भाकृअनुप
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वार्षिक प्रतिवेदन

ANNUAL REPORT
2022








भा.कृ.अनु.प.–भारतीय सब्जी अनुसंधान संस्थान
वाराणसी–२२१३०५

ICAR-Indian Institute of Vegetable Research
Varanasi – 221 305

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PREFACE

The global vegetable market has witnessed steady growth in recent years, driven by increasing consumer awareness of the health benefits of vegetables and the rising demand for vegetarian diets. Growing concerns about sustainability and environmental impact have also contributed to the popularity of vegetables as a sustainable food choice. The market is highly diverse, encompassing various types of vegetables, including leafy greens, root vegetables, cruciferous vegetables, and legumes. Vegetables are sources of various nutrition with the ability to produce income for growers both on and off the farm. The estimated production of vegetable in country was around 204.84 MT in 2021-22 from an area of 11.35 million hectares and productivity of 18.05 tons per hectare. The United Nations has set 17 Sustainable Development Goals (SDGs) for the year 2030. The vegetables and allied enterprises have an important role to play in achieving these goals. The ICAR-IIVR, Varanasi is putting in its effort to contribute in meeting these goals for no poverty, zero hunger, good health and elevate action through development of improved varieties, production and protection technologies, trainings and hand holding the farmers and other stakeholders.

The important institutional milestone that occurred in 2022 was the notification of 08 varieties and one hybrid through CVRC, identification of two varieties and one hybrid through AICRP (VC) and 15 varieties and 4 hybrids recommendation for notification by SVRC for cultivation in Uttar Pradesh. Under the mega programme integrated gene management, tomato lines for processing, high temperature tolerant tomato and brinjal, ToLCV resistant gene pyramided tomato, ChiLCV resistant chilli, YVMV and OELCV resistant lines of okra, CMS lines of cauliflower, were developed. The primary focus was to develop cultivar in response to biotic and abiotic stress to face the climate change. The untapped potential of underutilized crops such as winged bean, faba bean, water spinach and amaranth were demonstrated through mass popularization drive. A total of 1183 vegetables genetic resources in 14 vegetable crops were distributed to the different organisations on MTA basis. Under the biotechnology project, 5 transgenic lines of brinjal (*Cry1Aa3* and *Cry1Ac*), 8 tomato (*Cry1Ac*) and 4 *AtDREB1A* and 3 *BcZAT12* were maintained. In tomato, CRISPR/Cas9 genome editing work for male sterility (*SlCRK1*), multiple disease resistance (*SlDMR*6 and *SlPL*) and processing (*SlNVINHI*1 and *SlVPE*5) was initiated. A total of 20197.00 kg of seeds including 3120.20 kg of breeder seed of vegetable crops has been produced. The umbrella system of training in bitter gourd cv. Kashi Pratishtha was found to be superior under the polyhouse conditions. The other studies on vegetable production include pheno-phase based nutrient scheduling, improving water productivity, grafting, agronomic bio-fortification and post-harvest management of vegetable crops. For management of major insect pests and diseases of vegetable crops, investigation of novel botanicals insecticides, biological control of sucking insect-pest, integrated management of fungal diseases, bioprospecting of beneficial microbes and characterization of viruses were included. The institute has also expanded its outreach activities under SCSP, TSP and in NEH regions covering the states of UP, Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Sikkim, Meghalaya and Tripura. The organization of technology promotion day in different crops serves as the major platform for strengthening public private partnership (PPP). A national symposium commemorating the golden jubilee of AICRP(VC) was also organized with the participation of national researchers.

Our accomplishments in 2022 were possible because of the continuous encouragement, guidance and support of the senior officials of ICAR. I place on record my deep sense of gratitude to Dr. Himanshu Pathak, Secretary, DARE & DG, ICAR, Dr. A.K. Singh, DDG (Hort.), ICAR, Dr. V. Pandey, I/C ADG (Hort.), ICAR, New Delhi for their unconditional and incessant support in steering this institute on the path of excellence. I take this opportunity to congratulate all the staff members of this Institute whose sincere efforts have made ICAR-IIVR a name to reckon with. I feel elated to present the Annual Report of this premier Institute, dedicated for vegetable research and development. The contributions of all the three Heads (I/C) of Divisions, KVK's personals, Technicals, Administration, Accounts & other staff, especially, Dr. P.M. Singh, Chairman, PME Cell, ICAR-IIVR, Varanasi and his team in shaping this publication, are gratefully acknowledged.

