and pellets of potatoes (CAGR = 27.8%) and flour, meal, and powder (CAGR = 17.6%). Frozen potatoes are the leading products, worth about ₹5.35 billion, i.e., about 36.64% of the total export value from the export of 67770.56 tons (12.13% of total export volume) during TE 2022–23. The exports of other processed products like potato starch, flour, meal and powder of potatoes and prepared or preserved potatoes (not frozen) also show great potential for export in the future, and they have been growing at a positive CAGR over the last two decades (Table 2).

OUTREACH PROGRAMMES

A. TV/Radio Talk delivered

Sl. No.	Name of the person who delivered	Topic of the talk	Date	Name of the Channel and the Programme
1.	Dr. Anil Choudhry	Delivered TV talk on '*Parvatiya kshetra mein poshak dalahanphasalon ka mahatv*"	February 21, 2023	DD Shimla (HP)
2.	Dr Salej Sood	*Himachal Pradesh ke liye Bhojya evm viddhyan aaloo ki kismein*	March 16, 2023	Prasar Bharati, Doordarshan Kendra, Shimla
3.	Dr. Anil Choudhry	Delivered TV talk on '*Mote anaj ki kheti*'	April 1, 2023	DD Kisan Channel, New Delhi
4.	Dr. Sarla Yadav	हरी खाद की बुआई, उपयुक्त फसलों का चुनाव तथा मृदा में जुताई का तरीका तथा प्रबंधन	May 8, 2023	Krishi Darshan, Doordarshan Bihar
5.	Dr. Sarla Yadav	आलू फसल की बुआई से पूर्व खेत की तैयारी	May 18, 2023	Krishi Darshan, Doordarshan Bihar
6.	Dr Vikas Mangal	*Aloo Ki Unnat Kisme Evam Visheshtaye*	July 13, 2023	Prasar Bharati, Doordarshan Kendra, Shimla
7.	Dr Salej Sood	Shree Anna (Mota Anaj) *Faslon Ki Visheshtayen evm Unnat Prajatiyan*	July 19, 2023	Prasar Bharati, Doordarshan Kendra, Shimla
8.	Dr Dalamu	आलू की खेती व उसका प्रबंधन	August 16, 2023	Live Phone in Programme in "Krishi Darshan" of DD Shimla, H.P.
9.	Dr. Anil Choudhry	Delivered TV talk on '*Rabi phaslon ki kheti*'	September 28, 2023	DD-Shimla

Sl. No.	Name of the person who delivered	Topic of the talk	Date	Name of the Channel and the Programme
10.	Dr. Anil Choudhry	Delivered TV talk on '*Alu phasal prabandhan*'	November 10, 2023	DD Kisan Channel, New Delhi
11.	Dr. Ashwani K. Sharma	मैदानी इलाकों में आलू की फसल की देखभाल व रखरखाव	November 24, 2023	Live Phone in Programme in "Krishi Darshan" of DD Shimla, H.P.
12.	Dr. Sanjeev Sharma	आलू की फसल में रोग एवं कीट प्रबंधन	December 6, 2023	Live Phone in Programme in "Krishi Darshan" of DD Shimla, H.P.
13.	Dr. Sarla Yadav	आलू की मुख्य फसल में प्रमुख सस्य क्रियाएं तथा फसल प्रबंधन	December 13, 2023	Krishi Darshan, Doordarshan Bihar
14.	Dr. Sarla Yadav	आलू की पिछेती फसल की बुआई तथा किस्मों का चुनाव	December 22, 2023	Krishi Darshan, Doordarshan Bihar

Photos: Some outreach programmes of ICAR-CPRI, Shimla (Himachal Pradesh)

B. CPRI in News/TV/Youtube

Sl. No.	Topic of the talk	Date	Name of Newspaper/ media	Brief comments
	श्रेष्ठ संस्थान : केंद्रीय आलू अनुसंधान संस्थान, शिमला , हिमाचल प्रदेश	January 1, 2023	DD Kisan	The video is dedicated to ICAR-Central Potato Research Institute, Shimla, showcasing its significant achievements and research and extension in the field of potato production and processing. https://www.youtube.com/watch?v=9kPtxJxWQ5Q

Sl. No.	Topic of the talk	Date	Name of Newspaper/ media	Brief comments
1.	Farmers given exposure to improved potato variety	April 26, 2023	Highland Post, Shillong, Meghalaya	ICAR-Central Potato Research Institute Regional station Shillong in collaboration with Krishi Vigyan Kendra, Ri-Bhoi, organised a field day on improved processing of the potato variety Kufri Frysona today at Thadnongiaw village. The field day was organised to showcase the technology to the line departments, and 30 villagers at the field of Manosha Syngkli and Jemnud Marpan. https://highlandpost.com/farmers-given-exposure-to-improvedpotatovariety/?fbclid=IwAR1qdjUV2im6i9xPoAVH66qAb6MAbPQCUEyeF5A2jNGCNoB5hXvYhAS27OA
2.	Improved potato varieties with better yield suited to Manipur condition	September 20, 2023	The Sangai Express, Imphal, Manipur	Improved potato varieties with better yield suited to Manipur conditions - https://www.thesangaiexpress.com/Encyc/2023/9/20/Arati-Ningombam-Ch-Premabati-Devi-NgursangzualaSailo-Lily-K-Rangnamei-L-Kanta-Singh-Th-Motilal-Singh-A.html
3.	Precaution to be followed for Late Blight in Potato for Punjab	November 27, 2023	DD Punjabi	Awareness about preventive measures to save potato crop from late Blight as our model of CPRI INDO BLIGHTCAST was showing threat. (By Dr Sugani) (link- https://youtube.be/4cKZvwMxZYwsi=Vz_q997CUHmxwRYL)
4.	Training on "Advances in potato production technology" at ICAR-KVK, Ri-Bhoi	December 13, 2023	Highland Post, Shillong, Meghalaya	ICAR-Central Potato Research Institute Regional station Shillong in collaboration with Krishi Vigyan Kendra, Ri-Bhoi, organised one day training on "Advances in potato production technology". 53 farmers attended the programme. https://highlandpost.com/53-farmers-attend-training-on-potato-production-technology/

C. *Kisan Mela*/ exhibitions organized

Sl. No	Title of the exhibition	Date	Place	No. of participants
1.	Exhibition organized on the occasion of National potato day	February 15, 2023	CPRI-RS, Modipuram	300
2.	Potato Technologies Exhibition	December 5, 2023	CPRI-RS, Modipuram	200
3.	Potato Technologies Exhibition	December 23, 2023	CPRI-RS, Modipuram	300

Photos: Some outreach programmes of ICAR-CPRI RS, Modipuram (Uttar Pradesh)

D. Kisan gosthis/ Farmers' workshops organized

Sl. No	Title of the gosthi	Date	Place	No. of participants
1.	Kisan Samagam & Fourth Krishi Roadmap	February 21, 2023	Bapu Auditorium, Ganhi Maidan Patna.	>10000
2.	Farmer's day cum workshop	August 22, 2023	Nilgiri district of Tamil Nadu	60
3.	Farmer's day cum workshop	December 22, 2023	Nilgiri district of Tamil Nadu	50

E. *Kisan Mela*/ exhibitions participated

Sl. No	Title of the exhibition	Date	Organizers /Place	No. of participants
1.	North East Krishi Kumbha-2023	January 4-6, 2023	ICAR Research Complex for NEH Region, Umiam	More than 1000's visitors
2.	Kisan mela and Farmers Participation in Krishi Exhibition	January 22-24, 2023	By ICAR- DMAPR, Anand (Gujrat) at ICAR- DMAPR, Anand (Gujrat	500
3.	Kisan Mela cum Foundation Day of ICAR-Research Complex for Eastern Region	February 22, 2023	ICAR-Research Complex for Eastern Region, Bihar Veterinary University Campus, Patna	500
4.	National Horticulture Fair	February 22-25, 2023	Bengaluru	>1,00,000
5.	Kisan mela	February 26-27, 2023	RLBCAU	More than 500 visitors
6.	Pasu Pradarshini and Krishi Mela at Muzafarnagar (U.P.)	April 6-7, 2023	By Ministry of states for fisheries, animal husbandry and dairying GOI at Numaish ground, Muzafarnagar (U.P.)	1000
7.	Pashu pradarshini and Krishi Mela	April 6-7, 2023	ICAR-CIRC Meerut	1000

Sl. No	Title of the exhibition	Date	Organizers /Place	No. of participants
8.	125th Flower show	May 19-23, 2023	Department of Horticulture and Plantation Crops, The Nilgiris, Tamil Nadu, India	>1,00,000
9.	G-20 meeting	June 15-17, 2023	Agriculture Ministers at Hyderabad	>1000
10.	ICAR-KVK, Technology Day	July 16, 2023	Ooty	100
11.	Kisan Mela cum Foundation Day of ICAR-ATARI, Patna	August 19, 2023	BAMETI, Patna (Bihar)	200
12.	Potato exhibition and seed production	September 29-30, 2023	DHO Kannuj, State Medical College Triwa, Kannuj.	750
13.	Participated by putting stall in kisan mela	September 29-30, 2023	By District Agri. and Horticulture Deptt. Kannauj at Tirva Medical College, Deptt. Kannauj	500
14.	Kisan mela	October 4, 2023	Vikrant University	More than 500 visitors
15.	All India kisan mela	October 8-10, 2023	By CSA University of Agri and Technology, Kanpur (U.P.) at CSA University of Agri And Technology, Kanpur (U.P.)	3000
16.	Plant Genetic Resources Management	October 10, 2023	Rampuri, Shimla	500
17.	10th Indian Horticulture Congress – 2023 "Unleashing Horticultural Potential for Self-Reliant India"	November 6-9, 2023	College of Veterinary Campus, Assam Agricultural University, Khanapara, Guwahati, Assam	More than 200 visitors
18.	Participated by putting stall in kisan mela	November 24, 2023	By Bank of Baroda, regional office Meerut during at SVBP University Meerut at SVBP Agril University Meerut **(U.P.)**	500
19.	Kisan Mela for Farmers of east Khasi Hills – "Natural Farming: A way forward to sustainable agriculture"	December 8, 2023	IATC, 5th Mile, Upper Shillong	More than 200 visitors
20.	Participation in Krishi Exhibition	December 27, 2023	By ICAR- CIRG Meerut Cantt. the occasion of national conference on Agro- ecology based Agri- Food Transformation systems at ICAR-CIRG, Meerut Cantt. (U.P.)	300

F. Awareness programmes/camps

Sl. No.	Title of the programme	Date	Organizers / Place	No. of participants
1.	Awareness programme on waste to wealth composting approach	June 5, 2023	ICAR CPRI RS Shillong.	40 farmers
2.	Awareness program on "Soil and Water: A Source of Life" for Celebration of "World Soil Day"	December 5, 2023	ICAR CPRI RS Shillong.	35 farmers
3.	Importance of Soil and Water in our Life	December 5, 2023	ICAR-CPRI, Shimla	80 students






Photos: Some outreach programmes of ICAR-CPRI RS, Patna (Bihar)

G. Frontline Demonstrations (FLDs)

Sl. No	Title of demonstration	Place	No. of beneficiaries	Under which schemes (SCSP/TSP/ NEH/ABI/ Others)	Inputs distributed (Quantity)	Percentage yield increase over existing practice
1	Improved Potato Varieties & seed production technology	Lucknow, Lakhimpur,Khiri, Raibarreilly, Jhanshi, Ayodhiya, Mirjapur, Unnao, Hamirpur, Sitapur (Uttar Pradesh)	134	SCSP	134 q of Kufri Chipona-1, Kufri Chipona-3, Kufri Khayati, kufri Ganga, Kufri Bahar	25%
2	Scientific Potato Production	Jalandhar, Punjab	20	SCSP	200 quintal potato seed	_
3	Improved Potato Varieties	Kachat, Fagu PO, Shimla, HP	28	SCSP	9 quintals seed of Kufri Karan and 6 quintals seeds of Kufri Chandramukhi	20%
4	Scientific Potato Production	Nawada and Gaya, Bihar	100	SCSP	100 quintal potato seed (50 quintal at each)	-
5	Scientific Potato Production	Ujjain, MP	80	AICRP	80 quintal potato seed	-
6	Scientific Potato Production	Ujjain, MP	50	Institute	50 quintal potato seed	-
7	Varietal Production Technology	Meerut, Agra, Baghpat Farukhabad,Firojabad, Kannauj, Kanpur, Sahjahanpur, Hathrus in Uttar Pradesh	18	Institute	18 quintal potato seed	22.67%
8	Varietal Production Technology	Deesa, Ghandhinagar in Gujarat	5	Institute	5 quintal potato seed	19.05%
9	Varietal Production Technology	Hooghly (West Bengal)	5	Institute	5 quintal potato seed	25%

Sl. No	Title of demonstration	Place	No. of beneficiaries	Under which schemes (SCSP/TSP/ NEH/ABI/ Others)	Inputs distributed (Quantity)	Percentage yield increase over existing practice
10	Evaluation of Improved variety: Kufri Himalini	East Khasi Hills, Meghalaya	5	NEH	5q seed tubers	Local Variety 10t/ha k. Himalini 17.5t/ ha 75%
11	Evaluation of processing variety Kufri chipsona-1	West Jaintia Hills, Meghalaya	5	NEH	15q seed tubers	-
12	Improved potato Cultivation	Khawzawl, Mizoram	6	NEH	40q seed tubers	-
13	Evaluation of Processing variety: Kufri Chipsona-1	Thangsning village, East Kashi Hills District, Meghalaya	1	NEH	2q seed tubers	Farmers seed: k. Joyti 11.5t/ha K. Chip-1 23t/ ha 100%
14	Low-cost potato seed production through apical rooted cuttings.	East Khasi Hills, Meghalaya	13	NEH	20,000 Cuttings	Apical rooted cuttings yielded an average of 8 nos. of tubers/ plant and 10 g weight/tuber
15	Scientific cultivation of Potato (Kufri Pukhraj)	Medziphema, Nagaland	03	NEH	6q seed tubers	-
16	Evaluation of Improved varieties: Kufri Himalini and Kufri Girdhari	West Tripura & Sepahijala Dist, Tripura	03	NEH	4q seed tubers	Farmers seed: K. Jyoti 17t/ha K. Himalini 23t/ha K. Girdhari 20t/ha
17	Evaluation of Improved variety: Kufri Pukraj and Kufri Chipsona-3	West Tripura & Sepahijala Dist, Tripura	03	NEH	6q seed tubers	Farmers Seed: K. Jyoti 17t/ha K. Chipsona-3- 26t/ha K. Pukhraj 24t/ ha
18	Assessment of high yielding variety of potato variety: Kufri Pukhraj	East Garo Hills, Meghalaya	4	NEH	8q seed tubers	8.7t/ha. Introduction of Potato.
19	Scientific cultivation of processing variety, Kufri Frysona	Ri-Bhoi, Meghalaya	21	NEH	20q seed tubers	Introduction of Processing variety (K. Frysona) 30t/ ha

Potato Cafeteria: During 2023-24 crop season, potato cafeteria of 5-10 newly developed potato varieties were established at demonstration farm of ICAR-IARI, New Delhi, KVK Raebareli, Ayodhya, Baghpat, Muzaffarnagar -II and Lucknow districts of Uttar Pradesh and Ujwa in Delhi for to showcase the varietal diversity of potato and evaluation by the farmers and other potato stakeholders.

Photos: Some outreach programmes of ICAR-CPRI RS, Gwalior (Madhya Pradesh)

H. Field days

No	Title of field day	Place	Date	No. of beneficiaries
1.	Field day cum Farmer scientist interaction	Village–Bahlolpur, District Meerut	January 18, 2024	50
2.	Zero tillage potato in eastern Indo-Gangetic plains, Potato production with zero tillage & rice straw mulch (PZTM)	CPRI-Regional Station, Patna	February 24, 2023	100
3.	Improved processing variety of Potato Kufri Frysona	Thadnongiaw village, Ri-Bhoi district, Meghalaya	April 26, 2023	30
4.	Green manuring of soil before cultivation of potato as a main crop	CPRI-Regional Station, Patna	August 14, 2023	50
5.	Potato processing variety- Kufri Chipsona-1 and Kufri Chipsona-3	Thangsning village, East Kashi Hills District, Meghalaya	August 29, 2023	43

Photos: Some outreach programmes of ICAR-CPRI RS, Jalandhar (Punjab)

I. Visit Coordination

Sl. No.	Date/ Period	Visitor category	Organization / University / College / Category of Visitors	No. of Visitors
1.	03.01.2023	Students	Professor Jayashankar Telangana State, Agri,University,Agricollege, Palem	60
2.	05.01.2023	Students	Dolphin Institute of Biomedical & Natural Sciences, Dehradun	22
3.	06.01.2024	Students	IIMT University, Meerut (U.P.)	40
4.	09.01.2023	Students	Professor Jayashankar Telangana State,Agri,University,Agricollege, Aswaraopet	110
5.	09.01.2023	Students	Professor Jayashankar Telangana State,Agri,University, College of Community Science,Hyderabad	60
6.	09.01.2023	Students	Professor Jayashankar Telangana State,Agri,University,Agricollege, Sircilla	63
7.	12.01.2023	Students	Electronics & Communication, Engineering Dept, Inst. of technology, Ahmedabad	25
8.	13.01.2023	Students	Professor Jayashankar Telangana State,Agri,University,Agricollege, Palasa,Jagtial	112
9.	16.01.2023	Students	Maharashtra College	39
10.	16.01.2023	Farmers	Visit under ATMA, from Distt. Yamunanagar, Haryana	07
11.	23.01.2023	Students	Kerala Agricultural University,College of Agriculture,Padamakad,Kasaragal	96
12.	24.01.2023	Students	Kamaraj College of Engineering & Technology,Virudhunagar,Tamilnadu	45
13.	01.02.2023	Students	Govt. of Mah. IY College, Mumbai	46
14.	02.02.2023	Officials	Office of Project Director (ATMA) Dist. Guna, M.P.	7
15.	06.02.2023	Students	Dr.Y.S.R Horticultural University College of Horticulture,Andhrapradesh	120
16.	08.02.2023	Students	Tamil Nadu Agriculture University, Perambalur	110
17.	10.02.2023	Students	JKK Munnirajah College of Agri. Science, Tamil Nadu	103
18.	14.02.2023	Students	Imayam Institute of Agriculture & Technology, Tamil Nadu	98
19.	14.02.2023	Students	RVS Agriculture College, Thanjavar, Tamil Nadu	112
20.	15.02.2024	Farmers	Agri. Deptt, Etawah (U.P.)	40
21.	17.02.2023	Students	LPU Jalandhar	53
22.	20.02.2023	Students	Swami Vivekanand Group of Institute, Ramnagar, Punjab	27
23.	20.02.2023	Student	Dr.Y.S.R.Horticultural University College of Hort,Seethapuram,AP.	56
24.	22.02.2023	Farmers	Group of Farmers from different districts of Delhi	19
25.	22.02.2023	Students	Don Bosco College of Agriculture, Ranipet, Tamil Nadu	115
26.	22.02.2023	Officials	Development Department , Delhi Govt., N. Delhi	19
27.	24.02.2023	Students	Lovely Professional University, Jalandhar, Punjab	53
28.	28.02.2023	Farmers	*Gramin shiksha evam sahayata* Association, Palwal, Haryana	25
29.	28.02.2023	Students	Govt. Sr. Sec. School, Kot-Beja, Solan	39
30.	01.03.2023	Students	College of Agriculture, UAS, Dharwad	51
31.	02.03.2023	Students	Shrimati Indra Gandhi College,Trichy	46
32.	03.03.2023	Students	Krishna College of Agriculture & Technology, Tamil Nadu	86
33.	06.03.2023	Students	College of Agri Business Management, Ahmednagar	35