Varanasi
March 31, 2023

(T. K. Behera)
Director


भा.कृ.अनु.प.- भारतीय सब्जी अनुसंधान संस्थान
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Executive Summary

The institute has developed new vegetable varieties, production and protection technologies to enhance productivity and quality of vegetable crops with efficient transfer of technologies to the farmers' field during the reporting period.

Division of Vegetable Improvement

During the year 2022, a total of 1183 accessions in 14 vegetable crops and one bacterial culture were supplied to 35 organizations through Material Transfer Agreement (MTA) for use in research and demonstration. In collaboration with ICAR-NBPGR, scientists of the institute made exploration trips to the different parts of the country for augmenting new germplasm in the genebank after evaluation.

Two vegetable varieties and one hybrid developed at ICAR-IIVR, Varanasi were identified by AICRP (VC) for cultivation in different agro-climatic zones. These are Indian bean (VRB SEM–207), okra resistant variety (VRO-119) and brinjal hybrid long (IVBHL-22). Eight varieties namely Kashi Brinjal Green Round (IVBR-17) in brinjal; Kashi Agrim (VRFBB-91) in French bean; Kashi Arun (VRCAR-186) in carrot; Kashi Bouni Sem- 3 & Kashi Bouni Sem- 9 in Indian bean; Kashi Kalyani (VRSG-195) in sponge gourd; Kashi Basant (VRPK-230) in pumpkin and Kashi Vishan (VRCP-12) in cowpea and one hybrid Kashi Manohar (IVBHL-20) in brinjal were notified in the Gazette of India vide notification no. 3254 (E) dated 20 July, 2022. In addition, 15 varieties and 4 hybrids were recommended for notification by SVRC of Uttar Pradesh.

Under the Mega programme on Integrated Gene Management, in genetic improvement of Solanaceous crops, in tomato 57 exotic lines were imported for processing. Under hybrid evaluation progams, the hybrids *viz*., VRNTH-20131, VRNTH-20122, VRNTH-20149, VRNTH-20133 and VRNTH-20141 were found promsining in summer season for yields in the range of 43.1-57.5 t/ha. A genetic stock H-88-78-1 (INGR 22049) was registered for root knot nematode, collar rot (*Alternaria solani*), ToLCV and heat tolerance. MAS-led pyramiding of *Ty2*, *ty5* and *Ty6* genes was done in Kashi Aman. The new developed hybrid CRPVRTH-20-10 for year-round cultivation with yield potential in winter (104.33 t/ha), summer (46.66 t/ha) and rainy (66.99 t/ha) was identified. Further, tomato hybrid for processing namely VRTH-22-24 (5.08° Brix) and improved line VRT-67 (TSS: 5.36 °Brix) were identified. In addition, improved lines VRT-67 (35-40 t/ha, TSS: 5.36 °Brix), jointless tomato VRT-69 (90-95 t/ha), cherry tomato VRCYT-3 (35-38 t/ha), and beta carotene rich tomato VRKB-17 (37-40 t/ha) were developed and IC nos were obtained for 15 new tomato lines. In brinjal, a total 114 germplasm including 23 accessions of 8 related wild species were maintained. Among hybrids, IVBR-18-1 (36.8 t/ha) (round), and IVBL-25-1 (45.0 t/ha) (long) performed the best. Advance hybrids/line IVBHL-22 (31.8 t/ha) and IVBHL-24 (31.6 t/ha) performed better under high temperature (35-40°C). In chilli, 410 accessions and 223 advance lines were maintained, 11 new accessions were added and 28 new hybrids were evaluated. The lines derived from Kashi Anmol X IIVRC-452 PT-1, Pusa Jwala X EC-519636-PT-2-1-4 and Pusa Jwala X NG-3-PT-1-3-1 were found better for yield and resistance to leaf curl virus disease.