Sl. No.	Date/ Period	Visitor category	Organization / University / College / Category of Visitors	No. of Visitors
34.	06.03.2023	Students	S. Thangarsam Agriculture College, Tamil Nadu	111
35.	07.03.2023	Students	IGP College of Agriculture Sciences, Namakkad	115
36.	07.03.2023	Students	COA, Pamghat, Arunachal Pradesh	19
37.	09.03.2023	Students	Lady Doak College,Madhurai	52
38.	09.03.2023	Students	College of Agriculture & Technology, Tamil Nadu	82
39.	09.03.2023	Students	Adhiparasakthi Horticulture College, Coimbatore	114
40.	09.03.2023	Students	JCM Agri. College & University, Tamil Nadu	59
41.	09.03.2023	Students	RVS Padmavathi College & Horticulture, Dindigul	71
42.	09.03.2023	Students	Joya Agriculture College, Tamil Nadu	60
43.	09.03.2023	Students	College & Institute, Tamil Nadu	117
44.	09.03.2023	Officials	State Agriculture Management and Extension Training Institute (SAMETI), Mashobra	16
45.	10.03.2023	Students	AC & RI, TNAU, Tamil Nadu	95
46.	10.03.2023	Students	ACERI, TNAU, Coimbatore, Tamil Nadu	42
47.	11.03.2023	Students	CSA University of Agri. And Technology, Kanpur(U.P.)	33
48.	14.03.2023	Students	Palar Agriculture College, Vellore	113
49.	14.03.2023	Students	Quad E.Millath Govt College for womens,chennai.	60
50.	15.03.2023	Students	Providence womens college,Calicut Kerala	30
51.	17.03.2023	Students	CAU Imphal	13
52.	20.03.2023	Students	Bharath University, Chennai, Tamil Nadu	47
53.	24.03.2023	Students	Dhanalakshmi Srinivasan Engineering College Perambalur	50
54.	28.03.2023	Students	SRM College of Agricultural Sciences, Tamil Nadu	61
55.	31.03.2023	Students	College of Horticulture & Forestry, Thunag, Mandi	47
56.	03.04.2023	Students	College of Agriculture, UAS Bagalkot, Karnatala	70
57.	10.04.2023	Students	College of Agriculture, AUT, Rajasthan	55
58.	11.04.2023	Students	Agricultural Engg. College, Tamil Nadu Agricultural Univ., Coimbatore	31
59.	12.04.2023	Students	St.Mary's College,Sulthan Bathery,Wayanad(Dt),Kerala	11
60.	24.04.2023	Students	LPU, Jalandhar	18
61.	26.04.2023	Students	Odisha Univ. of Agriculture & Technology, Bhubaneshwar	43
62.	27.04.2023	Students	College of Agriculture, Bhawanipatna, OUAT	43
63.	27.04.2023	Students	College of Ayurvedic Pharmaceutical Sciences, Jogindernagar, Mandi	48
64.	01.05.2023	Students	College of Agriculture, OUAT, Bhubaneshwar	39
65.	04.05.2023	Students	Tamil Nadu Agricultural University, Coimbatore	38
66.	08.05.2023	Students	Rama University, Kanpur, U.P.	42
67.	15.05.2023	Students	H.P. University, Summer Hill, Shimla	10
68.	17.05.2023	Students	Lovely Professional University	110
69.	23.05.2023	Students	Kothari International School, Noida	137
70.	08.06.2023	Students	LMPKV, Rahun, Maharashtra	24
71.	15.06.2023	Students	Shoolini University, Solan, H.P.	30
72.	27.06.2023	Students	Veg. Sci. Deptt. GBPVA, Pantnagar, Uttarakhand	22
73.	04.07.2023	Students	Akal College of Agriculture, Baru Sahib, Sirmaur	22
74.	22.07.2023	Students	AC & RI Eachankottai, Thanjavur	150
75.	25.07.2023	Students	Jawahar Navodaya, Theog	49
76.	25.07.2023	Farmers and Extension Officials	Interstate exposure visit to Meghalaya	39

Sl. No.	Date/ Period	Visitor category	Organization / University / College / Category of Visitors	No. of Visitors
77.	03.08.2023	Farmers and Extension Officials	ATMA (Laitkroh), East Khasi Hills District, Meghalaya	41
78.	08.08.2023	Students	DAV Lakkar Bazar School, Shimla	34
79.	09.08.2023	Officials	Agriculture Officers of Nepal	5
80.	11.08.2023	Farmers and Extension Officials	ATMA (Mawshynrut), West Khasi Hills District, Meghalaya	25
81.	15.09.2023	Farmers	ATMA, Sawai, Madhopur, Govt. of Rajasthan	40
82.	19.09.2023	Students	Kalasalingam Academy of Research and Education	39
83.	20.09.2023	Students	GGSSS Lakkar bazaar, (HP Govt. School)	40
84.	21.09.2023	Students	University of Agricultural Sciences, GKVK, Bangalore	50
85.	25.09.2023	Farmers	CAFAD Ghaziabad, Vadodara Gujarat	54
86.	04.10.2023	Students	Bharathi Women's College, Chennai	119
87.	09.10.2023	Farmers	Department of Agriculture, Patan, Gujarat	25
88.	13.10.2023	Students	Idhaya College for Women, Kumbakonam	49
89.	13.10.2023	Students	Guru Kashi University, Bathinda, Punjab	27
90.	18.10.2023	Students	University of Kerala, Thiruvananthapuram	15
91.	20.10.2023	Students	Agricultural College, Mahanadi	52
92.	31.10.2023	Farmers	ATMA, Patan, Gujarat	25
93.	06.11.2023	Students	College of Agricultural Sciences & Applied Research BEST Innovation University, AP	21
94.	07.11.2023	Students	Department of Agricultural Extension Annamalai University, Chidambaram	139
95.	10.11.2023	Farmers and Extension Officials	ATMA (Mirang, Nongstoin and Mawthadraishan), West Khasi Hills District, Meghalaya	60
96.	17.11.2023	Students	Kendriya Vidyalaya EAC Upper Shillong Post Nonglyer, East Khasi Hills Shillong, Meghalaya 793009	80
97.	23.11.2023	Students	KV school	90
98.	30.11.2023	Farmers and Extension Officials	TOBU, RD Block, Mon, Nagaland.	13
99.	30.11.2023	Students	Dept. of Microbiology, Sathaye college, Mumbai, Maharashtra	23
100.	04.12.2023	Students	Shoolini University Solan, B. Tech Food Tech.	49
101.	05.12.2023	Students	Annamalai University, Annamalainagar	100
102.	06.12.2023	Students	GUSSS, Phagli, Shimla	22
103.	06.12.2023	Students	Govt. college of Arts, Science and Commerce, Khandola-GOA	24
104.	06.12.2023	Farmers	Agriculture Department, SAS Nagar, Mohali, Punjab	18
105.	07.12.2023	Students	Annamalai University, Annamalainagar	98
106.	08.12.2023	Students	Department of Agricultural Extension& Communication, College of Agriculture, Anand Agricultural University, Kheda, Gujarat	67
107.	11.12.2023	Official and students	CAU - College of Horticulture and Forestry, Pasighat	6
108.	18.12.2023	Students	Goel Institute of Technology & Management, Lucknow, UP	30

Sl. No.	Date/ Period	Visitor category	Organization / University / College / Category of Visitors	No. of Visitors
109.	21.12.2023	Trainees Officials	Joint Director, Agri. Training College , Bulandshahar (U.P.)	80
110.	21.12.2023	Students	Tamil Nadu Agricultural University, Coimbatore	79
111.	23.12.2023	Students	RG Girls Degree college , Meerut (U.P.)	20
112.	27.12.2023	Students	Tamil Nadu Agricultural University, Coimbatore	79
113.	01.01.2023 to 31.12.2023	Students	From different Agriculture/Horticulture Colleges of India and also from Schools	799

Photos: Some outreach programmes of ICAR-CPRI RS, Shillong (Meghalaya)

TRAINING AND CAPACITY BUILDING

I. TRAINING PROGRAMMES ATTENDED BY ICAR-CPRI EMPLOYEES

Name of the staff	Name of the Programme	Duration (From – To)	Place and Organizers
Scientific staff			
Dr. Salej Sood, Sr. Scientist	Scientific Project Management	January 15-19, 2024	IISER, Pune
Dr. Priyank Hanuman Mhatre, Scientist (SS)	Climate Risk Management: Policy and Governance	January 30 - February 3, 2023	Centre For Disaster Management, Mussoorie
Dr. Anil Kumar Choudhary, PS	Climate Risk Management: Policy and Governance	January 30 - February 3, 2023	Centre For Disaster Management, Mussoorie
Dr. Sunayan Saha, Sr. Scientist	Crop Simulation modeling for climate change studies	May 22-26, 2023	ICAR-IARI, New Delhi
Dr. Ajay Kumar Thakur, Sr. Scientist	CRISPR/Cas9-based Gene Editing Technologies in Plants	June 12-16, 2023	ICRISAT, Hyderabad
Dr. Dalamu, Sr. Scientist	Future prospects of crop bio fortification in India: An Antidote to Malnutrition	November 7-9, 2023	MANAGE, Hyderabad & ICAR CAFRI, Jhansi, Uttar Pradesh
Dr Sarala Yadav, Senior Scientist	Future prospects of crop bio fortification in India: An Antidote to Malnutrition	November 7-9, 2023	MANAGE, Hyderabad & ICAR CAFRI, Jhansi, Uttar Pradesh
Dr. Ajay Kumar Thakur, Sr. Scientist	Metagenomics Data Analysis	December 11-13, 2023	ICAR-IASRI, New Delhi
Dr. Dharmendra, Scientist	Recent advances in biocatalysts for biomass derived renewable chemicals	December 15 - January 4, 2024	TNAU, Coimbatore
Technical staff			
Sh. Rajender Kumar Samadhiya, STO	Good Agricultural Practices (GAPs)	January 20 - February 3, 2023	ICAR-IARI, New Delhi
Sh. Kapil Kumar Sharma, ACTO	Good Agricultural Practices (GAPs)	January 20 - February 3, 2023	ICAR-IARI, New Delhi New Delhi
Sh. Harvir Singh, ACTO	Motivation, Positive Thinking and Communication Skills	September 11-15, 2023	NAARM, Hydrabad
Rajdeep Bux	Training cum awareness workshop for Northern Region on J Gate@CeRA	October 17, 2023	CSKHPKV, Palampur
Sh. Akhilesh Kumar Singh, ACTO	Future prospects of crop bio fortification in India: An Antidote to Malnutrition	November 7-9, 2023	MANAGE, Hyderabad & ICAR CAFRI, Jhansi, Uttar Pradesh
Ms Vandana Parmar, Technician	Future prospects of crop bio fortification in India: An Antidote to Malnutrition	November 7-9, 2023	MANAGE, Hyderabad & ICAR CAFRI, Jhansi, Uttar Pradesh

Name of the staff	Name of the Programme	Duration (From – To)	Place and Organizers
Administrative staff			
Sh. Raghubir Singh Thakur, UDC	E-Governance Applications in ICAR	February 6-10, 2023	ICAR-IASRI, New Delhi
Sh. Kundan Lal, LDC	E-Governance Applications in ICAR	February 6-10, 2023	ICAR-IASRI, New Delhi
Smt. Chandni Bhagta, Assistant	E-Governance Applications in ICAR	February 6-10, 2023	ICAR-IASRI, New Delhi
Sh. Sachin Kanwar, Assistant	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Sh. Rakesh Negi, UDC	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Sh. Narender Paul, UDC	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Sh. Suresh Kumar Verma, PA	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Smt. Sandhya Srivastava, Assistant	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Smt. Kiran, LDC	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Sh. Pawan Kumar, Stenographer-III	Making a Secure & Resilient Workplace at ICAR/ICAR Institutes	February 22-24, 2023	ICAR-CPRI, Shimla
Sh. Sanjib Kumar, AAO	Technical Service Rules	July 10-11, 2023	NAARM, Hydrabad
Sh. Sandeep, AAO	Technical Service Rules	July 10-11, 2023	NAARM, Hydrabad

II. CAPACITY BUILDING PROGRAMMES ORGANIZED BY ICAR-CPRI, SHIMLA HQ AND ITS REGIONAL STATIONS

A. ICAR-CPRI, Shimla HQ

Title of the Programme	High-end Workshop (Karyashala) on "Serological and Molecular Diagnostics of Potato Pathogens"
Programme period, Duration & Venue	January 9-20, 2023 (12 days)
Team/Co-ordinators	Chandan Maharana, Aarti Bairwa, Kailash Chandra Naga, Rahul Kumar Tiwari, Vinay Sagar, Sanjeev Sharma
Total number of participants (No. of female participants in bracket)	23
Objectives of the Programme and Innovation brought, if any.	This SERB sponsored workshop under the scheme of Accelerate Vigyan on, 'Serological and Molecular Diagnostics of Potato Pathogens' was aimed to provide hands on training on basic serological and molecular diagnostics techniques to the young researchers.
Title of the Programme	**Hi-tech seed potato production**
Programme period, Duration & Venue	January 13 to February 3, 2023 (5 days), ICAR-CPRI, Shimla
Team/Co-ordinators	Ravinder Kumar, Milan K Lal, Rahul K Tiwari
Total number of participants (No. of female participants in bracket)	4
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of officers of Uttar Pradesh on Hi-Tech Seed Production like Tissue Culture, Aeroponics, Apical Rooted Cutting, etc
Title of the Programme	**Potato Value Chain: Seed Production, Pest Management, Post-Harvest Technology and Value Addition**
Programme period, Duration & Venue	February 8 - 10, 2023 (3 days), ICAR-CPRI, Shimla
Team/Co-ordinators	Brajesh Singh, Ravinder Kumar, Pynbianglang K., Milan K Lal, Rahul K Tiwari
Total number of participants (No. of female participants in bracket)	20 (4)
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of farmers of Madhya Pradesh on seed potato production technologies, post-harvest technologies and marketing
Title of the Programme	**Potato Value Chain: Seed Production, Pest Management, Post-Harvest Technology and Value Addition**
Programme period, Duration & Venue	February 13-15, 2023 (3 days), ICAR-CPRI, Shimla
Team/Co-ordinators	Brajesh Singh, Ravinder Kumar, Pynbianglang K., Milan K Lal, Rahul K Tiwari
Total number of participants (No. of female participants in bracket)	21
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of Gujarat farmers on seed potato production technologies, post-harvest technologies and marketing
Title of the Programme	**Potato Value Chain : Seed Production, Pest Management, Post-Harvest Technology and Value Addition**
Programme period, Duration & Venue	February 27 - March 1, 2023 (3 days), ICAR-CPRI, Shimla

Title of the Programme	High-end Workshop (Karyashala) on "Serological and Molecular Diagnostics of Potato Pathogens"
Team/Co-ordinators	Brajesh Singh, Ravinder Kumar, Pynbianglang K., Milan K Lal, Rahul K Tiwari
Total number of participants (No. of female participants in bracket)	28 (9)
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of Gujarat farmers on seed potato production technologies, post-harvest technologies and marketing
Title of the Programme	**Hi-Tech Seed Production: Tissue Culture, Aeroponics, Apical Rooted Cutting**
Programme period, Duration & Venue	September 20-22, 2023 (3 days), ICAR-CPRI, Shimla
Team/Co-ordinators	Alok Kumar & Pynbianglang K.
Total number of participants (No. of female participants in bracket)	4
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of officers of Haryana on Hi-Tech Seed Production like Tissue Culture, Aeroponics, Apical Rooted Cutting,etc
Title of the Programme	**Scientific potato cultivation in mountainous region**
Programme period, Duration & Venue	September 24-25, 2023 (2 days), Nang village, Leh,. Ladakh
Team/Co-ordinators	Brajesh Singh, Ravinder Kumar, Vinod Kapoor
Total number of participants (No. of female participants in bracket)	60
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of tribal farmers of Leh on scientific cultivation of potato.





Photos: Training programs organized by ICAR-CPRI, Shimla

B. ICAR-CPRI RS, Modipuram

Title of the Programme	Certificate course on Integrated Nutrients Management for Fertilizers Prospective dealers for fertilizer dealers sponsored by FAI
Programme period, Duration & Venue	August 2-16, 2023 (15 days)
Total number of participants (No. of female participants in bracket)	20
Objectives of the Programme and Innovation brought, if any.	To enhance the knowledge and skill of trainees regarding Certificate course on Integrated Nutrients Management


Photos: Training programs organized by ICAR-CPRI RS, Modipuram

C. ICAR-CPRI RS, Jalandhar

Title of the Programme	Agribusiness Development Program on Hi-Tech Potato Seed
Programme period, Duration & Venue	December 20, 2023 (1 day)
Team/Co-ordinators	Sukhwinder Singh, Brajesh Nare
Total number of participants (No. of female participants in bracket)	55
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on various agribusiness activities in potato production
Title of the Programme	**Hi-tech seed potato production**
Programme period, Duration & Venue	August 3, 2023

Title of the Programme	Agribusiness Development Program on Hi-Tech Potato Seed
Team/Co-ordinators	Sukhwinder Singh, Brajesh Nare
Total number of participants (No. of female participants in bracket)	93
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on various agribusiness activities in potato production

Photos: Training programs organized by ICAR-CPRI RS, Jalandhar

D. ICAR-CPRI RS Patna

Title of the Programme	Potato Seed distribution and imparting training to the SC Farmers on topic Improved Potato Cultivation at Mahuliyat and Village, Kauwakol, Nawada Bihar under SCSP component with assistance of KVK Nawada.
Programme period, Duration & Venue	December 29, 2023 (1 day)
Team/Co-ordinators	Dr RK Singh, Dr SP Singh Principal Scientist and Mr Sunil Kumar Singh Technical Assistant.
Total number of participants (No. of female participants in bracket)	50 (17)
Objectives of the Programme and Innovation brought, if any.	To acquaint the SC farmers about improved potato cultivation including seed production, ware potato production varieties and management etc.
Title of the Programme	**Potato Seed distribution and imparting training to the SC Farmers on topic Improved Potato Cultivation at KVK Amas Gaya Bihar under SCSP component with assistance of KVK Amas Gaya.**

Photos: Training program organized by ICAR-CPRI RS, Patna

E. ICAR-CPRI RS, Shillong

Title of the Programme	Training-cum-awareness programme on advance in Potato production technology
Programme period, Duration & Venue	January 30, 2023 (1 Day), KVK, Khawzawl, Champhai District, Mizoram.
Team/Co-ordinators	Dr. N. Sailo, Sr. Scientist, ICAR-CPRI RS Shillong Dr. Malsawmkimi, Sr Scientist and Head, KVK, Khawzawl, Champhai District Dr. Vanlalduati, SMS (Soil Sciences) KVK, Khawzawl, Champhai District
Total number of participants (No. of female participants in bracket)	43 (4)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Training cum Farmers interaction with scientist**
Programme period, Duration & Venue	February 24, 2023 (1 Day), Haorang Sabal & Mapao Khullen, Manipur
Team/Co-ordinators	Dr. N. Sailo, Sr. Scientist, ICAR-CPRI RS Shillong Dr. Arati Ningombam, Scientist, ICAR-RC-NEH, Imphal Dr. Bless Sailo, Scientist, ICAR-RC-NEH, Imphal Smt. Lily Rangnamei, SMS (Hort), KVK Imphal West
Total number of participants (No. of female participants in bracket)	52 (26)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Empowerment and livelihood improvement of tribal women through Potato production**
Programme period, Duration & Venue	February 23-25, 2023 (3 days), Seminar Hall, ICAR – CPRI, RS Shillong
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS) , ICAR- CPRI, RS Shillong Co Co-ordinator Dr. N. Sailo, Sr. Scientist, ICAR- CPRI, RS Shillong. Dr. Janani, P, Scientist (SS), ICAR- CPRI, RS Shillong.
Total number of participants (No. of female participants in bracket)	61 (all 61 are females)
Title of the Programme	**Scientific Cultivation Practices of Potato in reference to Tirap District**
Programme period, Duration & Venue	March 6-7, 2023 (2 days), KVK, Tirap Arunachal Pradesh
Team/Co-ordinators	Dr. Abhimanyu Chaturvedi, SMS, KVK, Tirap Dr. N. Kumar, Head, KVK, Tirap
Total number of participants (No. of female participants in bracket)	50 (40)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Improved potato production technology for West Jaintia Hills district, Meghalaya**
Programme period, Duration & Venue	March 9-11, 2023 (3 days) Conference Hall, KVK, Jaintia Hills.