In vegetable pea, a total of 289 germplasm lines were maintained alongwith *afila* pea lines in early group (VRPE-921 and VRPE-933). Total 102 lines were characterized for various horticultural traits. One unique genotype 'VRPE-29' (INGR22087) for extra earliness (days to flower ≤32 days) was registered, and 7 lines were granted with IC nos. In cowpea, 9 F_1 cross combinations were made and 268 lines were maintained. Two elite lines (VRCP-65-8 and VRCP-167-3) were promoted to AVT-II trials. In Indian bean, 136 lines were maintained and 76 superior lines of bush type were selected from 140 segregants based on yield, DYMV and high temperature tolerance. In French bean, 37 (bush type) and 30 (pole type) lines were maintained and 30 lines were adanced to next generations.

In bitter gourd, 156 lines were maintained and 12 advance lines were evaluated. Based on fruit yield, superior hybrids *viz*., VRBTGH-10 (3.65 kg/plant) and VRBTGH-22 (3.51 kg/plant), and gyneocious hybrid VRBTGYH-6 (3.81 kg/plant) were developed. A set of 148 germplasm were screened for powdery mildew and six lines were identified with partial resistance. In bottle gourd, 94 lines were evaluated and advanced line VRBG-7, and hybrids *viz*., VRBGH-15 and VRBGH-11 were identified based on yield and other traits. In ash gourd, 61 lines were maintained and 20 advance lines were evaluated. In sponge gourd, promising line VRSG-7-17 (1.47 kg/plant) and hybrid (VRSG-17-3 x VRSG-2-21) (1.58 kg/plant) were identified for horticultural traits and 105 lines were screened against downy mildew and virus resistance. The genotype VRSG-17-10 (1.57 kg/plant) and cv. Kashi Rakshita (1.57 kg/plant) were categorized as moderately resistant for downy mildew under the field conditions. In ridge gourd, 11 germplasm and five hyrbids were found promising based on horticultural traits. In Satputia, 6 lines were found promising and 15 populations were advanced. In cucumber, 62 germplasm including advance parthenocarpic line VRCUP-20-2 was

evaluated for horticultural traits. Two superior lines (VRCU-19-19 and VRCU-2240) were identified. Further, 58 lines were advanced and 60 lines were screened against ToLCNDV and VRCU-C-C-7 was found resistant. In pumpkin, 50 germplasm and 11 advance lines were evaluated and VRPK-05 was found promising, in Summer squash, 65 germplasm and 25 advance lines were evaluated. In watermelon, 76 germplasm and 17 advance lines were evaluated, and VRW-10, VRW-514, and VRW-54-2 were found promising. In muskmelon, 195 accessions were maintained and the monoecious inbred VRMM-140 was found having stable monoecious sex expression. Screening of 85 accessions showed three lines VRMM-160, VRMM-161 & VRMM-171 to be resistant against ToLCNDV.

In okra, 780 accessions were maintained and out of 115 green fruited hybrids, VRO-236× VRO-219 was found superior with high yield (595 g/plant). Four red fruited hybrids were found tolerant to YVMV and ELCV. Lines *viz*., VRO-219, VRO-236, VRO-220, VRO-235, VROR-160, VROR-165 and VROR-167 were identified as good combiners. Dwarf genotype VRO-416-10-1 was identified. Evaluation of wild relative of okra RCM/PK/63 was done for YVMV & ELCV resistance and cross-ability with cultivated species was studied.

In cauliflower, 23 CMS-based back crosses were advanced and five CMS lines found to be stable *viz*., VRCF-41 (28-30 ˚C), VRCF-131 & VRCF-132 (24-28 ˚C), VRCF-110 (22-25 ˚C) and VRCF-212 (20-23 ˚C). F_1 hybrids (VRCF-131×VRCF-75-1, VRCF-131×VRCF-86, and VRCF-222×VRCF-77) were introduced to multi-location testing for early and mid-season maturity (225-275 q/ha). Micropropagation of heat tolerant cauliflower line (VRCF-75-1) was initiated. In carrot, CMS-based F_1 hybrids (VRCAR-211×VRCAR-86 & VRCAR-211×Kashi Arun) and 1 OP genotype VRCAR-85 were in multi-location testing. A total 84 carrot lines (49 OP and 35 hybrids) were evaluated. Black and red coloured CMS lines (VRCAR-214 and VRCAR-252) were registered as unique germplasm.