Title of the Programme	Training-cum-awareness programme on advance in Potato production technology
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS) , ICAR- CPRI, RS Shillong Dr Dodo Pasweth, SS & Head, KVK, Jaintia Hills Co Co-ordinator Dr. Janani, P, Scientist (SS), ICAR- CPRI, RS Shillong Smt R Lyngdoh, SMS (Agronomy), KVK, Jaintia Hills
Total number of participants (No. of female participants in bracket)	60 (55)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Production Technology of Potato**
Programme period, Duration & Venue	March 9-11, 2023 (3 Days) at ICAR-RC-NEH, Tripura
Team/Co-ordinators	Dr. N. Sailo, Sr. Scientist, ICAR-CPRI RS Shillong Dr. Bapi Das, Scientist, ICAR-RC-NEH, Tripura
Total number of participants (No. of female participants in bracket)	80 (08)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on advanced method of potato production-agronomical practices, scope of marketing, important of seed and seed storage etc.
Title of the Programme	**Organic Potato Cultivation**
Programme period, Duration & Venue	March 10, 2023 (1 day), Krishi Vigyan Kendra, East Khasi Hills District, Upper Shillong
Team/Co-ordinators	Co-Ordinator: Dr. Janani, P, Scientist (SS), ICAR- CPRI RS Shillong Mr. Samborlang Malngiang, SMS (Fisheries) KVK, East Khasi Hills District Co-Coordinator: Dr. Clarissa Challam, Scientist (SS), ICAR- CPRI RS Shillong
Total number of participants (No. of female participants in bracket)	25 farmers (12)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Demonstration on apical-rooted cutting technology**
Programme period, Duration & Venue	July 13, 2023 (1 day), Bethany Society, Laitumkhrah
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS) , ICAR- CPRI, RS Shillong Co Co-ordinator Dr. N. Sailo, Sr. Scientist, ICAR- CPRI, RS Shillong
Total number of participants (No. of female participants in bracket)	20 (7 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on ARC
Title of the Programme	**Training on potato processing and value addition for farmers of Ri Bhoi District, Meghalaya**
Programme period, Duration & Venue	September 29, 2023 (1 day), ICAR – Central Potato Research Institute, RS Shillong, Meghalaya

Title of the Programme	Training-cum-awareness programme on advance in Potato production technology
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS), ICAR- CPRI, RS Shillong Co Co-ordinator Dr. Janani P, ICAR- CPRI, RS, Shillong
Total number of participants (No. of female participants in bracket)	30 (28 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Potato Processing
Title of the Programme	**Hands-on-training for potato seed production through Apical Rooted Cuttings**
Programme period, Duration & Venue	October 9-13, 2023 (5 days), Seminar Hall, ICAR- Central Potato Research Institute, Regional Station Shillong
Team/Co-ordinators	**Co-ordinator** Dr. Yvonne Angel Lyngdoh, Scientist (SS), ICAR- CPRI, RS Shillong **Co Co-ordinator** Dr. Janani P, ICAR- CPRI, RS, Shillong
Total number of participants (No. of female participants in bracket)	25 (11 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on ARC
Title of the Programme	**Scientist-Potato Cultivation**
Programme period, Duration & Venue	November 28-29, 2023 (2 days) at ICAR RC for NEH region, Nagaland Center
Team/Co-ordinators	Dr. N. Sailo, Sr. Scientist, ICAR-CPRI RS Shillong Dr. Aabon Yanthan, Scientist, ICAR-RC-NEH, Imphal Dr. Ruth Assumi, Scientist, ICAR-RC-NEH, Imphal Dr. Pempa L. Bhutia, Scientist, ICAR-RC-NEH, Imphal
Total number of participants (No. of female participants in bracket)	25 (20 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on ARC
Title of the Programme	**Advances in potato production technology**
Programme period, Duration & Venue	December 5, 2023 (1 day), Williamnagar, East Garo Hills, Meghalaya
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS), ICAR- CPRI, RS Shillong Dr. Brijendra Singh Rajawat, Principal Scientist & Head, KVK, East Garo Hills Co Co-ordinator Dr. Trudy Tengse A. Sangma, SMS (Horticulture), KVK East Garo Hills
Total number of participants (No. of female participants in bracket)	44 (40 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Scientific Potato Cultivation**
Programme period, Duration & Venue	December 7-9, 2023 (3 days) at ICAR-RC-NEH, Tripura & KVK, Sepahijala
Team/Co-ordinators	Dr. N. Sailo, Sr. Scientist, ICAR-CPRI RS Shillong Dr. Bapi Das, Scientist, ICAR-RC-NEH, Tripura Dr. Utpal Dey, SMS, KVK, Sepahijala

Title of the Programme	Training-cum-awareness programme on advance in Potato production technology
Total number of participants (No. of female participants in bracket)	83 (09 Female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Advances in potato production technology**
Programme period, Duration & Venue	December 13, 2023 (1 day), Conference Hall, ICAR-KVK, Ri-Bhoi
Team/Co-ordinators	Co-ordinator Dr. Yvonne Angel Lyngdoh, Scientist (SS), ICAR- CPRI, RS Shillong Dr. Meghna Sarma, SMS (Agronomy), ICAR- KVK, Ri-Bhoi
Total number of participants (No. of female participants in bracket)	54 (53 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato
Title of the Programme	**Waste to wealth composting approach**
Programme period, Duration & Venue	December 22, 2023 (1 day), 5th mile, upper shillong
Team/Co-ordinators	Dr. Janani P, ICAR- CPRI, RS, Shillong
Total number of participants (No. of female participants in bracket)	30 (25 female)
Objectives of the Programme and Innovation brought, if any.	To sensitize farmers on Scientific cultivation of Potato

Photos: Training programs organized by ICAR-CPRI RS, Shillong

III. PARTICIPATION IN SEMINAR/ SYMPOSIUM/ CONFERENCES/ WORKSHOPS/ MEETINGS/OTHERS

Name of staff	Name of the Programme	Venue / Organized by	Date
Dr. Mehi Lal	National Symposium on "Plant health for Sustainable Agriculture"	SVPUAT, Meerut Uttar Pradesh	January 6-7, 2023
Dr. Aarti Bairwa	International Conference on Biotic and Abiotic Stress of Crop Plants and their Sustainable Management	Department of Plant Pathology, Institute of Agriculture (PSB) Visva-Bharati, Sriniketan , Birbhum, West Bengal	February 2-3, 2023
Dr. SK Luthra	राष्टीय आलू दिवस एवं कृषक जागरूपता दिवस	CPRI RS, Modipuram, Meerut	February 15, 2023
Dr. Mehi Lal, Sr. Scientist, Bandana, Sr. Scientist, ICAR – CPRI, RS, Modipuram	05th International Conference on "Identification, convergence, implementation & Extension of Science – Tech – Research for sustainable Development – 2023	Shobhit institute of engineering and technology Deemed to – be – University, Meerut	February 21-22, 2023
Dr. Bandana	International Conference 5th International Conference on Agriculture, Biotechnology, Life sciences, Social sciences and allied sciences, ICIESSD-2023, at Shobit Institute of Engg. & Tech. Meerut.	Shobit Institute of Engg. & Tech. Meerut	February 21-22, 2023
Dr. Sarla Yadav, Sr. Scientist, ICAR-CPRI, RS, Patna	International Conference on "Innovative Approaches in Basic & Applied Sciences for Societal Development	GBPUA&T, Pantnagar, Uttarakhand	March 24-25, 2023
Dr. Aarti Bairwa	3rd International Conference on " Innovative Approaches in Agriculture, Horticulture & Allied Sciences (IAAHAS-2023)"	Indian Society of Agriculture & Horticulture Research Development, (ISAHRD) Chandigarh SGT University, Gurugram (ICAR Accredited)	March 29-31, 2023
Drs. Tanuja Buckseth, Scientist, Aarti Bairwa, Sr. Scientist, ICAR-CPRI, Shimla.	Innovative Approaches in Agriculture, Horticulture & Allied Sciences	(Online Mode)	March 29-31, 2023
Dr. SK Luthra	Pashu Pradarshini and Krishi Mela	Numaish Ground, Muzzafarnagar	April 6, 2023
Dr. Dalamu	"International workshop on E-processing and management of DUS testing data in plant variety examination-Using example of rapeseeds/mustard"	NBPGR New Delhi organized by PPV&FRA New Delhi	May 25-26, 2023
Dr. Brajesh Singh, Director, Dr. Vinod Kumar, PS, Dr. Sanjeev Sharma, Head, PP, Dr. Anil Kumar Choudhary, PS, Dr. Kailash Chandra Naga, Scientist, Dr. Milan Kumar Lal, ICAR-CPRI, Shimla	Global Conference on precision Horticulture for Improved Livelihood Nutrition and Environment Services	Jalgaon, Maharashtra	May 28-31, 2023

Name of staff	Name of the Programme	Venue / Organized by	Date
Dr. Kailash Chandra Naga	Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Service	Jain Irrigation System Ltd and CHAI, Jalgaon	May 28-31, 2023
Dr. Sanjeev Sharma	Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Service	Jain Irrigation System Ltd and CHAI, Jalgaon	May 28-31, 2023
Dr. Sanjeev Sharma	Review meeting of ICAR-CPRI, Shimla with Hon'ble Agriculture Minister at Krishi Bhawan, New Delhi	Krishi Bhawan	May 31, 2023
Dr. Sanjeev Sharma	Institute Animal Ethic Committee (IAEC) meeting of Central Research Institute, Kasauli	CRI, Kasauli	June 7, 2023
Dr. Janani P	National Conference on "Rebooting the hill farming for future sustainability and livelihood"	ICAR Research Complex for NEH Region, Umiam, Meghalaya.	June 8-9, 2023
Dr. Yvonne Angel Lyngdoh	National Conference on "Rebooting the hill farming for future sustainability and livelihood"	ICAR Research Complex for NEH Region, Umiam, Meghalaya.	June 8-9, 2023
Dr. Ngursangzuala Sailo	National Conference on "Rebooting the hill farming for future sustainability and livelihood"	ICAR Research Complex for NEH Region, Umiam, Meghalaya.	June 8-9, 2023
Dr. Clarissa Challam	National Conference on "Rebooting the hill farming for future sustainability and livelihood"	ICAR Research Complex for NEH Region, Umiam, Meghalaya.	June 8-9, 2023
Drs. Clarissa Challam, Scientist, Ngursangzuala Sailo, Sr. Scientist, P. Janani, Scientist, Dr. Yvonne Angel Lyngdoh, Scientist ICAR-CPRI, RS, Shillong	National Conference on "Rebooting the Hill Farming for Future Sustainability and Livelihood"	ICAR Research Complex for NEH Region, Umiam, Meghalaya	June 8-9, 2023
Dr. Salej Sood	National Conference on Natural & Organic Farming for Ecological, Economical & Nutritional Security	Organic Agricultural Society of India, Department of Organic Agriculture & Natural Farming College of Agriculture, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur-176062 (HP)	June 7-9, 2023
Dr. Sanjeev Sharma	Institute Animal Ethic Committee (IAEC) meeting of School of Pharmacy, Abhilashi University, Mandi	Abhilashi University, Mandi	June 10, 2023
Dr. Alok Kumar	National Training Conclave, 2023	Convention Centre, ITPO, Pragati Maidan, New Delhi, Organized by Capacity Building Commission (CBC), New Delhi	June 11, 2023

Name of staff	Name of the Programme	Venue / Organized by	Date
Dr. Salej Sood	International Conference on Millets: Breeding, Physiology, Genomics, Biotechnology, and Nutraceuticals-2023 (ICM-BPGBN-2023)	Department of Biosciences, Rajagiri College of Social Sciences, Cochin - 683 104, Kerala	July 5-7, 2023
Dr. Bandana, Sr. Scientist, ICAR-CPRI, RS, Modipuram	Vth International Conference in hybrid mode on "Innovative and Current Advance in Agriculture and Allied Sciences – 2023	Online mode	July 10-16, 2023
Dr. Subhash S., Scientist, ICAR-CPRI, RS, Modipuram	"38th Annual Meeting of the International Society of Chemical Ecology – 2023"	Indian Institute of science, Bengaluru	July 23-27, 2023
Dr. R K Singh	Six monthly meeting of NARAKAS	NARAKAS Patna	July 27, 2023
Dr. Mehi Lal	Wiley online Library: How can it help researcher-CERA Consortium	Wiley & Online attended	August 3,2023
Dr. Sarla Yadav	BTM/ATM " Importance of fertilizers in cultivation of potato crop"	BAMETI, Patna (Bihar)	August 21, 2023
Dr. Mehi Lal	National dialogue for shaping for future of Indian Agriculture: A way forward	NASS Lecture, By CHAI	August 26, 2023
Dr. Sanjeev Sharma	Virtual consultation meeting on Tomato, Onion & Potato (TOP) crops	Deptt of Rural Development, Ministry of Rural Development, GoI	August 28, 2023
Dr. R K Singh	3rd All India Conference on Official Language	Shiv Chhatrapati Sports Complex, Pune (Official Language, Ministry of Home Affairs, Govt of India.)	September 14-15, 2023
Dr. Dalamu	"First Global symposium on Farmer's Right"	NASC New Delhi organized by FAO Rome and hosted by Ministry of Agriculture, GoI	September 12-15, 2023
Dr. Anuj Bhatnagar	2nd International conference on prospects and challenges of environment and bio logical sciences in food production system for livelihood security of farmers	ICAR-CIARI, Port Blair	September 18-20, 2023
Dr. Sanjeev Sharma	Institute Animal Ethic Committee (IAEC) meeting of Central Research Institute, Kasauli	CRI, Kasauli	September 20, 2023
Dr. Kailash Chandra Naga	National Symposium on "Crop Health Management: Safeguarding Crop through Diagnostics and Innovations"	ICAR-VPKAS, Almora	September 29-30, 2023
Dr. R K Singh	XVI Agricultural Science Congress & ASC Expo 2023	NAAS, New Delhi (Hosted by ICAR-CMFRI Kochi)	October 10-13, 2023

Name of staff	Name of the Programme	Venue / Organized by	Date
Drs. Brajesh Singh, Director, Jagdev Sharma, Vinod Kumar, Sanjeev Sharma, Dinesh Kumar, Alok Kumar, Vinay Sagar, Anil Choudhary, Salej Sood, Vikas Mangal, Dalamu, Devendra Kumar, Anuj Bhatnagar, SK Luthra, Sanjay Rawal, VK Gupta, Anil Sharma, Raj Kumar, Prince Kumar, RK Singh, SP Singh, Sarla Yadav, Subhash Katare, Murlidhar Sadawarti, Priyank Mahatre, Divya K. Lekhshamnan, N Sailo, P. Janani	41st Group Meeting of AICRP (Potato)	CCS HAU, Hisar, Haryana	October 16-18, 2023
Dr. R K Singh Dr. S P Singh Dr. (Mrs) S Yadav	41st Group Meeting of AICRP (Potato)	CCS HAU Hisar	October 16-18, 2023
Dr. Salej Sood, Sr. Scientist, ICAR-CPRI, Shimla	International Conference on "Biochemical and Biotechnological Approaches for Crop Improvement"	NASC, New Delhi	October 30 - November 1, 2023
Dr. Yvonne Angel Lyngdoh	10th Indian Horticulture Congress – 2023 "Unleashing Horticultural Potential for Self-Reliant India"	College of Veterinary Campus, Assam Agricultural University, Khanapara, Guwahati, Assam	November 6-9, 2023
Dr. Prince Kumar, Scientist, ICAR-CPRI, RS, Jalandhar	05th International Conference on "Sustainable Natural Resource Management under Global Climate Change"	NASC Complex, New Delhi	November 7-10, 2023
Dr. Raj Kumar	International Webinar on "DUS & PVP Data Management"	Online by PPV & FRA new Delhi	November 17, 2023
Dr. Dalamu	Online webinar "DUS and PVP data management"	Online organized by PPV&FRA New Delhi	November 17, 2023
Dr. Anil Kumar Choudhary, PS, ICAR-CPRI, Shimla	XXIIth Biennial National Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security"	ICAR-CCARI, Ela, Goa	November 22-24, 2023
Dr. Raj Kumar	KMS for DUS Characterization of Crops	Online by PPV & FRA new Delhi	November 29, 2023
Dr. Alok Kumar, Head, SS, ICAR-CPRI, Shimla	International Conference on "Protected Cultivation of Horticultural Crops, Post – Harvest Handling and Digital Agriculture"	SHUAT, Prayagraj, Allahabad	November 29-30, 2023
Dr. Anil Choudhary	Soil Testing	Lahaul & Spiti (HP)	December 5, 2023
Dr. SK Luthra	Aloo utpadan takniki	CPRI, RS, Modipuram	December 9, 2022
Dr. Devendra Kumar, PS, ICAR-CPRI, RS, Modipuram	National Conference on "Plant Physiology – 2023"	IARI, New Delhi	December 9-11, 2023
Dr. RK Singh, Head, ICAR-CPRI, RS, Modipuram	National Seminar on "Natural & Organic Farming for Sustainable Agriculture"	ICAR-IISR, Lucknow	December 29, 2023

IV. INVITED LECTURES DELIVERED IN OTHER UNIVERSITIES/ INSTITUTES ETC. BY THE SCIENTISTS

Name of Staff	Lecture	Programme	Organized by	Place	Date
Dr Mehi Lal	Field diagnosis of potato pathogens	In High end workshop (Karyashala) on "Serological &Molecular Diagnostics of Potato Pathogens	ICAR-CPRI Shimla	ICAR-CPRI Shimla	January 9-20, 2023
Dr Aarti Bairwa	Aeroponic root leachates (ARL): A novel strategy for the management of potato cyst nematode (*Globodera* spp.)".	International Conference on Biotic and Abiotic Stress of Crop Plants and their Sustainable Management	Department of Plant Pathology, Institute of Agriculture (PSB)	Visva-Bharati, Sriniketan , Birbhum, West Bengal	February 2-3, 2023
Dr. Bandana	Basic techinique of potato processing		प्रशिक्षण कार्यक्रम -एच . आर. डी. ट्रेनिंग प्रोग्राम के अंतग्रत कृषि विज्ञान केन्द्रों पर कार्यरत वैज्ञानिकों को प्रशिक्षण	SVBPUAT, Modipuram, Meerut	February 6, 2023
Dr R K Singh	Seed Analysis	Training for sill development of officers/ employees of seed testing laboratory of Govt of Bihar.	Deputy Director (Agron) Seed Analysis, Bihar Patna.	BAMETI PATNA	March 2, 2023
Dr Aarti Bairwa	Role of cropping systems in the management of Potato Cyst Nematodes (*Globodera* spp.) in the Northern-western hills of India.	3rd International Conference on " Innovative Approaches in Agriculture, Horticulture & Allied Sciences (IAAHAS-2023) "	Indian Society of Agriculture & Horticulture Research Development, (ISAHRD) Chandigarh, SGT University, Gurugram		March 29-31, 2023
Dr. Janani P	Future Prospects of Organic Farming of Potato in NER	National Seminar on"Natural Farming in North East India: A vision towards Sustainable Agriculture, Livelihood and Nutritional Security"	BIRAC' s BioNEST Bio Incubator (B3I) Facility,NEHU, Tura Campus, Meghalaya In collaboration with ICAR RC NEH Region, Meghalaya; IPR Cell, NEHU, Shillong; & IIS, Gujarat University.	North-Eastern Hill University, Umshing Mawkynroh, Shillong 793022	May 21, 2023
Dr Mehi Lal	Abiotic Stress Management in Mushroom Production	Training on Production Technology for edible and medicinal mushroom	Division of Plant Pathology	SVB Patel Uni of Agriculture & Technology, Meerut (UP)	May 25,2023
Dr Kailash Chandra Naga	Insect pest of potato and their management	Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Service	Jain Irrigation System Ltd & CHAI	Jalgaon	May 28-31, 2023

Name of Staff	Lecture	Programme	Organized by	Place	Date
Dr Sanjeev Sharma	Diseases and their impact on potato production	Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Service	Jain Irrigation System Ltd & CHAI	Jalgaon	May 28-31, 2023
Dr Ngursangzuala Sailo	Macro-propagation and ex-situ conservation of orchids	Two Days Training Cum Awareness Programme in Orchids	ICFRE-Bamboo and Rattan Center, Ministry of Env.	Online Mode	4-5, July 2023
Dr. Janani P	Agro techniques for the production of Quality potato seed	Five days Master Trainers Training of Potato	Meghalaya Basin Development Authority, Shillong, Meghalaya 793003	ICAR-CPRI RS Shillong	July 10, 2023 August 31, 2023
Dr Yvonne Angel Lyngdoh	Common diseases / pest of potato and their management	Five days Master Trainers Training of Potato	Meghalaya Basin Development Authority, Shillong, Meghalaya 793003	ICAR-CPRI RS Shillong	July 10, 2023 July 18, 2023 July 25, 2023 August 31, 2023
Dr Ngursangzuala Sailo	Post-Harvest Management of Potato	Five days Master Trainers Training of Potato	Meghalaya Basin Development Authority, Shillong, Meghalaya 793003	ICAR-CPRI RS Shillong	July 10, 2023 July 18, 2023 July 25, 2023 August 31, 2023
Dr Subhash S	Estragole, a potential attractant of the winged melon aphid, *Aphis gossypii.*	38th Annual Meeting of the International Society of Chemical Ecology (ISCE 2023)	International Society of Chemical Ecology (ISCE 2023)	Indian Institute of Science, Bengaluru,	July 23-27, 2023
Dr Mehi Lal	कीट रोग प्रबंधन मे पोषक प्रबंधन का महत्तव	Certificate Courses on Integrated Nutrient Management for fertilizer dealers	FAI & ICAR-CPRI RS, Modipuram	ICAR-CPRI RS, Modipuram	August 2-16, 2023
Dr Dalamu	"Advances in biotic and abiotic stress management in potato crop"	21 days Summer School on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management (ECOBASM-2023)	Astha Foundation, Meerut	Online	August 10-30, 2023
Dr Anuj Bhatnagar	Impact of climatic factors on whitefly incidence, disease transmission & potato yield loss due to ToLCND Virus in North western India	& cochairmen in technical session VII in 2nd International conference on Prospects and Challenges of Environment and Bio logical sciences in Food Production System for Livelihood Security of Farmers	ICAR-CIARI, Port Blair.	Port Blair	September 18-20, 2023

Name of Staff	Lecture	Programme	Organized by	Place	Date
Dr Kailash Chandra Naga	Genetic insights into neonicotinoids resistance: *CPY6CY3* as a key player in *Myzus persicae"*	National Symposium on "Crop Health Management: Safeguarding Crop through Diagnostics and Innovations"	ICAR-VPKAS, Almora	Almora	September 29-30, 2023
Dr Alok Kumar	Implementation of Career Development Centres	One-day workshop titled "Sustainability of Career Development Centres and NARES – Blended Learning Platform (BLD)"	ICAR-NAARM, Hyderabad	CSKHPKV, Palampur, Himachal Pradesh	October 4, 2023
Dr Alok Kumar	Implementation of Career Development Centres	One-day workshop titled "Sustainability of Career Development Centres and NARES – Blended Learning Platform (BLD)"	ICAR-NAARM, Hyderabad	AAU, Anand, Gujarat	October 10, 2023
Dr Yvonne Angel Lyngdoh	Scientific production technology for commercialization of important *kharif* and *rabi* vegetables in North-Eastern states	Skill training of Rural youths (STRY)	Meghalaya Agricultural Management and Extension Training Institute (MAMETI)	Integrated agricultural Training center (IATC), Upper Shillong – 793005 Meghalaya	October 17, 2023
Dr. Janani P	Potato storage and hands-on training in chips and French fry making.	Skill training of Rural youths (STRY)	Meghalaya Agricultural Management and Extension Training Institute (MAMETI)	Integrated agricultural Training center (IATC), Upper Shillong – 793005 Meghalaya	November 9, 2023

OTHER CELLS AND UNITS

LIBRARY AND DOCUMENTATION SERVICES

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

Resource Development

At the headquarter (Shimla), a total of 21 documents were purchased, procured and added to library resources. The total collection at Shimla stands at 40252 documents comprised of 16599 books, 15780 back volume of journals, 2754 serials, 2271 annual reports, 586 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 28052 books; journals back volumes and other documents i.e. AR/ Reprints and Bulletins etc as per the details below (Table-1).

Table-1: Library Collection of CPRIC & CPRS

Regional Stations/units	Books	Back vols. of Journals	Other Documents (AR/Rpr/Bull)	Total	Current Journals subscribed (Indian)
CPRIC, Modipuram	4733	6014	2562	13309	**02**
CPRS, Jalandhar	3366	1591	473	5430	**02**
CPRS, Patna*	2118	1280	--	3398	**02**
CPRS, Gwalior	1221	4	81	1306	**02**
CPRS, Ooty	1688	580	565	2833	**02**
CPRS, Shillong	1561	-	171	1732	**02**
CPRS, Kufri	144	-	-	144	--
TOTAL	14831	9469	3852	28152	12

Periodicals and Serials Management

A total of current journals comprising of 4 foreign and 16 Indian have been subscribed at Shimla. Out of which 4 foreign and 16 Indian journals were subscribed on payment basis and rest 20 on exchange or gratis. In all 190 issues of such journals were received, marked and kept in library for use. Besides. 108 books were classified, catalogued, labeled, pasted and transcribed and entered in Library Automation Software for use. The library has the complete series of CABCD (till December 2017 and ISA databases for retrospective and current scientific literature search and use of scientists.

Computerized & Net Based Services

The institute scientists were facilitated with full text access to 5 online databases, 8 institutes subscribed foreign journals and more than 3900+ journals from 913 national and international publishers through ICAR's e-resources consortia (Consortia for E-Resources in Agriculture). The library resources e.g. library catalogue (OPAC), foreign journals, CD Net searching, and Current Journals Received Last Week were regularly updated and maintained on library web page. Now scientists are making use of mostly library resources online from their desktop. Many relevant web sites were visited and information and data were downloaded therefrom for scientists' use. 31 Extension/Technical/Annual Reports/Station Annual Reports/Content Pages of Potato books available at CPRI library/ Training Manuals/Newspaper clipping were scanned and uploaded in institute's website under the link "Institutional Repository of CPRI".

Readers and Reference Service

A total of 602 documents were circulated (borrowed and returned) for home studies and 889 readers consulted 6468 documents within the library. Besides, 7 outside scientists and research scholars of various research organizations consulted the library resources. 6 new members were enrolled and 8 old members withdrew their library membership due to their transfer or retirement. At present 96 readers are active members of library including RAs/SRAs. Library received thousands of reference queries from the users of the library and responded to them satisfactorily. Besides, 354 job requests were received for 60130 copies of photocopying and printing work of different scientific and administrative documents.

Documentation and Information Services

190 issues of journals were scanned for potato literature and 221 potato articles were found and recorded. Approximately, 16 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 thousands of pages were scanned for integrating into institute OPAC.

Resource Generation and utilization

The library has generated the revenue of Rs.4,587.00 which includes the amount of photocopying charges (Rs.4,587.00), library discount on books (Rs.3380.00) in addition to normal 10% GOC discount saved on purchase of library books and journals through CPRI Book store. A total of Rs. *7,23,493.00* was spent on purchase of library resources like books *(Rs.51,905.00),* and subscription of journals *(Rs.5,33,689.00)* at HQ library Shimla.

HINDI CELL

Celebrating Hindi Diwas and Hindi Pakhwada-2023

'Hindi Pakhwada' was celebrated with great enthusiasm at ICAR-Central Potato Research Institute, Shimla from September 14, 2023 to September 28, 2023. It was inaugurated on the occasion of Hindi Day on September 14, 2023 in which Dr. Usha Rani, Assistant Professor, Himachal Pradesh University, Shimla was present as the chief guest. Director of the institute, Dr. Brajesh Singh welcomed the chief guest, after that in his address he informed about the research work being done in the institute and told that our institute is a scientific institute, yet more than 90% of the work done here is in Hindi, he also assured to do 100% work in Hindi in future and gave information about the history of the institute and its activities. Thereafter, in his address, the Chief Guest congratulated all the officers/employees of the institute on Hindi Day and wished all the officers/employee's good luck for the competitions to be organized during the Pakhwada.

Closing of Hindi Pakhwada and Prize Distribution Ceremony

'Hindi Pakhwada Closing Ceremony' was organized on October 20, 2023. At the beginning of the function, Mr. Rajdeep Bux, Incharge (Library) welcomed the chief guest and all the officers and employees present. First of all, he informed about the Hindi related works being done in the institute and the competitions organized during the Hindi Pakhwada. After that, Ms. Sunita, Deputy Director, Official Language introduced the Chief Guest and announced the awards of the competitions organized during the fortnight and the winning participants were awarded by the Director of the institute Dr. Brajesh Singh and Chief Guest of the program and all other participants were given special awards for their special contribution during the Pakhwada.

Official Language Conference organized at Central Potato Research Institute, Shimla

An official language seminar was organized at ICAR-Central Potato Research Institute, Shimla on November 02, 2023. In which Dr. Kanwar Dinesh Singh, Associate Professor and Head of the English Department, Rajiv Gandhi Government College, Shimla was present as the keynote speaker and the Director of the Institute, Dr. Brajesh Singh, Director, CPRI, Shimla presided over the program. More than 30 representatives from all the member offices of the Town Official Language Implementation Committee participated in the function. Chairman of the program and director of the institute Dr. Brajesh Singh, welcomed all the guests to the institute and informed them about the work being done in the institute. After this, the main speaker of the seminar, Dr. Kanwar Dinesh Singh, discussed the detailed dimensions of Hindi language in his speech. At the end of the speech, a question-and-answer session was also held in which the participants present got their queries resolved from the keynote speaker.

Inspection of Central Potato Research Institute, Shimla Headquarters by the Second Sub-Committee of the committee of Parliament on Official Language

The Institute Headquarter, Shimla was inspected by the Second Subcommittee of the Parliamentary Official Language on October 5, 2023. The said inspection was conducted at Hyatt Hotel, Dharamshala, Himachal Pradesh. During the inspection, on behalf of the Council Headquarters, Assistant Director General Dr. Sudhanshu Pandey and Assistant Chief Technical Officer Shri B.S. Parswal was present and Shimla headquarters was represented by Dr. Jagdev Sharma, Principal Scientist and Ms. Sunita, Deputy Director (Official Language) and Mr. Joginder Singh Thakur, Administrative Officer were also present in the meeting.

WORKS SECTION

S. No.	Name of the infrastructure	Details	If Inaugurated, when and by whom
1.	Renovation of Polyhouses	Two polyhouses were renovated at Fagu farm.	-
2.	Seed Treatment Facility	To ensure decontamination from Potato Cyst nematodes (PCN), a facility for treatment of Seed Potatoes was created at Kufri-Lister house.	-

PUBLICATIONS

I. Research Articles

1. Altaf, M. A., Shahid, R., Kumar, R., Altaf, M. M., Kumar, A., Khan, L. U., Saqib, M., Nawaz, M. A., Saddiq,B., Bahadur,S., Tiwari,R.K., Lal,M.K. & Naz, S. (2023). Phytohormones mediated modulation of abiotic stress tolerance and potential crosstalk in horticultural crops. *Journal of Plant Growth Regulation*, *42*, 4724–4750. https://doi.org/10.1007/s00344-022-10812-0

2. Altaf, M.A., Sharma, N., Singh, J., Samota, M.K., Sankhyan, P., Singh, B., Kumar, A., Naz, S., Lal, M.K., Tiwari, R.K. & Kumar, R. (2023). Mechanistic insights on melatonin-mediated plant growth regulation and hormonal cross-talk process in solanaceous vegetables. *Scientia Horticulturae*, *308*,111570. https://doi.org/10.1016/j.scienta.2022.111570

3. Altaf, M.A., Sharma, N., Srivastava, D., Mandal, S., Adavi, S., Jena, R., Bairwa, R.K., Gopalakrishnan, A.V., Kumar, A., Dey, A., Lal, M.K., Tiwari, R.K., Kumar, R., & Ahmed, P. (2023). Deciphering the melatonin-mediated response and signalling in the regulation of heavy metal stress in plants. *Planta, 257*, 115. https://doi.org/10.1007/s00425-023-04146-8

4. Altaf, M.A., Shahid, R., Lal, P., Ahmad, R., Zulfiqar, F., Kumar, A., Hayat, F., Kumar, R., Lal, M.K., Naz, S., & Tiwari, R.K. (2023). Current understanding of boosting power of salicylic acid for abiotic stress tolerance in horticultural crops. *South African Journal of Botany*, *163*, 285-293. https://doi.org/10.1016/j.sajb.2023.10.048

5. Altaf, M.A., Naz, S., Kumar, R., Sardar, H., Nawaz, M.A., Kumar, A., Lal, P., Ahmad, R., Hayat, F., Wani, M.A., Tiwari, R.K., & Lal, M.K. (2023). Unraveling the mechanisms of cadmium toxicity in horticultural plants: Implications for plant health. *South African Journal of Botany*, *163*, 433-442. https://doi.org/10.1016/j.sajb.2023.10.064

6. Bairwa, A., Dipta, B., Mhatre, P.H., Venkatasalam, E.P., Sharma, S., Tiwari, R., Singh, B., Thakur, D., Naga, K.C., Maharana, C., & Sharma, A.K. (2023). *Chaetomium globosum* KPC3: An antagonistic fungus against the potato cyst nematode, *Globodera rostochiensis*. *Current Microbiology, 80*(4), 125. doi: 10.1007/s00284-023-03228-w. PMID: 36872375

7. Bairwa, A., Dipta, B., Verma, G., Venkatasalam, E.P., Shanthi, A., Jeevalatha, A., Naga, K.C., Sharma, S., Thakur, D., & Mhatre, P.H. (2023). Development and evaluation of loop-mediated isothermal amplification assay for rapid and sensitive detection of potato cyst nematode, *Globodera pallida* from soil. *3 Biotech*, *13*,123

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II Popular Articles

1. बन्दना, विनीत शर्मा, अशोक कुमार चौहान, देवेन्द्र कुमार एवं ब्रजेश सिंह (फरवरी 2023) आलू आधारित प्रसंस्करण संयंत्र, अनुसूचित जाति उपयोजना के अंतर्गत भा.कृ.अनु.प. – केन्द्रीय आलू अनुसंधान संस्थान, शिमला 171001(हि. प्र.) एवं भा.कृ. अनु.प. – केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केंद्र, मोदीपुरम, मेरठ (उ.प्र.) द्वारा प्रकाशित (15 फरवरी, 2023 को भा०कृ. अनु.प. – केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केंद्र, मोदीपुरम, मेरठ (उ.प्र.)- 250110 पर आयोजित आलू दिवस के अवसर पर वितरण हेतु प्रसार पत्रक)

2. बन्दना, विनीत शर्मा, अशोक चौहान एवं कुसूम सिंह, 2023। आलू प्रसंसकरण हेतु मशीनीकरण के न्यूनीकरण हेतु विभिन्न यंत्र विषय के अंतर्गत, ग्रामीण महिलाओं हेतु श्रम दक्ष तकनीकियाँ । कीर्तिमणि त्रिपाठी, लक्ष्मीकांत, साधना पाण्डेय, शांतनु कुमार दुबे, श्री ज्ञान सागर प्रकाशन, पेज सं- 221-228।

3. Challam, C., Sailo, N., Janani, P., & Lyngdoh, Y.A. (2023). Hi-tech Potato Seed Production Technologies. In: Souvenir, State Level Kisan Mela on "Innovative farming approaches in potato and other tuber crops farming for empowering farmers" pp 47-49.

4. Chaudhary, B., Luthra, S.K., Gupta, V.K., & Dalamu. (2023). Management of early planted crop of potatoes. *AgriGates-An International Multidisciplinary e-Magazine*. *63*(8), 164-171

5. देवी, एस., कौर, आर. पी., नारे, बी., सिंह, एस. एवं सिंह, ए. के. (2023). नेट हाउस में हाई टेक बीज उत्पादन. फल- फूल, *43* (4),15-16.

6. देवेंद्र कुमार, अनुज भटनागर,मनोज कुमार, सतीश कुमार लूथरा, विनय सिंह, ध्रुव कुमार, संजय रावल, विजय किशोर गुप्ता, बबीता चौधरी, बंदना, मेही लाल, पूजा मानकर, एव सुभाष एस (फरवरी, 2023). आलू की उन्न्त उत्पादन तकनीक, प्रसार प्रतक।अनुसूचित जाति उपयोजना के अंतर्गत प्रकाशित०भा०कृ०अनु०प०-केंद्रीय आलू अनु संस्थान, क्षेत्रीय केंद्र, मोदीपुरम, मेरठ, पेज*1-6* .

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10. पूजा मानकर, देवेंद्र कुमार, मनोज कुमार, सतीश कुमार लूथरा, विनय सिंह, संजय रावल, अनुज भटनागर, विजय किशोर गुप्ता, बबीता चौधरी, मेही लाल, एव सुभाष एस (फरवरी, 2023). आलू की उन्नत उत्पादन तकनीक, प्रसार प्रतक।अनुसूचित जाति उपयोजना के अंतर्गत प्रकाशित०भा०कृ०अनु०प०-केंद्रीय आलू अनु संस्थान, क्षेत्रीय केंद्र, मोदीपुरम, मेरठ, पेज*1-6* .

11. प्रिंस कुमार, जगदेव शर्मा, विजय कुमार दुआ, अनिल शर्मा, राज कुमार, मनकरन सिंह सिधू, संकेत मेहता एवं मनोज कुमार (2022). आधुनिक सूचना प्रोद्योगिकी तकनीक द्वारा आलू में मुख्य पोषक तत्वों का प्रबंधन। कृषि किरण, 13, 24-28.

12. प्रियदर्शनी खांबाल्कर, शाशी सिंह यादव, मुरलीधर सदावर्ती एवं जनमेजय शर्मा (2023)। वर्तमान जलवायु परिद्रश्य में मोंटे अनाज का महत्व। मरुधरा कृषि। वर्ष-4, अंक-5, (सितम्बर-अक्टूबर), 2023.

13. राजेश कुमार सिंह, देवेन्द्र कुमार, अनुज भटनागर, सतीश कुमार लूथरा, विनय सिंह, ध्रुव कुमार, संजय रावल, विजय किशोर गुप्ता, बबिता चौधरी, मेही लाल, बंदना, पूजा मानकर एवं सुभाष एस (2023). उत्तर प्रदेश के लिए आलू की उन्नत उत्पादन तकनीक, प्रसार बुलेटिन, भाकृअनुप - केन्द्रीय आलू अनुसंधान संस्थानक्षेत्रीय केंद्र, मोदीपुरम, मेरठ.

14. सरला यादव, शिव प्रताप सिंह एवं राजकुमार सिंह (2023). भोज्य आलू उप्पादन की उन्नत तकनीक, किसान भारती। अक्टूबर अंक: पृष्ठ*28-30* .

15. Sadawarti, M.J., Singh, S.P., Katare, S., Buckseth, T., Singh, B., Sharma, S.K., Samadhiya, R.K., Singh, Y.P., Gupta, S.K, Singh, S. & Khambalkar, P.A. (2023). Factors influencing seed potato quality in India. *Krishisewa*, Page No.1-10.

16. Sadawarti, M.J., Singh, S.P., Katare, S., Samadhiya, R.K., Singh, Y.P., Sharma, S.K., Singh, S., Gupta, S.K., Devi, S., Buckseth, T., Kumar, V., Singh, B. & Khambalkar, P.A.

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III Books & Monographs

1. Thamaraselvi, S.P., Bojan, V., Fernandez, C.C., Raja, P., Manivasakan, S., Vijayakumar, M., Rajendran, L. & Mhatre, P.H. (2023). A guide on potato cultivation. JPS Scientific Publisher Thiruvannamalai, ISBN: 978-93-95967-42-6, p.130.

IV Training Manuals /Technical bulletins/Extension Bulletins

1. Lyngdoh, Y.A., Sailo, N., Challam, C., Kharumnuid, P., Jaiswal, A., & Janani, P. (2023). *Potato value addition*. ICAR-CPRI, Shimla (English and Khasi).
2. Lyngdoh, Y.A., Sailo, N., Challam, C., Kharumnuid, P., Jaiswal, A., & Janani, P. (2023). *Potato processing varieties for cultivation in Meghalaya region*. ICAR-CPRI, Shimla (English and Khasi).
3. Maharana, C., Bairwa, A., Naga, K.C., Tiwari, R.K., Sagar, V. & Sharma, S. (2023). *Serological and Molecular Diagnostics of Potato Pathogens*. ICAR-Central Potato Research Institute, Shimla, HP, India, p. 113.
4. Soam, S.K., Kumar, A., Balakrishnan, M., & Dhumantharao, T.R. (2023). *Proceedings and recommendations of National Conference on Policy Development and Implementation Strategies for Academia-Industry Government (AIG) Linkages in Agricultural Higher Education in India*. NAHEP component 2, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India, p. 50.
5. शिव प्रताप सिंह, सरला यादव एवं राजकुमार सिंह (2023). *उत्तर पूर्वी मैदानी क्षेत्र में फसल सघमता हेतु आलू +मक्का की अन्तर्वर्ती खेती*. केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केन्द्र, पटना, बिहार.
6. सरला यादव, शिव प्रताप सिंह एवं राजकुमार सिंह (2023). मूल बीज *(टी. पी. एस.) से आलू की खेती*. केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केन्द्र, पटना, बिहार.
7. शिव प्रताप सिंह, राज कुमार सिंह एवं सरला यादव (2023). *भोज्य आलू उत्पादन की उन्नत तकनीक*. प्रसार पुस्तिका, केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केन्द्र, पटना, बिहार.
8. सरला यादव राजकुमार सिंह एवं शिव प्रताप सिंह (2023). आलू के बीज उत्पादन हेतु प्रमुख किस्में, रोग एवं कीट प्रबंधन. प्रसार पुस्तिका, केन्द्रीय आलू अनुसंधान संस्थान क्षेत्रीय केन्द्र, पटना, बिहार.