Under biotechnological interventions, transgenic lines of brinjal with *Cry1Aa3*, and *Cry1Ac*; tomato with *Cry1Ac*, and multiple stress tolerant (drought, salt and cold stress) transgenics lines *AtDREB1A* and *BcZAT12* were maintained. In tomato, CRISPR/Cas9 genome editing technology was applied for construct development and transformation efficacy for male sterility (*SlCRK1* gene), multiple disease resistance (*SlDMR6* and *SlPL* genes) and processing quality with high TSS (*SlINVINH1* and *SlVPE5*).

In underexploited vegetables, 266 lines of winged bean were characterized, 79 lines were advanced to next generation and promising lines VRWBH 3-17, VRWB12-18, and VRWB29-18 were identified. A total of 45 vegetable soybean, 36 waterchestnut and 6 lotus lines were maintained. In water spinach, 20 lines were characterized, of which VRWS-1, VRWS-28, VRWS-31 and VRWS-32 were found promising. Sixteen lines of spinach beet/palak were evaluated and VRPLK-2 (INGR22086) was registered as unique germplasm for heat stress. Work was also continued on velvet bean, baby corn, Laipatta and amaranth.

Under vegetatively propagated and perennial vegetable crops, in pointed gourd, 82 accessions of female clones were characterized and VRPG-217, VRPG-219 and VRPG-188 lines were found suitable for confectionery. Fifty nine lines of teasle gourd were maintained and maximum fruit yield per plant was observed in VRSTG-22 (1.85 kg). Thirty eight lines of spine gourd were characterized and VRSEG-20 and VRSEG-22 (2.04 kg) were found promising. Twenty eight lines of ivy gourd were evaluated and VRIG-17 (8.94kg) was found promising. In basella, 39 lines were evaluated and VRB-48 was found promising. In moringa, 22 lines were characterized and highest fruiting was observed in genotype VRMO-9 (1290 fruits).

Under mega programme on seed enhancement in vegetables, a total of 20197.00 kg vegetable seeds of ICAR-IIVR varieties of tomato, brinjal, chilli, okra, cowpea, pea, bottle gourd, bitter gourd, pumpkin, cucumber, sponge gourd, ridge gourd, ash gourd, radish, French bean, Indian bean, carrot, cauliflower and palak etc., were produced for the seed indenters and farmers. Among the total seeds, 17041.20 kg was truthfully labelled seeds of OP varieties of IIVR, 35.55 kg F_1 hybrid seeds, and 3120.20 kg breeder seeds were produced. Besides, 189.50 kg F_1 hybrids, and 65707 kg seeds of vegetables, paddy, wheat, turmeric, lentil, arhar and mustard were also produced at Regional Research Station, Sargatia. Drying and storage was standardized for carrot and vegetable soybean. Studies on seed dormancy in bitter gourd and post-harvest ripening duration in ash gourd were undertaken.

Division of Vegetable Production

In technologies for protected vegetable production, among different training systems (drape, pinch, umbrella, 2-Stem, 4-Stem, 6-Stem, 3G, unpruned), umbrella system was found suitable for bitter gourd cv. Kashi Pratishtha under polyhouse conditions. In pheno-phase based nutrient scheduling, based on the tissue analyses, it was estimated that tomato removes 357.0 kg N/ha, 85.0 kg P/ha and 527.0 kg K/ha. Spray application of PGRs in combination of GA_3 @ 100 ppm, NAA @ 100 ppm, putrescine @ 0.1 M and melatonin @ 10 µM in muskmelon cv. Kashi Madhu resulted in parthenocarpic fruit development. Among the tested varieties, tomato hybrid VRNTH 19083 and bitter gourd hybrid Kashi Pratishtha were found promising for cultivation under naturally ventilated protected condition. Five doses i.e 75% of estimated dose of fertilizers (EDF), 100% EDF, 125% EDF, 150% EDF and 175% EDF of fertilizers were made based on plant nutrient uptake for evaluation in tomato. Out of five EDF doses, EDF @125% was found to be the best in terms of yield (11.06 kg/plant) and most of the yield associated traits such as number of clusters, fruit weight and size. In agronomic bio-fortification studies in vegetables, Micromix C recorded the highest pod yield (105.5 q/ha) followed by Micromix B (104.7 q/ha) in pea var. Kashi Nandini in rabi season.