V Book Chapters

1. Altaf, M.A., Naz, S., Kumar, R., Tiwari, R.K., Lal, M.K. (2023). Role of nitric oxide in regulating physiological and molecular aspects of plants under abiotic stresses. In: Anket Sharma, Sangeeta Pandey, Renu Bhardwaj, Bingsong Zheng, Durgesh Kumar Tripathi (Ed.), The Role of Growth Regulators and Phytohormones in Overcoming Environmental Stress. (pp.235-248). Academic Press, Cambridge, Massachusetts (Elsevier, Netherland).
2. Bandana, Sharma, V., Chaudhary, B., Luthra, S.K., Gupta, V.K., & Kumar, M. (2022). Physiological and biochemical aspects of potato storage under different temperatures. In: Emerging sustainability trends in agricultural, rural and environmental development. Society of biological sciences and rural development 10/96, Gola bazar, New Jhusi, Allahabad.
3. Berliner, J., Mhatre, P.H., Manimaran, B., & Meena, S. (2023). Nematode trophic diversity in agricultural ecosystem of the Nilgiris, Tamil Nadu, Inia. In: David V and Packiam SM. (eds). Recent advancement in Agricultural & Industrial Entomology & Environmental Sciences & their impact on food and environmental security. ISBN: 978-93-5914-962-2, pp 148-153.
4. Bhatt, A., Mangal, V., Rajotia, M.S., Sharma, A., Sood, S., Kashyap, S., & Verma, L.K. (2023). Reactive Nitrogen Species (RNS) and Melatonin Interaction in Plant. In: Melatonin in Plants: A Regulator for Plant Growth and Development, pp. 173-201. Singapore: Springer Nature Singapore.
5. Divya, K.L., & Mhatre, P.H. (2023). Post harvest management and value addition. Thamaraselvi S.P., Bojan V., Fernandez C.C., Raja P., Manivasakan S., Vijayakumar, M., Rajendran L. and Mhatre P.H. (eds). A guide on potato cultivation. JPS Scientific Publisher Thiruvannamalai, India ISBN: 978-93-95967-42-6, pp 101-111.

6. Dash, G.K., Purkaystha, S., Sahoo, S.K., Kumar, A. Jena, J., Nayak, L., Lal, P., Kumar, R., Tiwari, R.K. & Lal, M.K. (2023). Redesigning root architecture for improved performance of plants under stress. In: Aftab, T. (eds) New Frontiers in Plant-Environment Interactions. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-43729-8_19

7. Tiwari, J.K., Buckseth, T., Zinta, R., Thakur, K., Singh, R.K., Kumar, D., Dua, V.K., & Kumar, M. (2023). Functional genomics for improving nitrogen use efficiency in potato. In Tiwari *et al.* (eds) Potato improvement, production and utilization technologies: an approach to doubling farmer's income. DPH, Astral International Pvt. Ltd., New Delhi. pp 241-246.

8. Tiwari, J.K., Zinta, R., Luthra, S.K., Kumar, V., Buckseth, T., Dalamu, & Singh, R.K. (2023). Somatic hybridization in potato improvement. In Tiwari *et al.* (eds) Potato improvement, production and utilization technologies: an approach to doubling farmer's income. DPH, Astral International Pvt. Ltd., New Delhi. pp 71-81.

9. Lal, M.K., Tiwari, R.K., Lal, P., Kumar, A., Kumar, R. (2023). Regulatory role of melatonin in post-harvest management of vegetables and fruits. In: Kumar, R., Altaf, M.A., Lal, M.K., Tiwari, R.K. (eds) Melatonin in Plants: A Regulator for Plant Growth and Development. Springer, Singapore. https://doi.org/10.1007/978-981-99-6745-2_10.

10. Kumar, M., Kumar, P., Sharma, A., & Sharma, J. (2023). Progressing towards precision nutrient management in potato production. In: Singh, H.P., Parihar, J.S., Kumar, D., Chaudhary, H. and Singh, B. (eds), *Shodh Chintan*, 15, 152-160.

11. Mhatre, P.H., & Divya, K.L. (2023). Varieties suitable for potato cultivation in Nilgiris. Thamaraselvi, S.P., Bojan, V., Fernandez, C.C., Raja, P., Manivasakan, S., Vijayakumar, M., Rajendran, L., & Mhatre, P.H. (eds). A guide on potato cultivation. JPS Scientific Publisher Thiruvannamalai, India. ISBN: 978-93-95967-42-6, pp:16-27.

12. Mhatre P.H., & Divya K.L. (2023). Potato cyst nematode and its management. In: Thamaraselvi S.P., Bojan, V., Fernandez, C.C., Raja, P., Manivasakan, S., Vijayakumar, M., Rajendran, L., & Mhatre P.H. (eds). A guide on potato cultivation. JPS Scientific Publisher, Thiruvannamalai, India ISBN: 978-93-95967-42-6, pp: 92-100.

13. Priyadarshani, Khambalkar, Sadawarti, Joshi, E., & Yadav, S. (2023). Climate Smart Agriculture and Carbon Sequestration. In the book Climate Smart Approaches towards Sustainable Crop Production. Vital biotech publication Kota, Rajasthan, India. pp: 149-178.

14. Pradeepkumar, T. & Divya K.L. (2023). Underexploited vegetables for coastal India for Nutrition and Entrepreneurship. In Vegetables for nutrition and Entrepreneurship. eds: Singh, B and Kalia, P. Springer Nature. pp 436-479.

15. Rajotia, Singh, M., Sharma, A., Bhatt, A., Mangal, V., Sood, S., Thakur, A.K., Kashyap, S., & Verma, L.K. (2023). Melatonin Detection and Quantification Techniques." In Melatonin in Plants: A Regulator for Plant Growth and Development, pp. 19-38. Singapore: Springer Nature Singapore, 2023.

16. Ranjan, S., Mangal, V., Prakash, A., Altaf, M.A., Sahoo, S.K., Lenka, B., Behera, B., Kumar, R., Kumar, A., Tiwari, R.K. and Lal, M.K. (2023). Melatonin-induced tolerance against salt stress. In: Advancement of Melatonin Research in Plants (pp. 186-201). CRC Press.

17. Kumar, R. (2023). Viral diseases and their management in potato production. In: Tiwari, J.K., Buckseth, T., Dalamu, Bairwa, A., Pandey, N.K. & Kumar M. (eds) Potato: Improvement, Production and Utilization Technologies-An Approach to Doubling Farmers' income. Daya Publishing House, Astral International Pvt. Ltd. New Delhi, pp. 151-160.

18. Kumar, R., Tiwari, R.K., Maharana, C., Kochhar, T. & Kumar, R. (2023). Diagnostic of potato viruses. In: Tiwari, J.K., Buckseth, T., Dalamu, Bairwa, A., Pandey, N.K. & Kumar M. (eds) Potato: Improvement, Production and Utilization Technologies-An Approach to Doubling Farmers' income. Daya Publishing House, Astral International Pvt. Ltd. New Delhi, pp. 367-374.

19. Singh, R.K., Buckseth, T., Tiwari, J.K., Sharma, A.K., Kumar, M., & Pandey, N.K. (2023). Seed potato production scenario in India. In: Tiwari et al (eds) Potato improvement, production and utilization technologies: an approach to doubling farmer's income. DPH, Astral International Pvt. Ltd., New Delhi. Pp. 197-204.

20. Yadav, S. (2023). Seed germination, viability and vigor. Handbook of plant biotechnology. Bhavya books (BET) TM P: 615-626.

21. Sahoo, Kumar, S., Lenka, B., Behera, B., Altaf, M.A., Kumar, R., Kumar, A., Tiwari, R.K., & Lal, M.K. (2023). Role of melatonin in drought tolerance: Physiological and molecular perspectives. In: Advancement of Melatonin Research in Plants, pp. 221-236. CRC Press.

22. Buckseth, T., Singh, R.K., Tiwari, J.K., Kumar, V., Sharma, A.K., & Pandey, N.K. (2023). Production of disease-free planting material through hi-tech systems including aeroponics. In: Tiwari et al (eds) Potato improvement, production and utilization technologies: an approach to doubling farmer's income. DPH, Astral International Pvt. Ltd., New Delhi. pp 205-218.

23. Buckseth, T., Sharma, S., Singh, R.K., & Tiwari, J.K. (2023). Micropropagation in potato. In: Tiwari et al (eds). Potato improvement, production and utilization technologies: an approach to doubling farmer's income. DPH, Astral International Pvt. Ltd., New Delhi. pp 258-261.

VI Papers presented in Conferences / Seminars

1. Bandana, Sharma, V., Tiwari, R., Sharma, S., Patel, A., Kumar, D., & Singh, B. (2023). *Amino acids and phenols accumulation in potato tubers: Simulation studies under water logging conditions*. Paper presented in 5th International Conference on Agriculture, Biotechnology, Life sciences, Social sciences and allied sciences, ICIESSD-2023, at Shobit Institute of Engg. & Tech. Meerut New Age Mobilization society, New Delhi.

2. Bairwa, A., Sharma, S., Sharma, A.K., Dalamu, Kumar, M., Mhatre, P.H., Naga, K.C., Maharana, C., & Singh, B. (2023). *Role of cropping systems in the management of Potato Cyst Nematodes (Globodera spp.) in the Northern-western hills of India*. Paper presented in 3rd International Conference on Innovative Approaches in Agriculture, Horticulture & Allied Sciences, organized by Indian Society of Agriculture & Horticulture Research Development, (ISAHRD) Chandigarh, Punjab at Gurugram during March 29-31, 2023.

3. Berliner, J., Mhatre, P.H., Manimaran, B., & Meena S. (2023). *Nematode trophic diversity in agricultural ecosystem of the Nilgiris, Tamil Nadu, India*. Paper presented in recent advancement in Agricultural & Industrial Entomology & Environmental Sciences & their impact on food and environmental security. Organized by Entomological Research Institute & Dr B. Vasantharaj David Foundation at Chennai, Tamil Nadu, during September 29-30, 2023.

4. Choudhary, A.K., Sharma, J., Dua, V.K., Kumar, D., Singh, N. and Singh, B. (2023). Foliar-P fertilization coupled with microbial inoculants lead to improved productivity and quality in Himalayan acid soils. Paper presented in Global Conference on Precision Horticulture for Improved Livelihood, Nutrition and Environmental Services, May 28-31, 2023, ASM-N Delhi and JISL, Jalgaon, Jalgaon, Maharashtra. pp 84

5. Challam, C., Sailo, N., Buckseth, T., Janani, P., Das, B., Lyngdoh, Y.A., & Singh, B. (2023). Revitalizing traditional potato strains: incorporating local landraces into seed production. Paper presented in National Conference on "Rebooting the hill farming for future sustainability and livelihood" on June 8-9, 2023 ICAR RC for NEH Region.

6. Challam, C., Buckseth, T., Sailo, N., Janani, P., Lyngdoh, Y.A., & Singh, B. (2023). Apical Rooted Cuttings: Empowering Potato Farmers through Innovative Seed Systems. Paper presented in International Conference on Agriculture in Hilly and Mountain Landscapes: An Interdisciplinary Perspective on November 22-24, 2023.

7. Kumar, A., Pynbianglang, K., & Kumar, S. (2023). Drone based extension strategies in agriculture and allied sector. In: Souvenir of International Conference on Protected Cultivation of Horticultural Crops, Post-Harvest Handling and Digital Agriculture held at SHUATS, Allahabad, India during November 29-30, 2023, pp. 230-241.

8. Lal, M., Sharma, S., Chaudhary, S., & Kumar, M. (2023). Evaluation of new chemistry molecules for the development of spray schedules against late blight of potato in subtropical plains of India. P. 22. Paper presented at International conference on "Identification, Convergence, Implementation & Extension of Science-Tech-Research for Sustainable Development (ICIESSD)-2023 during February 21-22, 2023.

9. Kaur, R.P., Kumar, R., Sood, S., Devi, S., Bhardwaj, V., & Kumar, V. (2023). Speed

breeding approaches for increasing genetic gain in potato. Paper presented at Crop Improvement and Genetic Enrichment at Progressive Horticulture Conclave (PHC2023), Organized by G.B.P.U.A.&T

10. Singh, R.K., Singh, S.P., Sadawarti, M.J., Yadav, S., Kumar, V., & Singh, B. (2023). Comparative advantage of soil test based NPK applications over their recommended doses in potato under rice-potato cropping system. Paper presented at XVI Agricultural Science Congress & ASC Expo: Transformation of Agri-Food Systems for Achieving Sustainable Development Goals October 10-13, 2023 Kochi, Kerala India.

11. Buckseth, T., Naik, P.S., Sadawarti, M.J., Challam, C., Singh, R.K., Tiwari, J.K., Sharma, A.K., Bairwa, A., & Kumar, V. (2023). In vivo Rapid Seed Potato Multiplication through Sprouts. Paper presented at Innovative Approaches in Agriculture, Horticulture & Allied Sciences (IAAHAS- 2023)3rd International Conference Book of Abstracts Organized by Indian Society of Agriculture & Horticulture Research Development, (ISAHRD) Chandigarh SGT University, Gurugram (ICAR Accredited) and Just Agriculture- the Magazine on March 29-31, 2023 at SGT University, Gurugram.

12. Kumar Alok, Pynbianglang K., K. Sanjiv (2023). *Drone based extension strategies in Agriculture & allied sector*. Lead Paper presented in International Conference on Protected cultivation of Horticultural Crops, Post-Harvest Handling and Digital Agriculture, organized by SHUATS, Prayagraj at SHUATS, Prayagraj during November 29-30, 2023.

13. Kumar Alok, Upadhyay, A., K. Sanjiv & Meena, P.C. (2023). *Consumer Behaviour for Value added Millet Products*. Paper presented in ISEE National Seminar on Evolving Extension Science Towards Secondary Agriculture for Sustainable Development, organized by ISEE, New Delhi, & UAS Bengaluru at UAS Bengaluru during June 22-24, 2023.

VII Abstracts/Symposia etc.

1. Choudhary, A.K., Sharma, J., Rawal, S., Janani, P., & Singh, B. (2023). *Influence of organic farming, integrated crop management and conventional farming practices on potato productivity, profitability & ecological footprints in wet-temperate Himalayas* (Oral). In Proceedings of 'XXII Biennial National Symposium of Indian Society of Agronomy, November 22-24, 2023, ICAR-CCARI, Ela, Goa', ISA Symposium Extended Summaries, Vol. II, 209-211pp

2. Dutta, M., Raturi, V., Goel, K., Kumar, R., Kundu, P., Mali, S., Sharma, P., Swarankar, M., Gupta, V.K., Sood, S., Acharya, V., & Zinta, G. (2023). *Multi-omics analysis shed light on thermotolerance mechanisms in potato (Solanum tuberosum L.)*. Poster presented in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) January 6-9, 2023, NABI-CIAB, Mohali, India.

3. Harish, M.N., Choudhary, A.K., Singh, S.R.K. & Raut, A.A. (2023). *Effect of tillage and phosphorus fertilization on growth indices in wheat under maize-wheat cropping system* (Oral). In Proceedings of 'XXII Biennial National Symposium of Indian Society of Agronomy, November 22-24, 2023, ICAR-CCARI, Ela, Goa', ISA Symposium Extended Summaries, Vol. I, 142-143pp

4. Kaur, R. P., Kumar, R., Sood, S., Devi, S., Bhardwaj, V. & Kumar, V. (2023). *Speed breeding approaches for increasing genetic gain in potato.* In: Souvenir-cum-Compendium of Abstracts: Progressive Horticulture Conclave towards Transforming Horticulture: Science and Technology (Editors: R.K. Srivastava, R. Rai, D.C. Dimri, Y. Kushwaha, S. Belwal andS.K. Dwivedi), held at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. p.53.

5. Mali, S., Dutta, M., Goel, K., Kumar, R., Acharya, V., Gupta, V.K., Sood, S., & Zinta, G. (2023). Genome-wide identification and expression profiling of JmjC domain-containing histone demethylase gene family in potato (Solanum tuberosum L.). Poster presented in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) January 6-9, 2023, NABI-CIAB, Mohali, India.

6. Sood, S., Bhardwaj, V., Mangal, V., Kumar, A., Singh, B., Dipta, B., Kaundal, B., Thakur, A.K., Kumar, V., Singh, B. (2023). *Genome-Wide Association Mapping and Genomic Prediction for Agronomic Traits in Tetraploid Potatoes.* Oral presentation made in the "International Conference on Biochemical and Biotechnological Approaches for Crop Improvement", organized by

IARI, NIPB, Society for Plant Biochemistry and Biotechnology and NBRI held at NASC, complex, New Delhi on October 30 - November 1, 2023.

7. Sood, S., Bhardwaj, V., Mangal, V., Dipta, B., & Kumar, V. (2023). *Use of high throughput markers for biotic stress resistance in crop plants.* In: DST SERB Workshop on "Serological and Molecular Diagnostics of Potato Pathogens" at ICAR-Central Potato Research Institute, Shimla, HP, India p 55-60.

8. Sadawarti, M.J., Gupta, V.K., Samadhiya, R.K., Singh, S.P., Kumar, V., Katare, S., & Verma, D. (2023). *Advance heat tolerant potato hybrids evaluation for yield and quality parameters for west-central India.* In Proceedings of 'XVI Agriculture Science Congress and Expo: Horticulture Based Transformation of Food Systems (Sub theme- Vegetable and Tuber Crops), October 10-13, 2023, Kochi, Kerala.

9. Singh, S.P., Sadawarti, M.J., Rawal, S., Dua, V.K., Sharma, S.K., & Singh, Y.P. (2023). Comparative advantage of zero tillage over conventional tillage for potato in rice-potato cropping system. In Proceedings of 'XVI Agriculture Science Congress and Expo: Ensuring Food and Nutritional Security- Production, Consumption and Value Addition (Sub theme- Resource Efficient, Environment Friendly Production of Nutrient Dense Farm Products in India), October 10-13, 2023, Kochi, Kerala,

10. Varatharajan, T., Dass, A., & Choudhary, A.K. (2023). *Yield and energy dynamics of black gram intercropped maize under various integrated crop management practices* (Poster). In Proceedings of 'XXII Biennial National Symposium of Indian Society of Agronomy, November 22-24, 2023, ICAR-CCARI, Ela, Goa', ISA Symposium Extended Summaries, Vol. II, pp: 135-136.

VIII Copyrights / Patents (Granted /Applied)

Sl. No.	Title	Registration Number and date	Status	Inventors
1	Wind operated aerial insect trap.	Design No. 377369-001, dated January 13, 2023	Granted	Sharma Kapil Kumar, Kumar Santosh, Dua VK, Sharma Jagdev, Choudhary Anil K, Sharma Sanjeev, Pandey NK, Verma Jagdish Chand, Chand Jagdish, Kishore Hari, Yogesh, Kumar Sushil, Sharma Vineeta and Ram Laiq
2	Dipstick for estimation of glucose in potato tubers and method thereof	No. 37808, dated September 9, 2021	Granted	Bandana, SomDutt, A. Jeevalatha, Brajesh Singh and B.P. Singh
3	Plant Holding and Lifting System	No. 470843, dated November 21, 2023	Granted	Er. Sukhwinder Singh
4	Modular Structure for Covering an Area with a Net	No. 479312, dated December 8, 2023	Granted	Er. Sukhwinder Singh and Dr. Brajesh Nare
5	A System of Sugarcane Bud Planter Integrated with Fungicide Application Unit	No.490572, dated December 28, 2023	Granted	Drs. Brajesh Nare, VK Tewari, Prateek Shrivastava and Chanchal Gupta
6	System and Method for Spraying Liquid Chemical on Objects Using Ultrasonic Sensor	No.438002, dated July 10, 2023	Granted	Drs. VK Tewari, A Arudra, SP Kumar and Brajesh Nare
7	Weeder i.e. Trapezoidal Blade Weeder	No.318894-001, dated June 17, 2022	Granted	Dr. Brajesh Nare, Er. Sukhwinder Singh, Dr. SK Chakravarti, Late Dr. VK Dua and Dr. Sanjay Rawal

HAPPENINGS AT ICAR-CPRI, SHIMLA

Webinar on World Intellectual Property Day

On the occasion of World Intellectual Property Day on April 26, 2023 a webinar was organized with the theme "Women & IP Accelerating Innovation and Creativity". The webinar was hosted by Er. Sukhwinder Singh and the key speakers were Dr. Sugni Devi from CRRI RS, Jalandhar and Dr. Dalamu from Kufri. Director, CPRI and all the scientists & female staff attended the webinar.