Under organic production, the highest yield of 297.74 q/ha in cauliflower was recorded in the treatment having application of 200 kg N/ha through vermiconpost coupled with weed mat mulching. The yellow fleshed hybrid cherry tomato-1 produced significantly higher yield (176 q/ha) than red fleshed hybrid Cherry tomato-2 under organic farming. In summer season, sponge gourd and pumpkin, whereas in kharif season bottle gourd, okra, sponge gourd and cowpea were found promising crop for organic farming. The quality in terms of ascorbic acid, lycopene and antioxidant of cherry tomato was improved under organic farming as compared to inorganic treatment. Drip irrigation scheduling and mulching studies were undertaken in tomato and okra. In tomato, black-silver much was found most effective with maximum fruit yields (3.44 kg/plant and 544.97 q/ha) and WUE (26.55 q/ha/cm). In okra, maximum fruit yield of 466.2 g/plant and 121.96 q/ha was reported in 50% ET with black silver mulch.

In enhancing productivity, quality and tolerance to biotic and abiotic stresses in vegetables by grafting technology six rootstocks of brinjal e.g., IC 111056, IC-354557, Surya, *Solanum laciniatum, S. gilo* and *S. torvum* were evaluated for brinjal hybrid-Kashi Sandesh. The maximum number of fruits (43.6) and fruit yield (8.71 kg/plant) with low collar rot infestation (2.5%) were observed on Surya rootstock. In cucumber, Kashi Nutan produced the maximum number of fruits (15.1/plant), fruit yield (2.835 kg/plant and 168.78 q/ha) when cucumber was grafted over Summerfit (hybrid of acid melon x snap melon) rootstock. Evaluation of cucurbitaceous vegetables for salinity stress tolerance (3 and 6 dS m^{-1} of irrigation water) revealed that ash gourd and pumpkin have ability to tolerate salt stress condition better than the other cucurbit species tested. Similarly, in tomato, graft combination IVBR-17 brinjal root stock with Kashi Chayan was identified as the best combination with least yield reduction (25.39%) under high salinity stress (8 dS m^{-1}) followed by Kashi Adarsh grafted on IVBR-17 and Kashi Chayan grafted on IC-111056.

In bioregulator induced drought stress tolerance in okra, 24 genotypes of okra were screened for moisture stress tolerance at germination stage where 18% polyethylene glycol (PEG 6000) was used for induction of moistute stress. It was revealed that VRO110, VRO106 and Pusa Makhmali genotypes have better seedling vigour index and germination percentage under moisture stress condition. Furthermore, the same 24 okra genotypes were also evaluated for their moisture stress tolerance capacity under field condition, where moisture stress was induced by withholding of irrigation at 55 days of sowing for 20 days. Based on the physiological (relative water content, membrane stability index, total chlorophyll content) and yield attributes, study it was revealed that VRO128 and VRO160 have better moisture stress tolerance ability.

In influence of polyamines on postharvest senescence and quality of high value vegetables, spermine (1.5 mM) followed by bilayer chitosan (1%) and carboxy methyl cellulose (0.5%) coating showed lowest weight loss (47.6%) and preserved overall fruit quality during storage. Shelf life extension of capsicum and cherry tomato with the combinatorial treatment showed shelf life extension up to 60 and 40 days, respectively under cold storage conditions (10ºC). Sensory evaluation of carrot genotypes indicated correlation in VRCAR-206 (red) was most distant in comparison to VRCAR-127 (yellow) and VRCAR-165 (white) coloured carrots. It was observed that the peel of bottle gourd cv. "Kashi Ganga" was a rich source of bio-active compounds and antioxidant activity over fruit pulp.

Kitchen garden modules for 100 m^2 and 150 m^2 were standardized from which 312 g and 301 g vegetables per person per day, respectively can be harvested throughout the year for a family of 5 to 8 members. These modules were popularized among 398 farm families. A total of 15 training programmes for entrepreneurship development were conducted ranging from 3 to 15 days for 466 beneficiaries. Economic impact assessment of tomato cv. Kashi Aman was carried out using 'Economic surplus model' and 'Partial budgeting technique'. Internal Rate of Return (IRR) was 85% and Benefit Cost Ratio (BCR) 62.91 in the present technology, and therefore it was found economical for farmers.