World Environment Day 2023

World Environment Day was organized at ICAR-CPRI RS Patna on June 5, 2023. Teachers and students of Primary School, Amukuda, Patna Sadar, Patna-14 along with the staff of the center were also present in this program. The purpose of calling the children in the program was to make them aware of the environment so that they can make themselves as well as their families aware of it. At the beginning of the program, the scientist-in-charge administered the oath of World Environment Day to all the teachers, students and employees present in the program. In the program, the scientist-in-charge, Dr. Shiv Pratap Singh, Principal Scientist and Dr. (Mrs.) Sarla Yadav, Senior Scientist expressed their views on the importance of environment. In this, they were provided information about soil, air, water conservation etc. Children participated enthusiastically in this and showed interest in environmental conservation.

Celebration of International Yoga Day

On the occasion of 9th International Yoga Day on June 21, 2023, a yoga session for the staff of the institute was organized in the auditorium. Dr. Som Dutt performed some easy yoga *asanas* which the entire staff replicated as per his instructions. All the regional stations of CPRI also celebrated International Yoga Day.

National Sports Day

National Sports day was observed on August 28, 2023. The day started with the oath ceremony after that a number of field and indoor sports events for the staff like races for women, carom matches, chess and volley ball for men and women was organized throughout the day.

Hindi Diwas Celebration

Hindi Diwas was celebrated on September 14,2023 as a mark of initiation of Hindi Pakhwara. The function was presided over by Dr. Usha Rani, Associate Professor (Hindi) from Himachal Pradesh University, Shimla. She deliberated a talk on the growing importance of Hindi in the offices as well as why it is important to use Hindi over English.

Organisation of Hindi Karyashala for staff

A Hindi Karyashala for all the staff members of CPRI was organized on September 26, 2023 as a part of Hindi Pakhwara. All staff including Scientists, Technicals, Administrative and SSS participated in this workshop. Emphasis on the use of more and more simple Hindi language in the office was the main focus of this workshop.

Swachh Bharat Abhiyan 3.0

The institute observed Swachh Bharat Abhiyan for a month from October 2 to 31, 2023. A number of activities were undertaken during this period. An awareness programme for school children was organised in the primary school of Kanlog where children were educated about the importance of cleanliness. An awareness camp to make the village people understand how important it is to keep our surroundings clean was organised at Jathia Devi where people from different villages participated in huge number. On the concluding of this celebration Sh. Bhupender Kumar Attri, Commissioner, Municipal Corporation, Shimla chaired the occasion. He addressed the staff and briefed about the cleanliness drive being undertaken by MC, Shimla to keep the city clean and green. The labour staff and the staff associated with cleaning of the institute were also honoured by the chief guest by giving them mementoes. The regional stations also conducted many activities during Swachh Bharat Abhiyan 3.0

CAS Meeting

Career Advancement Meeting for scientists was held on November 3, 2023. The meeting was chaired by Dr. KR Dhiman Former Head of CPRI RS Kufri and former VC of Dr. YSParmar University of Horticulture and Forestry, Nauni Solan.

Celebration of Vigilance Awareness Week

Vigilance Awareness Week was observed during October 30 to November 6, 2023. A number of programmes were organised during the week. It started with the oath ceremony on October 30, after that a quiz competition was organised followed by an essay writing competition the next day. Posters and banners were also displayed at different locations in the institute. The week ended with the prize distribution to the winners of the competitions held during the period and address of Dr. Ashwani Kumar Sharma, Vigilance Officer and Dr. Brijesh Singh, Director of the institute.

Ayurveda Day Celebration

8th Ayurveda day was celebrated in the institute on November 10, 2023. Dr. KK Sharma, BAMS Ex-SDMO/OSD/Registrar of Ayurveda Department was the chief guest on tis occasion. He told about a number of advantages that ayurveda has for the well being of humans as compare to the the other available treatment methods and practices.

Research Advisory Committee Meeting

29th Research Advisory Committee Meeting was held during November 17-18, 2023. The meeting was chaired by Dr. KR Dhiman.

Organisation of Diwali Mela

Diwali Mela was organised on November 19, 2023 just before Diwali for the staff and their families at the institute. A number of stalls comprising eatables by staff members and other local vendors, gift items, shawls, decorative lights, games for children and others were put up in this mela. Lucky seven, tombola and tug of war among different divisions were the main attraction of this mela along with slow scooter race, musical chair for ladies and different kind of races for children were also a part of this mela. The winners of different events were given prizes by the chief guest along with lucky coupon draw at the end of the day long mela.

Institute Research Committee Meeting

Institute Research Committee Meeting was held during November 20-21, 2023. The meeting was chaired by Dr. Brajesh Singh, Director.

World Soil Day

World Soil Day was celebrated on December 5, 2023. On this occasion 80 students from Shoolini University of Solan were invited. They were addressed by the Director of the Institute followed by a lecture delivered by Dr. Anil Chaudhry on the topic Soil & Water: A Source of Life". They were made aware about the importance of soil and water in our life through the lecture. All CPRI regional stations also celebrated World Soil Day

ICAR-CPRI, Shimla won the title of ICAR Overall Champion Trophy in Sports Competitions

Central Potato Research Institute, Shimla has been making excellent contribution in sports competitions. The Institute's sports team participated in ICAR-Zonal sports competitions at CIPHET, Ludhiana and 39 participants from the Institute's headquarters and regional stations participated in various sports. In these games, the participants of the Institute brought laurels to the Institute by securing 8 gold medals, 5 silver medals, 4 bronze medals. It was a matter of pride for the entire potato family when the Institute also won the title of ICAR Overall Champions Trophy in these games. The winners were also given a very warm welcome at the institute and the Director of the Institute, Dr. Brajesh Singh felicitated all the winners in the auditorium of the institute. Apart from this, Fit India Movement program was also organized at CPRI under Azadi Ka Amrit Mahotsav and on this occasion many programs were organized to test the fitness level of the employees and their family members.

AWARDS & RECOGNITIONS

A. ICAR-CPRI BEST WORKER AWARD FOR YEAR 2023

Sl. No.	Name of the Awardee	Category	Award
1.	Dr. Mehi Lal ICAR-CPRI, RS, Modipuram	Scientific	ICAR-CPRI Best Worker Award
2.	Smt. Shruti Gupta ICAR-CPRI, Shimla	Technical	ICAR-CPRI Best Worker Award
3.	Sh. Sandeep Dahiya ICAR-CPRI, RS, Modipuram	Administrative	ICAR-CPRI Best Worker Award

B. OTHER AWARDS

Sl. No.	Name of Award	Name of the Scientist	Awarded Institution
1	Outstanding Scientist of the year Award 2023	Dr. Bandana	5th International Conference on Agriculture, Biotechnology, Life sciences, Social sciences and allied sciences, ICIESSD-2023 (February 21-22, 2023), at Shobit Institute of Engg. & Tech. Meerut. New Age Mobilization society, New Delhi.
2	Best Oral presentation award: 2023.	Clarissa Challam, N Sailo, T Buckseth, Janani P, B Das, YA Lyngdoh and B Singh	A presentation on "Revitalizing traditional potato strains: incorporating local landraces into seed production during National Conference on "Rebooting the hill farming for future sustainability and livelihood" on June 8-9, ICAR RC for NEH Region.
3	Indian Potato Journal Medal for best paper award 2022 (awarded in 2023)	Pandey N.K., Kharumnuid P., Sant Kumar, Chakrabarti S.K. and Vinay Bhardwaj	Indian Potato Association, Shimla, HP
4	Hindustan Icon Award	Dr. Vikas Mangal	Hindustan Agricultural Research Welfare Society.
5	Best Oral Presentation Award	Dr. Anil Kumar Choudhary	A presentation on 'Foliar-P fertilization coupled with microbial inoculants lead to improved productivity and quality in Himalayan acid soils' during Global Conference on Precision Horticulture for Improved Livelihood, Nutrition and Environmental Services, May 28-31, 2023, ASM-N Delhi and JISL, Jalgaon, Jalgaon, Maharashtra
6	ISA Fellow-2022 Award	Dr. Anil Choudhary	Indian Society of Agronomy, IARI-New Delhi
7	Eminent Scientist Award	Dr. Alok Kumar	International Conference on Protected cultivation of Horticultural Crops, Post-Harvest Handling and Digital Agriculture, organized by SHUATS, Prayagraj at SHUATS, Prayagraj during November 29-30, 2023.

C. RECOGNITIONS

Sl. No.	Name of Recognitions	Name of the Scientist	Awarded Institution
1	Deputy Director General (Horticulture), Nominee for the DPC of the Assessment promotion of ARS scientist under new Career Advancement Scheme (ICAR-CCRI, Nagpur)	Dr. Alok Kumar	ICAR
2	Outside Expert of Institute Technology Management Committee (ITMC) of ICAR-Directorate of Mushroom Research, Solan.	Dr. Sanjeev Sharma	ICAR
3	Member of Institute Management Committee (IMC) of ICAR-Directorate of Mushroom Research, Solan.	Dr. Sanjeev Sharma	ICAR
4	Nominated as Socially Aware Nominee of Institute Animal Ethic Committee (IAEC) of Central Research Institute (CRI), Kasuali; School of Pharmacy, Abhilashi University, Mandi; Indira Gandhi Medical College, Shimla; LR Institute of Pharmacy, Solan; School of Pharmacy & Emerging Sciences, Baddi University of Emerging Sciences & Technology, Baddi, Solan by CCSEA	Dr. Sanjeev Sharma	Deptt of Animal Husbandary & Dairying, Ministry of Fisheries, Animal Husbandary and Dairying, GoI.
5	Nominated as Scientist from Outside institute for the Institute Animal Ethic Committee (IAEC) of Shiva Institute of Pharmacy, Bilaspur (HP) by CCSEA	Dr. Sanjeev Sharma	Deptt of Animal Husbandary & Dairying, Ministry of Fisheries, Animal Husbandary and Dairying, GoI.
6	DBT Nominee as Outside Expert of Institute Biosafety Committee (IBSC) of Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan (HP).	Dr. Sanjeev Sharma	Deptt. of Biotechnology, GoI.
7	Secretary, Indian Potato Association, Shimla.	Dr. Sanjeev Sharma	Indian Potato Association, Shimla.
8	Joint Secretary, Hill Society of Agriculture, Uttarakhand	Dr. Sanjeev Sharma	Hill Society of Agriculture, Uttarakhand
9	Member, Editorial Board of Plant Disease Research	Dr. Sanjeev Sharma	Indian Society of Plant Pathologists (INSOPP), Ludhiana.
10	Item Writer (Expert) **for Test Development of the Program AIEEA-PG through Online Mode (E-Sulekh)**	Anil Choudhry	National Testing Agency (NTA), Ministry of Education, Govt. of India, New Delhi for the Year 2023-24
11	'Guest Editor' for the special issue 'The Role of Macro- and Micronutrients in Plant Growth and Development'	Anil Choudhry	Agronomy' Journal (IF 3.7)
12	Visited Excellence in Breeding under BMGF project IRRI, Philippines for exposure on Intensive genomic selection & modern experimental design analysis during February 13-24, 2023	Dr. Salej Sood	BMGF project IRRI, Philippines

Sl. No.	Name of Recognitions	Name of the Scientist	Awarded Institution
13	Member, Strengthening Extension Delivery Mechanism at District Level through KVK & ATMA	Dr. Alok Kumar	MANAGE, Hyderabad
14	Chief Editor, Research Journal of Agriculture and Veterinary Sciences, EMBAR Publishers	Dr. Alok Kumar	Research Journal of Agriculture and Veterinary Sciences, EMBAR Publishers
15	Member, Editorial Board, Indian Journal of Pure and Applied Biosciences	Dr. Alok Kumar	Indian Journal of Pure and Applied Biosciences
16	Executive Councilor, Sothern Zone for Indian society of Extension Education, New Delhi	Dr. Alok Kumar	Indian society of Extension Education, New Delhi
17	Member, SAC, KVK Kinnaur	Dr. Alok Kumar	Dr YS Parmar university of Horticulture & Forestry, Solan

D. EDUCATIONAL PROGRAMME- STUDENTS (M.SC. & PH. D) GUIDED BY SCIENTISTS AS GUIDE/ SUPERVISOR

Educational Programme

Sl. No.	Name of the Scientist	Student Name	Title of the thesis	Programme Name (M.Sc./Ph.D./ Other-Pl. specify)	University /Institute Name
1	Dr. Salej Sood	Jagmeet	Characterization and genome wide	Ph.D	Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)
2	Dr. Salej Sood	Ashwini Kumar	Development of Non-Recombined Lines using Reverse Genetic Approach in Potato	Ph.D	Lovely Professional University, Punjab
3	Dr. SP Singh	Sri Aman Pratap Singh Chauhan	Evaluation of natural farming system of potato (Solanum tuberosum L) in gird region	M Sc Ag (Agronomy)	Rajmata Vijayaraje Scindia Krishi Vishwavidhyalayya Gwalior 474002 (MP)
4	Dr. SP Singh	Sri Rajendra Patel	Evaluation of organic nutrient management options in Sesame - potato cropping system	Ph.D (Agronomy)	Rajmata Vijayaraje Scindia Krishi Vishwavidhyalayya Gwalior 474002 (MP)
5	Dr. Alok Kumar	Sri Ashutosh Upadhyay	Consumer Behaviour and Market Potential for Value added Millet Products	MBA/ PGDM(ABM)	ICAR-NAARM, Hyderabad

E. ICAR-CPRI in Media

केंद्रीय आलू अनुसंधान केंद्र शिमला ने शोध के बाद किया दावा

कैंसर से बचाएगा और बीपी घटाएगा आलू

इन वैज्ञानिकों ने किया अध्ययन

आलू के साथ-साथ अन्य फसलों की भी खेती करें किसान

दैनिक भास्कर

भास्कर Exclusive - सीपीआरआई शिमला ने आलू की कुफरी किरण नाम से नई किस्म की तैयार, 100 से 120 दिन में तैयार होगी फसल

हिमाचल में कम खराब होने वाली आलू की नई किस्म तैयार, देश के गरम हिस्सों और दक्षिणी राज्यों में भी उगाई जा सकेगी

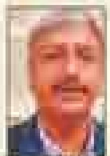
25 टन प्रति हेक्टेयर उत्पादन दे सकती है कुफरी किरण

केंद्रीय आलू अनुसंधान संस्थान में आलू दिवस मनाया

गुणवत्ता युक्त आलू के लिए हो रहे नए शोध

आलू की विभिन्न प्रजातियों को देखते अधिकारी।

संतुलित समेकित खेती का संकल्प दिलाया



STAFF POSITION

List of Scientific staff at ICAR-CPRI, Shimla & its Regional Stations as on 31.12.2023

1. **Dr. Brajesh Singh, Principal Scientist & Director**

Division of Crop Improvement & Seed Technology

2. **Dr. Vinod Kumar, Principal Scientist & Acting Head**
3. Dr. Salej Sood, Senior Scientist
4. Dr. (Mrs.) Tanuja Buckseth, Scientist
5. Sh. Hemant Balasaheb Kardile, Scientist
6. Dr. Ajay Kumar Thakur, Senior Scientist
7. Dr. Vikas Mangal, Scientist

Division of Crop Production

8. **Dr. Jagdev Sharma, Principal Scientist & Head**
9. Dr. Anil Kumar Choudhary, Principal Scientist
10. Sh. Paresh Baldeorao Chaukhande, Scientist
11. Dr. Yogesh Gautam, Principal Scientist

Division of Social Sciences

12. **Dr. Alok Kumar, Principal Scientist & Head**
13. Dr. Pynbianglang Kharumnuid, Scientist

Division of Plant Protection

14. **Dr. Sanjeev Sharma, Principal Scientist & Head**
15. Dr. Vinay Sagar, Principal Scientist
16. Dr. (Ms.) Aarti Bairwa, Senior Scientist
17. Dr. Kailash Chandra Naga, Scientist
18. Sh. Chandan Maharana, Scientist

Division of CPB & PHT

19. **Dr. Dinesh Kumar, Principal Scientist & Acting Head**
20. Dr. Som Dutt, Principal Scientist
21. Dr. Dharmendra Kumar, Scientist

CPRI-CPRI Kufri-Fagu Unit

22. **Dr. Ashwani Kumar Sharma, Principal Scientist & SIC**
23. Dr. (Ms.) Dalamu, Senior Scientist

ICAR-CPRI Regional Station, Modipuram

24. **Dr. Rajesh Kumar Singh, PS & Head**
25. Dr. Devendra Kumar, Principal Scientist
26. Dr. SK Luthra, Principal Scientist
27. Dr. Vinay Singh, Principal Scientist
28. Dr. Anuj Bhatnagar, Principal Scientist
29. Dr. Sanjay Rawal, Principal Scientist
30. Dr. Dhruv Kumar, Principal Scientist
31. Dr. Vijai Kishore Gupta, Principal Scientist
32. Dr. (Mrs.) Babita Chaudhary, Principal Scientist
33. Dr. Mehi Lal, Senior Scientist
34. Dr. (Ms.) Bandana, Senior Scientist
35. Dr. (Ms.) Pooja Praful Mankar, Scientist
36. Dr. Subhash. S, Scientist

ICAR-CPRI Regional Station, Jalandhar

37. **Dr. Anil Sharma, Principal Scientist & Head**
38. Dr. Raj Kumar, Principal Scientist
39. Dr.(Ms) Ratna Preeti Kaur, Senior Scientist
40. Dr. Sunayan Saha, Senior Scientist
41. Er. Sukhwinder Singh, Scientist (SG)
42. Dr. Prince Kumar, Scientist
43. Dr. (Mrs.) Sugani Devi, Scientist
44. Er. Brajesh Nare, Scientist
45. Dr. Arvind Kumar Jaiswal, Scientist

ICAR-CPRI Regional Station, Gwalior

46. **Dr. Subhash Katare, Principal Scientist & SIC**
47. Dr. Murlidhar J. Sadawarti, Senior Scientist

ICAR-CPRI Regional Station, Shillong

48. Dr. (Mrs.) Clarissa Challam, Scientist &SIC

49. Dr. Ngursangzuala Sailo, Senior Scientist
50. Dr.(Mrs.) P Janani, Scientist
51. Dr. (Mrs.) Yvonne Angel Lyngdoh, Scientist

ICAR-CPRI Regional Station, Muthorai (Ooty)

52. Dr. Mhatre Priyank Hanuman, Scientist & SIC

53. Mrs. Divya K. Lekshmanan, Scientist
54. Dr. Praveen S. Patted, Scientist

ICAR-CPRI Regional Station, Patna

55. Dr. Raj Kumar Singh, Principal Scientist & SIC

56. Dr. Shiv Pratap Singh, Principal Scientist
57. Dr. (Mrs.) Sarala Yadav, Senior Scientist

List of Technical staff at ICAR-CPRI, Shimla & its Regional Stations as on 31.12.2023

ICAR-CPRI, Shimla

1. Mrs. Tarvinder Kochhar, CTO
2. Mr. Dharminder Verma, CTO
3. Mr. Kameshwar Sen, CTO
4. Mr. Rajdeep Bux, ACTO
5. Mr. Kana Singh Chauhan, ACTO
6. Mr. Parvesh Jassal, ACTO
7. Mr. Avinish Kumar Atrey, ACTO
8. Mr. Chander Mohan Singh Bist, ACTO
9. Mr. Santosh Kumar, ACTO
10. Dr. Sumita Sharma, ACTO
11. Mr. Vinod Kumar, ACTO
12. Mrs. Shruti Gupta, ACTO
13. Mr. Tilak Raj, ACTO
14. Mr. Rakesh Kumar Patyal, STO
15. Mrs. Asha Thakur
16. Mr. Dharminder Kumar Gupta, STO
17. Mr. Dharam Prakash Gautam, TO
18. Mr. Sheesh Ram Thakur, TO
19. Mr. Sushil Singh, TO (Driver)
20. Mr. Naresh Kumar Sharma, TO
21. Mr. Naresh Chand, TO
22. Mr. Rajinder Kumar, TO
23. Mrs. Madhu Bala, TO
24. Mr. Ram Singh, TO
25. Mrs. Manjeet Syal, TO
26. Mr. Naresh Kumar, TO
27. Mr. Ranjesh Bhardwaj, TO
28. Mr. Roop Lal, STA (Driver)
29. Mr. Ravinder Kumar, STA
30. Mr. Deep Ram, STA
31. Mr. Rakesh Kumar, STA
32. Mr. Jagdish Chand (Welder), STA
33. Mr. Jagdish Chand (Carpenter), STA
34. Mr. Dev Raj, TA
35. Mr. Parmesh Dutt, ST
36. Mr. Neem Chand, ST
37. Mr. Laiq Ram, ST
38. Mr. Surinder Pal, ST
39. Mr. Mansha Ram, ST
40. Mr. Arjun Dass, ST
41. Mr. Vivek Kumar, Technician
42. Mr. Sanjay Kumar, Technician
43. Mr. Rakesh Kumar, Technician
44. Mrs. Sonam, Technician
45. Mrs. Vandana Parmar, Technician
46. Miss. Vineeta Sharma, Technician
47. Mr. Kulwant Singh, Technician

ICAR-CPRI, Kufri-Fagu Unit

48. Mr. Kedar Singh, TO
49. Mr. Ajit Singh, STA
50. Mr. Ram jivan, STA
51. Mr. Sayed Danish Abbas Rizvi, STA
52. Mr. Mohan Lal, TA

ICAR-CPRI, Regional Station, Modipuram

53. Mr. Mahipal Singh Bharti, CTO
54. Mr. Harvir Singh, CTO
55. Dr. Ashok Kumar, CTO
56. Mr. Krishan Pal Singh, CTO
57. Mr. Ompal, CTO
58. Mrs. Kusum Singh, ACTO
59. Mr. Yogesh Kumar Gupta, ACTO
60. Mr. Harvir Singh, ACTO
61. Mr. Murari Lal, ACTO
62. Mr. Subhash Chand, ACTO
63. Dr. Vineet Sharma, ACTO
64. Mr. Avinash Chaudhary, ACTO
65. Mr. Dinesh Singh, ACTO
66. Dr. Sanat Kumar, ACTO
67. Mr. Harvinder Singh, ACTO
68. Mr. Udai Vir Singh, ACTO
69. Mr. Ved Singh, ACTO
70. Mr. Pushpendra Kumar, STO
71. Mr. Vishvanath Bindermali, STO
72. Mr. Manish Maan, STO
73. Mr. Mahesh Pal Singh, To (Driver)
74. Mr. Madan Pal, ST
75. Mr. Satpal Singh, ST
76. Mr. Siddharth Saroha, Technician
77. Mr. Rohit Verma, Technician
78. Mr. Ajay Kumar, Technician

ICAR-CPRI, Regional Station, Jalandhar

79. Mr. Munna Lal, CTO
80. Dr. Kapil Kumar Sharma, CTO
81. Mr. Akhilesh Kumar Singh, ACTO82. Mr. Parveen Kumar, TO
82. Mr. Narinder Mayer, TO
83. Mr. Kulwinder Singh, TO
84. Mr. Pardeep Kumar Upadhaya, TO
85. Mr. Anil Kumar Chandel, STA
86. Mr. Som Dutt Randev, STA
87. Mr. Vijay Kumar, TO
88. Mr. Pawan Kumar, ST
89. Mr. Virender Kumar, Technician

ICAR-CPRI, Regional Station, Gwalior

91. Dr. Yogendra Pal Singh, ACTO
92. Dr. Sanjay Kumar Sharma, ACTO
93. Mr. Shyam Kumar Gupta, ACTO
94. Mr. Rajender Kumar Samadhiya, ACTO
95. Mr. Surendar Singh, TO
96. Mr. Nihal Singh, STA (Driver)
97. Mrs. Nisha Verma, Hindi Translator (TA)
98. Mr. Tara Chand, ST
99. Mr. Sanjeev Kumar Meena, Technician
100. Mr. Vinod Kumar Meena, Technician

ICAR-CPRI, Regional Station, Patna

101. Mr. Arjun Kumar Sharma, ACTO
102. Mr. Rakesh Srivastava, TO
103. Mr. Anil Kumar, TO
104. Mr. Alekh Narain, TO
105. Mr. Narendra Kumar, TO
106. Mr. Lal Babu Das, STA (Driver)
107. Mr. Sunil Kumar Singh, ST
108. Mr. Rishav Kumar, Technician
109. Mr. Pratish Kumar Patel
110. Mr. Sumit Kumar, Technician
111. Mr. Akhilesh Singh, Technician

ICAR-CPRI, Regional Station, Shillong

112. Mr. Sabarius Nongrum, ST
113. Mr. Anubhav Kumar, TT

ICAR-CPRI, Regional Station, Ooty

114. Mr. R Lakshmanan, STA
115. Mr. B. Suresh, ST

List of Admin staff at ICAR-CPRI, Shimla & its Regional Stations as on 31.12.2023

ICAR-CPRI, Shimla

1. Shri Alok Kumar, CAO
2. Ms. Sunita, Deputy Director (language)
3. Sh. Chander Prakash, FAO
4. Sh. Joginder Singh Thakur, AO
5. Smt. Poonam Sood, AAO
6. Smt. Meena Verma, AAO
7. Smt. Babli Bhawani, AAO
8. Sh. Surjit Singh, PPS
9. Sh. Gurjeet Singh, PS
10. Smt. Shashi Bala Thakur, PS
11. Sh. Suresh Kumar, PS
12. Sh. Krishan Lal, Assistant
13. Ms. Rita Walia, Assistant
14. Mrs. Urmila Verma, Assistant
15. Mrs. Sunita Thakur, Assistant
16. Sh. Om Parkash, Assistant
17. Mrs. Shyam Lata Beakta, Assistant
18. Smt. Chandni Baghta, Assistant
19. Sh. Deep Ram, Assistant
20. Sh. Pawan Kumar, Assistant
21. Sh. Sachin Kanwar, Assistant
22. Sh. Hans Raj, Assistant
23. Sh. Girish Thakur, PA
24. Mrs. Nirmala Chauhan, UDC
25. Sh. Ashwani Gupta, UDC
26. Sh. Tej Singh, UDC
27. Mrs. Geeta Devi, UDC
28. Mrs. Sonia Chauhan, UDC
29. Mrs. Punam Jyoti, UDC
30. Sh. Mohinder Singh, UDC
31. Sh. Narender Paul, UDC
32. Sh. Raghubir Singh, UDC
33. Sh. Gokal Ram, UDC
34. Sh. Rakesh Negi, UDC
35. Sh. Ashish Kalyan, UDC
36. Sh. Kundan Lal, UDC
37. Sh. Nand Lal, UDC
38. Smt. Kiran, UDC

ICAR-CPRI, Regional Station, Jalandhar

39. Miss. Prawartika Das, AAO
40. Sh. Suresh Kumar Verma, PA
41. Mrs. Daishey Tuli, UDC
42. Sh. Daljit Singh, UDC
43. Sh. Naresh Kumar, UDC

ICAR-CPRI, Regional Station, Modipuram

44. Sh. Sandeep, AAO
45. Sh. Rajesh Kumar, PS
46. Smt. Sneh Lata, UDC
47. Smt. Seema Verma, UDC
48. Sh. Ashok Kumar, UDC
49. Sh. Pradyuman K. Saraswat, UDC
50. Sh. Suraj Singh, LDC

ICAR-CPRI, Regional Station, Patna

51. Sh. Jagbir Singh, AAO
52. Mrs. Sandhya Srivastata, Assistant
53. Sh. RK Gupta, UDC
54. Sh. Pawan Kumar, Steno Gr-III
55. Sh. Rajesh Chauhan, LDC

ICAR-CPRI, Regional Station, Gwalior

56. Sh. Kamal Chand Verma, Assistant
57. Sh. Sunil Kumar, LDC

ICAR-CPRI, Regional Station, Ooty

58. Smt. IC Dharmapaul, AAO

List of Skilled Support staff at ICAR-CPRI, Shimla & its Regional Stations as on 31.12.2023

ICAR-CPRI, Shimla

1. Sh. Subhash Chand, SSS
2. Sh. Rajinder Kumar, SSS

3. Sh. Sanjeevan Kumar, SSS
4. Sh. Narender Kumar, SSS
5. Smt. Kajal, SSS
6. Sh. Padam Dev, SSS
7. Sh. Roshan Lal, SSS
8. Smt. Manjit, SSS
9. Sh. Amar Nath, SSS
10. Sh. Padam Chand, SSS
11. Sh. Ashok Kumar, SSS

ICAR-CPRI, Kufri-Fagu Unit

12. Sh. Hira Singh, SSS
13. Sh. Saran, SSS
14. Sh. Roop Singh, SSS
15. Sh. Jia Lal, SSS
16. Sh. Hira Singh, SSS
17. Sh. Rajinder Singh, SSS

ICAR-CPRI, Regional Station, Modipuram

18. Sh. Jagtey, SSS
19. Sh. Som Pal, SSS
20. Sh. Mani Ram, SSS
21. Sh. Rajpal, SSS
22. Sh. Rajbir Singh, SSS
23. Sh. Raj Kumar, SSS
24. Sh. Sudesh Pal, SSS
25. Sh. Gyanendra Kumar, SSS
26. Sh. Mukesh, SSS
27. Sh. Murari, SSS
28. Sh. Rajpal Singh, SSS

ICAR-CPRI, Regional Station, Patna

29. Sh. Teka Rai, SSS
30. Sh. Jagat Kumar, SSS

ICAR-CPRI, Regional Station, Jalandhar

31. Mrs. Passo, SSS
32. Smt. Rashpal Devi, SSS
33. Sh. Ram Lubhaya, SSS
34. Sh. Ram Sarup, SSS
35. Sh. Jagan Nath, SSS

ICAR-CPRI, Regional Station, Gwalior

36. Sh. Ram Singh, SSS
37. Sh. Jagdish, SSS
38. Sh. Shyam Singh, SSS
39. Sh. Parkash Tomar, SSS
40. Sh. Virendra Singh, SSS
41. Sh. Ranbir Singh, SSS
42. Sh. Kallu, SSS
43. Sh. Ashok Kumar, SSS
44. Smt. Vimla Devi, SSS
45. Sh. Jaswant Singh, SSS
46. Sh. Kedar, SSS
47. Sh. Punjab Singh, SSS
48. Sh. Ram Parkash, SSS
49. Sh. Bharat Singh, SSS
50. Sh. Mannu Singh, SSS
51. Sh. Lala Ram, SSS
52. Sh. Tilak Singh, SSS
53. Sh. Net Ram, SSS
54. Sh. Mangal, SSS
55. Sh. Jandel Singh, SSS
56. Sh. Bhagirath, SSS
57. Sh. Ramdin, SSS
58. Sh. Sikander Singh, SSS

ICAR-CPRI, Regional Station, Shillong

Nil

ICAR-CPRI, Regional Station, Muthorai

Nil

Sanctioned, Filled & Vacant Position of Scientific Staff of CPRI & its Regional Stations as on 31.12.2023

S.N.	Name of the Station	JD/HoD/HoRS			Sr. Scientist			Scientist			Total		
		S	F	V	S	F	V	S	F	V	S	F	V
1	CPRI, Shimla including AICRP & CPRI KufriFagu Unit	05	04	**01**	07	03	**04**	30	15	**15**	42	22	**20**
2	CPRS, Jalandhar	01	01	**00**	01	00	**01**	10	08	**02**	12	09	**03**
3	CPRIRS, Modipuram	01	01	**00**	04	03	**01**	10	09	**01**	15	13	**02**
4	CPRIRS, Gwalior	00	00	**00**	03	01	**02**	03	01	**02**	06	02	**04**
5	CPRIRS, Patna	00	00	**00**	01	00	**01**	04	03	**01**	05	03	**02**
6	CPRIRS, Ooty	00	00	**00**	00	00	**00**	03	03	**00**	03	03	**00**
7	CPRIRS, Shillong	00	00	**00**	00	00	**00**	04	04	**00**	04	04	**00**
	TOTAL	**07**	**06**	**01**	**16**	**07**	**09**	**64**	**43**	**21**	**87**	**56**	**31**

*Excluding RMP

Sanctioned, Filled & Vacant Position of Scientific Staff of CPRI & its Regional Stations as on 31.12.2023 (excluding 01 RMP position)

Sl. No.	Discipline	HoD/ HoRS			Principal Scientist (DR)			Senior Scientist (DR)			Scientist (including Sr. Sci.&PS promoted Through CAS)			Total		
1		**S**	**F**	**V**	**S**	**F**	**V**	**S**	**F**	**V**	**S**	**F**	**V**	**S**	**F**	**V**
2	AGRICULTURAL BIOTECHNOLOGY	-	-	-	-	-	-	1	-	**1**	3	3	-	4	3	**1**
3	AGRONOMY	-	-	-	-	-	-	1	1	-	4	3	**1**	5	4	**1**
4	AG. ENTOMOLOGY	-	-	-	-	-	-	2	2	-	5	2	**3**	7	4	**3**
5	AG. ECONOMICS	-	-	-	-	-	-	1	-	**1**	1	-	**1**	2	-	**2**
6	AG METEOROLOGY	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
7	AGRICULTURAL MICROBIOLOGY	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
8	COM. APPLN.& IT	-	-	-	-	-	-	-	-	-	1	1	-	1	1	-
9	AG. EXTENSION	-	-	-	-	-	-	1	-	**1**	1	1	-	2	1	**1**
10	AG. ENGG.(FM&P)	-	-	-	-	-	-	-	-	-	3	2	**1**	3	2	**1**
11	PL.BIOCHEMISTRY	-	-	-	-	-	-	1	1	-	2	1	**1**	3	2	**1**
12	FOOD TECHNOLOGY	-	-	-	-	-	-	1	-	**1**	1	1	-	2	1	**1**
13	VEG. SCIENCE	-	-	-	-	-	-	1	-	**1**	14	11	**3**	15	11	**4**
14	NEMATOLOGY	-	-	-	-	-	-	-	-	-	2	2	-	2	2	-
15	GENETICS AND PLANT BREEDING	-	-	-	-	-	-	2	1	**1**	8	7	**1**	10	8	**2**
16	PL. PATHOLOGY	-	-	-	-	-	-	2	1	**1**	7	2	**5**	9	3	**6**
17	PL. PHYSIOLOGY	-	-	-	-	-	-	1	-	**1**	5	2	**3**	6	2	**4**

Sl. No.	Discipline	HoD/ HoRS			Principal Scientist (DR)			Senior Scientist (DR)			Scientist (including Sr. Sci.&PS promoted Through CAS)			Total		
18	SOIL SCIENCE SOIL CHEM./ FERT. MICRO	-	-	-	-	-	-	1	-	1	2	-	2	3	-	3
19	SEED SCIENCE AND TECHNOLOGY	-	-	-	-	-	-	1	1	-	3	3	-	4	4	-
20	Head, Crop Improvement &Seed Technology	1	-	1	-	-	-	-	-	-	-	-	-	1	-	1
21	Head, Social Science	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
22	Head, Crop Production	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
23	Head, CPB&PHT	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
24	Head, Plant Protection	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
25	Head, CPRI RS, Modipuram	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
26	Head, CPRI RS, Jalandhar	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
	TOTAL	**7**	**6**	**1**	-	-	-	**16**	**7**	**9**	**64**	**43**	**21**	**87**	**56**	**31**

S-Cadre Strength F-In Position V-Vacancy

Scientific Category

New Joining

1. Dr. Brajesh Singh, Principal Scientist joined to the post of Director, ICAR-CPRI, Shimla on **21.01.2023 (AN).**

2. Dr. Jagdev Sharma, Principal Scientist joined to the post of Head, Division of Crop Production, ICAR-CPRI, Shimla on **15.06.2023 (AN).**

3. Dr. Sanjeev Sharma, Principal Scientist joined to the post of Head, Division of Plant Protection, ICAR-CPRI, Shimla on **16.06.2023 (FN).**

4. Dr. Dinesh Kumar, Principal Scientist joined to the post of Head, Division of CPB & PHT, ICAR-CPRI, Shimla on **21.06.2023 (FN).**

5. Dr. Alok Kumar, Principal Scientist joined to the post of Head, Division of Social Science, ICAR-CPRI, Shimla on **11.07.2023 (AN).**

6. Dr. Anil Sharma, Principal Scientist joined to the post of Head, ICAR-CPRI RS, Jalandhar on **21.06.2023 (AN).**

7. Dr. Rajesh Kumar Singh, Principal Scientist joined to the post of Head, ICAR-CPRI RS, Modipuram on **14.11.2023 (FN).**

8. Dr. Praveen S. Patted, Scientist (Seed Science & Technology) joined at ICAR-Central Potato Research Institute, Shimla on **20.07.2023 (AN) and** ICAR-CPRI RS, Ooty on 28.11.2023 (AN).

Transfers (Inter-institute)

1. Dr. Vinay Bhadwaj, Scientist (Vegetable Science), ICAR-Central Potato Research Institute, Shimla relieved on **10.02.2023** (AN) for joining to the post of Director, ICAR-NRCSS, Ajmer, Rajasthan.

2. Dr. Changan Sushil Sudhakar, Scientist (Plant Biochemistry), ICAR-Central Potato Research Institute, Shimla relieved on **03.03.2023** (AN) to join at ICAR-NIASM, Pune.

3. Dr. Manoj Kumar, Principal Scientist (Soil Science), ICAR-Central Potato Research Institute, Regional Station, Modipuram relieved on **29.08.2023** (AN) to join at ICAR-PIM Unit, ICAR Hqrs., Krishi Bhawan, New Delhi.
4. Dr. Ravinder Kumar, Senior Scientist (Plant Pathology), ICAR-Central Potato Research Institute, Shimla relieved on **04.10.2023** (AN) to join at Indian Agricultural Research Institute, New Delhi
5. Dr. Rahul Kumar Tiwari, Scientist (Plant Pathology), ICAR-Central Potato Research Institute, Shimla relieved on **15.12.2023** (AN) to join at ICAR-Indian Institute of Sugarcane Research, Lucknow
6. Dr. Milan Kumar Lal, Scientist (Plant Physiology), ICAR-Central Potato Research Institute, Shimla relieved on **15.12.2023** (AN) to join at ICAR-National Rice Research Institute, Cuttack, Odisha.

Promotions

Sl.No.	Name of Scientist & Discipline	Level on promotion	Date of promotion
Promoted vide ICAR, New Delhi Office Order dated 15.05.2023			
1	Dr. Anil Kumar Choudhary (Agronomy)	Level-14 of 7th CPC (Pre-revised Pay Band Rs. 37,400 – 67,000 + RGP Rs.10,000)	16.10.2018

Retirement

Dr. Name Singh, Principal Scientist, ICAR-Central Potato Research Institute, Regional Station, Modipuram retired from Council's service w.e.f. **31.01.2023 (AN**.)

Death

1. Dr. Vijay Kumar Dua, Principal Scientist (Agronomy), Division of Crop Production, ICAR-CPRI, Shimla expired on **28.03.2023.**

SANCTIONED FILLED AND VACANT POSITION OF TECHNICAL CATEGORY AS ON 31.12.2023.

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	29	5	2	8	7	13	7	4	4	12	9	4	2	8	5	**83**	**65**	**18**
Cat. II Sr. Tech. Asstt. (T-4) Tech. Asstt. (T-3)	9	5	-	-	4	3	13	10	2	1	3	1	-	-	-	-	**31**	**20**	**11**
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	2	-	-	-	-	-	-	**6**	**5**	**1**
Cat. III Computer programmer T-6	1	-	-	-	-	-	-	1	-	-	-		-	-	-	-	**1**	**1**	**0**
Lib. Information / Documentation																			
Cat. II Lib. Asstt. (T-3)	1	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	**3**	**1**	**2**
Asstt. Librarian (T-5)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Documentalist , T-3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Tech. Asstt. (Stat.) (T-3)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Functional Group	**Hqrs.**		**Shillong**		**Jalandhar**		**Modipuram**		**Gwalior**		**Patna**		**Ooty**		**Kufri**		**Total**		
	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	**S**	**F**	**V**
Photography																			
Cat. I Photographer	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**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**	**0**
Sr. Mechanic (T-2)	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	**2**	**2**	**0**
Fitter (T-1)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Welder	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**0**

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
Mechanic cum Electrician	1	1	-	-	2	-	1	-	-	-	-	-	-	-	-	-	**4**	**1**	**3**
Operator Electrical	1	1	-	-	-	1	1	-	-	-	1	-	-	-	-	-	**3**	**2**	**1**
Driver	3	1	2	-	2	-	2	1	2	-	2	1	-	-	-	-	**12**	**3**	**9**
Tractor Driver	1	1	1	-	1	-	4	-	3	1	1	-	1	-	-	-	**12**	**2**	**10**
Cat. II Foreman (T-4)	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	**2**	**1**	**1**
Asstt. Foreman (T-3)	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	**1**	**1**	**0**
Overseer (Civil) T-3	1	-	-	-	-	-	-	01	-	-	-	-	-	-	-	-	**1**	**1**	**0**
Cat. III Instrument Engineer, T-7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0**	**1**
Total	**61**	47	**08**	02	**22**	12	**41**	26	**13**	10	**19**	11	**05**	02	**08**	05	**178**	115	**63**

Sanctioned, Filled and Vacant Position of Technical Category as on 31.12.2023

Category	Sanctioned	Filled	Vacant
Category-I	**115**	**81**	**34**
Category-II	**49**	**31**	**18**
Category-III	**04**	**03**	**01**
Total	**168**	**115**	**53**

Promotions:

1. Sh. Naresh Kumar, Senior Technical Assistant, CPRI, Shimla promoted to Technical Officer from 15.4.2022
2. Sh. Ranjesh Bhardwaj, Senior Technical Assistant, CPRI, Shimla promoted to Technical Officer from 7.6.2022
3. Sh. Dev Raj, Senior Technician, CPRI, Shimla promoted to Technical Assistant from 11.7.2022
4. Sh. Mohan Lal, Senior Technician, CPRI, Shimla promoted to Technical Assistant from 11.7.2022
5. Sh. Jagdish Chand, Technical Assistant, CPRI, Shimla promoted to Sr. Technical Assistant from 1.1.2022
6. Sh. Nihal Singh, Sr. Technical Assistant, CPRS, Gwalior promoted to Technical Officer from 27.5.2022
7. Sh. Pawan Kumar Malik, Technical Officer, CPRIRS Modipuram (Now IARI, New Delhi) promoted to Senior Technical Officer from 24.12.2021
8. Dr. Kapil Kumar Sharma, Assistant Chief Technical Officer, CPRS, Jalandhar promoted to Chief Technical Officer from 23.2.2022
9. Sh. Harvinder Singh, Sr. Technical Officer, CPRIRS Modipuram promoted to Assistant Chief Technical Officer from 28.10.2020
10. Sh. Dharminder Verma, Assistant Chief Technical Officer, CPRI, Shimla promoted to Chief Technical Officer from 15.6.2022
11. Smt. Tarvinder Kochhar, Assistant Chief Technical Officer, CPRI, Shimla promoted to Chief Technical Officer from 07.06.2022
12. Review Case of Sh. Harvir Singh, ACTO, CPRIRS, Modipuram promoted to T-4 to T-5 from 30.9.2006

13. Sh. Vijay Kumar, Sr. Technical Assistant, CPRS, Jalandhar promoted to Technical Officer from 17.11.2022
14. Sh. Ashok Kumar, Sr. Technical Assistant(Driver), CPRI, Shimla promoted to Technical Officer from 1.3.2023
15. Sh. Udaivir Singh, Sr. Technical Officer, CPRIRS, Modipuram promoted to Assistant Chief Technical Officer on 16.2.2022
16. Smt. Shruti Gupta, Sr. Technical Officer, CPRI, Shimla promoted to Assistant Chief Technical Officer on 22.2.2023
17. Sh. Tilak Raj, Sr. Technical Officer, CPRI, Shimla promoted to Assistant Chief Technical Officer on 24.9.2022
18. Sh. Rajindra Kumar Samadhya, Sr. Technical Officer, CPRS, Gwalior promoted to Assistant Chief Technical Officer on 25.3.2020
19. Sh. Om Pal, Assistant Chief Technical Officer, CPRIRS, Modipuram promoted to Chief Technical Officer on 13.10.2023
20. Sh. Kameshwar Sen, Assistant Chief Technical Officer, CPRI, Shimla promoted to Chief Technical Officer on 05.01.2023
21. Sh. Ved Singh, Sr. Technical Officer, CPRIRS, Modipuram promoted to Assistant Chief Technical Officer on 5.1.2023

Retirements:

1. Sh. Radha Krishan, Sr. Technical Assistant (Driver), CPRS, Gwalior retired on 31.5.2023
2. Sh. Hari Kishor, Technical Officer, CPRI, Shimla retired on 31.7.2023
3. Sh. Jaswinder Singh, Chief Technical Officer, CPRS, Jalandhar retired on 30.9.2023
4. Sh. Ashok Kumar, Technical Officer, CPRI, Shimla retired on 30.11.2023

Transfer/ Inter-Institutional Transfer:

1. Sh. Rahul, Technician, CPRI, Shimla inter-institutional - transferred to Wheet & Barley Research Institute, Karnal on 11.01.2023
2. Sh. Vipin Kumar, Technical Assistant, CPRIRS, Modipuram inter-institutional -transferred to IARI, New Delhi along with post on 31.03.2023
3. Sh. Shed Danish Abbas Rizvi, Sr. Technical Assistant, CPRIRS, Modipuram transferred to Kufri-Fagu Unit, CPRI, Shimla on 4.10.2023
4. Dr. Kapil Kumar Sharm, CTO, CPRI, Shimla transferred to CPRS, Jalandhar on 15.12.2023
5. Sh. Yogesh Kumar Gupta, ACTO, CPRS, Jalandhar transferred to CPRIRS, Modipuram on 7.12.2023
6. Sh. Sheesh Ram, Technical Officer, Crop Improvement and Seed Technology Division transferred to Canteen & Guest House on 12.02.2023
7. Sh. Vivek Kumar, Technician, Social Science Division transferred to Crop Improvement and Seed Technology Division on 1.12.2023

Administrative staff sanctioned /Filled/Vacant Position as on 31.12.2023 at CPRI, Shimla

Group	Shimla			Shillong			Jalandhar			Modipuram			Gwalior			Patna			Ooty			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
CAO	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**	**0**
Dy.Director Comptroller	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0**	**1**
SF&AO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
AO	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	**1**	**1**
F&AO	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**	**0**
AAO	4	3	1	1	0	1	1	1	0	1	1	0	1	0	1	0	1	-1	0	1	-1	**8**	**7**	**1**
AF&AO	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	**0**	**2**

Group	Shimla			Shillong			Jalandhar			Modipuram			Gwalior			Patna			Ooty			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
DD (OL)	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**	**0**
PPS	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**	**0**
PS	3	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	**4**	**4**	**0**
PA	2	1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	**4**	**2**	**2**
Asstt.	16	11	5	1	0	1	2	0	2	2	0	2	1	1	0	1	1	0	1	0	1	**24**	**13**	**11**
UDC	6	12	-6	0	0	0	1	3	0	1	4	-3	0	0	0	1	1	0	0	0	0	**9**	**20**	**-11**
LDC	3	3	0	1	0	1	1	0	1	1	1	0	1	1	0	1	1	-1	1	0	1	**9**	**6**	**3**
Steno.G-III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	0	0	0	**0**	**1**	**-1**
Total	**43**	**38**	**5**	**3**	**0**	**3**	**6**	**5**	**1**	**6**	**7**	**-1**	**3**	**2**	**1**	**4**	**5**	**-2**	**2**	**1**	**1**	**67**	**58**	**9**

Appointment/New joining

Administrative Staff. Promotions

1. Sh Kamal Chand Verma, Assistant, CPRI, Shimla promoted to the post of Assistant w.e.f. 09.03.2023.

Appointment/Promotion/Retirement/Transfers/Deaths

1. Sh Tejbir Singh,LDC,CPRI(RS),Modipuram retired on 31.01.2023.
2. Sh Sukh Pal Sharma, Assistant,CPRI(RS), Jalandhar Expired on 12.03.2023
3. Sh Amar Chand , Assistant, CPRI, Shimla Retired on 31.05.2023
4. Sh Rakesh, Assistant, CPRI(RS), Jalandhar Voluntary Retired on 04.12.2023
5. Ms. Sandhya Srivastava, Assistant, Jalandhar transferred to CPRI (RS) Patna and relieved on 15.12.2023.
6. Sh Sanjib Kumar, AAO, CPRI (RS), Gwalior transferred to ICAR-MGIFRI, Motihari Patna and relieved on 13.10.2023(A/N).

Granted financial up-gradation under MACP Scheme

1. Ms. Sandhya Srivastava, Assistant, CPRI (RS), Jalandhar granted 3rd MACP w.e.f. 02.10.2022 in Pay Matrix Level 7.
2. Smt. Shyam Lata Beakta, Assistant, CPRI, Shimla, granted 3rd MACP w.e.f. 30.01.2023 in Pay Matrix Level 7.

Transfers on selection basis

1. Sh Raj Kumar, SFAO, CPRI Shimla relieved w.e.f. 27.01.2023(A/N) to join as CFAO at ICAR-CSWRI, Avikanagar
2. Sh.Kamal Chand Verma, UDC, CPRI Shimla, relieved w.e.f. 07.03.2023 (AN) and Joined as Assistant at CPRI (RS) Gwalior.

INSTITUTE BUDGET (2023-24)

Annexure A

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
ANNUAL ACCOUNT 2023-24

Following is the statement of revenue generated by the Institute as per the Annexure "A" of the Annual Account for the year

S. No.	Head of Account	Revenue Receipts 22-23	Revenue Receipts 23-24
		Amount	Amount
1	Sale of Farm Produce	80,51,948.00	120,97,039.00
2	Sale of Fish & Poultry	0.00	0.00
3	Sale of Land	0.00	0.00
4	Sale of Building	0.00	0.00
5	Sale of Vehicle, other Machine tools	7,48,025.00	55,989.00
6	Sale of Livestock	0.00	0.00
7	Sale of Publication and advertisement	0.00	0.00
8	Licence Fee	11,69,159.00	13,06,057.00
9	Interest earned on loans & advances	4,41,794.00	3,08,558.00
10	Leave salary and pension contribution	0.00	42,499.00
11	Receipts from schemes	0.00	0.00
12	Analytical and testing fee	0.00	0.00
13	Pre-shipment fee	0.00	0.00
14	Application fee from candidates	0.00	0.00
15	Diploma Charges	0.00	0.00
16	Receipts from services rendered	0.00	0.00
17	Unspent balance of Grants of previous years	0.00	0.00
18	Interest earned on short term deposits	27,19,017.00	39,87,953.00
19	Income generated from Internal Resource Generation schemes	31,07,433.00	32,83,876.00
	a) Training	0.00	0.00
	b) Consultancy	0.00	0.00
	c) Contract Research	0.00	0.00
	d) Sale of Technology	0.00	0.00
	e)other (Specify the source)	0.00	0.00
20	Net Profit in Revolving funds	0.00	0.00
21	Recoveries of Loans & Advances	4,20,600.00	7,53,650.00
22	Miscellaneous Receipts	37,57,601.00	11,81,027.00
(A)	TOTAL: OTHER RECEIPTS (A)-2022-23	204,15,577.00	230,16,648.00
(B)	DEDUCT: to be transferred to Grant Account No.:11084229362		
17	Unspent balance of Grants of previous years	0.00	0.00
18	Interest earned on short term deposits	27,19,017.00	39,87,953.00
	Transferred to Grant Account ICAR	27,19,017.00	39,87,953.00

S. No.	Head of Account	Revenue Receipts 22-23	Revenue Receipts 23-24
		Amount	Amount
(C)	DEDUCT: 100% To be remitted to Corpus Fund A/C of Council: 42285360283		
3	Sale of Land	0.00	0.00
4	Sale of Building	0.00	0.00
5	Sale of Vehicle, other Machine tools	7,48,025.00	55,989.00
6	Sale of Livestock	0.00	0.00
9	Interest earned on loans & advances	4,41,794.00	3,08,558.00
10	Leave salary and pension contribution	0.00	42,499.00
21	Recoveries of Loans & Advances	4,20,600.00	7,53,650.00
	Transferred to Corpus Fund A/c 42285360283 (C)	16,10,419.00	11,60,696.00
(D)	Balance AVAILABLE (A-B-C)	160,86,141.00	178,67,999.00
(i)	Transferred to Institute Corpus Fund 70%	112,60,299.00	125,07,599.00
(ii)	Transferred to Central Council Corpus Fun 30%	48,25,842.00	53,60,400.00
Net Profit in Revolving funds			
		FY 22-23	FY 23-24
S. No.	Head of Account	Amount	Amount
1	Income genretated from Revolving fund during the year (Sch-14)	497,95,896.00	1217,95,068.00
2	Expenditure made From revouing fund during the year (Sch-20)	814,64,245.00	927,45,556.00
3	Net profit from Revolving from during the year (if +ive)	-316,68,349.00	290,49,512.00
4	Transferred to Institute Corpus Fund 70%	0.00	203,34,658.00
5	Transferred to Central Council Corpus Fund 30%	0.00	87,14,854.00

	For current Financial Year 2023-24		
Particulars	From revenue	From Revolving fund	Total
Transferred to Institute Corpus Fund 2023-24	112,60,299.00	0.00	112,60,299.00
Transferred to Central Council Corpus Fund 2023-24	64,36,261.00	0.00	64,36,261.00
Transferred to Grant Account ICAR 2023-24	27,19,017.00	0	27,19,017.00
Total 2023-24	204,15,577.00	0.00	204,15,577.00
For Next Financial Year 2024-25			
Transferrable to Institute Corpus Fund 2024-25	125,07,599.00	203,34,658.00	328,42,257.00
Transferrable to Central Council Corpus Fund 2024-25	65,21,096.00	87,14,854.00	152,35,950.00
Transferred to Grant Account ICAR-2024-25	39,87,953.00	0	39,87,953.00
Total 2024-25	230,16,648.00	290,49,512.00	520,66,160.00

Annexure-B

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
ANNUAL ACCOUNTS 2023-24

Details of Institute Govt. Grant expenditure for the year 2023-24

(Rs in Actuals)

S. No.	Head	Allocation Govt. Grant 2023-24	Allocation out of ICAR Non-scheme (salary+pension+non-schmez0	TOTAL ALL OCATION 2023-24	Expenditure (Govt.Grant) 2023-24					Expendirure-Non Scheme	TOTAL EXPENDITURE 2023-24
1	2	3		5 (3 + 4)	6						8 (6 + 7)
					Other than NEH & TSP	NEH	TSP	SCSP	Total Scheme		
1	Works										
	A. Land										
	B. Building										
	i. Office building	750000.00	0.00	750000.00	88382.00	670000.00	0.00	0.00	758382.00	0.00	758382.00
	ii. Residential building	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	iii. Minor Works	1020000.00	0.00	1020000.00	1069130.00	0.00	0.00	0.00	1069130.00	0.00	1069130.00
2	Equipments	4800000.00	0.00	4800000.00	3442959.00	1214692.00	0.00	48188.00	4705839.00	0.00	4705839.00
3	Information Technology	1600000.00	0.00	1600000.00	1149952.00	177145.00	0.00	279582.00	1606679.00	0.00	1606679.00
4	Library Books and Journals	300000.00	0.00	300000.00	310627.00	0.00	0.00	0.00	310627.00	0.00	310627.00
5	Vehicles & Vessels	2200000.00	0.00	2200000.00	1010616.00	1199390.00	0.00	0.00	2210006.00	0.00	2210006.00
6	Livestock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Furniture & fixtures	1430000.00	0.00	1430000.00	427823.00	838750.00	0.00	170701.00	1437274.00	0.00	1437274.00
8	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total – CAPITAL (Grants for creation of Capital Assets)	12100000.00	0.00	12100000.00	7499489.00	4099977.00	0.00	498471.00	12097937.00	0.00	12097937.00
1	Establishment Expenses(Salaries)										
	i. Establishment Charges	414707000.00	0.00	414707000.00	414705942.00	0.00	0.00	0.00	414705942.00	0.00	414705942.00
	ii. Wages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	iii. Overtime Allowance	0.00		0.00	0.00	0.00	0.00	0.00	0.00		0.00
	Total – Establishment Expenses (Grant in Aid - Salaries)	414707000.00	0.00	414707000.00	414705942.00	0.00	0.00	0.00	414705942.00	0.00	414705942.00
1	Pension & Other Retirement Benefits	330000000.00	0.00	330000000.00	329999982.00	0.00	0.00	0.00	329999982.00	0.00	329999982.00
2	T.A.										
	A. Domestic TA / Transfer TA	6000000.00	0.00	6000000.00	6006671.00	0.00	0.00	0.00	6006671.00	0.00	6006671.00

S. No.	Head	Allocation Govt. Grant 2023-24	Allocation out of ICAR Non-scheme (salary+pension+non-schmez0	TOTAL ALL OCATION 2023-24	Expenditure (Govt.Grant) 2023-24					Expendirure-Non Scheme	TOTAL EXPENDITURE 2023-24
1	2	3		5 (3 + 4)	6						8 (6 + 7)
					Other than NEH & TSP	NEH	TSP	SCSP	Total Scheme		
	B. Foreign TA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total – Traveling Allowance	*6000000.00*	*0.00*	*6000000.00*	*6006671.00*	*0.00*	*0.00*	*0.00*	*6006671.00*	*0.00*	*6006671.00*
3	Research & Operatinal Expenses										
	A. Research Expenses	13700000.00	0.00	13700000.00	*7096536.00*	*4299497.00*	*992055.00*	*1263130.00*	*13651218.00*	0.00	13651218.00
	B. Operational Expenses	1150000.00	0.00	1150000.00	784101.00	355652.00	0.00	0.00	*1139753.00*	0.00	1139753.00
	Total - Research & Operational Expenses	14850000.00	0.00	14850000.00	7880637.00	4655149.00	992055.00	1263130.00	14790971.00	0.00	14790971.00
4	Administrative Expenses										
	A. Infrastructure	15100000.00	0.00	15100000.00	14904891.00	140013.00	10095.00	0.00	15054999.00	0.00	15054999.00
	B. Communication	780000.00	0.00	780000.00	728606.00	49411.00	0.00	0.00	778017.00	0.00	778017.00
	C.Repair & Maintenance										
	i. Equipments,Vehicles & Others	3000000.00	0.00	3000000.00	2809838.00	212222.00	0.00	0.00	3022060.00	0.00	3022060.00
	ii. Office building	2800000.00	0.00	2800000.00	2425966.00	353600.00	0.00	0.00	2779566.00	0.00	2779566.00
	iii.Residential building	1040000.00	0.00	1040000.00	1039074.00	0.00	0.00	0.00	1039074.00	0.00	1039074.00
	iv. Minor Works	570000.00	0.00	570000.00	567744.00	0.00	0.00	0.00	567744.00	0.00	567744.00
	D. Others (excluding TA)	38360000.00	0.00	38360000.00	28636133.00	8588631.00	495670.00	734389.00	38454823.00	0.00	38454823.00
	Total - Administrative Expenses	61650000.00	0.00	61650000.00	51112252.00	9343877.00	505765.00	734389.00	61696283.00	0.00	61696283.00
5	Miscellaneous Expenses										
	A. HRD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B. Other Items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C. Publicity & Exhibitions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D. Guest House – Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	E. Other Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total - Miscellaneous Expenses	0.00	0.00	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
	Total --Grants in Aid - General	82500000.00	0.00	82500000.00	394999542.00	13999026.00	1497820.00	1997519.00	412493907.00	0.00	82493925.00
	Grand Total (Capital + Establishment+General)	839307000.00	0.00	0.00	817204973.00	18099003.00	1497820.00	2495990.00	839297786.00	0.00	839297786.00

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