Three outreach programmes were carried out at institute. In TSP programme, 1512 tribal households were adopted. Under SCSP programme more than 2400 households were provided technological support. Under NEH programme, technology demonstrations were provided to more than ten thousand beneficiaries resulting 62% increase in yield and Rs. 20,000 to Rs. 25,000 savings per household.

Division of Vegetable Protection

In project bio-intensive management of major insect pests of vegetables in the current scenario of weather change, amongst the 3 tested modules, chemical pest management module *i.e.*, spraying of Imidacloprid 17.8 SL @ 0.35 ml/l at 30 DAT, Spiromesifen 22.9 SC @ 1.25 ml/l at 50 DAT and Indoxacarb 14.5 SC @ 1 ml/l at 70 DAT was found highly effective in managing major insec pests of tomato. In toxicological investigations on the novel and botanical insecticides against major insect pests of vegetables, Chlorantraniliprole 18.5 SC @ 60 g a.i./ha can be recommended as an environment friendly option to manage pod borer *Maruca vitrata* in cowpea. Botanicals like azadirachtin @ 2 ml/L and garlic oil @ 2 ml/L are recommended as alternative options to manage the insect pests of cabbage in an eco-friendly and cost-effective manner. In biological control of major vegetable insect pests, combination of neonicotinoids (Imidacloprid 17.8 SL, Thiamethoxam 25 WG and Acetamiprid 20 SP) and three entomopathogenic fungi (B*eauveria bassiana, Metarhizium anisopliae* and *Lecanicillium lecanii*) at half of their recommended doses could not only be a green eco-friendly option against the black bean aphid (*Aphis craccivora)* but also able to minimize the chemical insecticides load in the environment. Distribution and abundance of cucurbit fruit fly *Zeugodacus* (=*Bactrocera*) *cucurbitae* in relation to abiotic parameters was studied and observed that maximum and minimum tempretaures and

morning relative humidity governed prime role for their seasonal abundance. In development of effective integrated management package for important fungal diseases of vegetable crops, it is concluded that the seed treatment with *T. asperallum* @ 0.5%+ CRB7 @ 0.5% resulted 91.6% seedling stand of brinjal (cv. Kashi Uttam).

In bioprospecting of microorganisms associated with vegetables against plant pathogens, highest yield (167.78 q/ha) was also recorded in seedlings of cabbage treated with *Trichoderma asperellum*. In pea, minimum root rot/wilt incidence developed in talc based bioformulation of *Actinomyces* sp. strain N1.2. In management of important bacterial diseases of vegetables, incidence of bacterial soft rot was recorded minimum (1.6%) on summer squash line VRSS-65. Pure cultures of bacterial wilt (*R. Solanacearum*) and bacterial blight (*X. campestris*) were established. In-Planta technique for mass screening of resistant germplasm in solanaceous vegtable crops were standardized and chemical and biological module was found most effective in tomato (VRT-50) with highest yield (46.60 t/ha) and lowest early blight disease (33% PDI) incidence.

In characterization of viruses infecting vegetable crops and their management, out of 102 cucurbits, 16 were detected with crinivirus and 23 were infected by polerovirus. Further, mixed infection of polerovirus and crinivirus were also detected among bitter gourd, satputia, muskmelon and sponge gourd. Sequences analysis of cucurbit chlorotic yellows virus isolates (OQ285908-11) showed cucurbits infected Indian isolates shared 94-98% nucleotide homology among themselves. Phylogenetic analysis was performed using the Indian isolates and homologous sequences of corresponding genomic region available for CCYV, CYSDV, CABYV and LABYV. Characterization of virus associated with new necrosis disease in tomato confirmed the association of watermelon bud necrosis virus (WBNV). In management of plant parasitic nematodes infecting vegetable crops, pure culture of *Meloidogyne incognita* had been identified and maintained. *Trichoderma* isolates TTV1, TTV2 and Tasp were found most effective by causing highest juvenile mortality (100%) at 50% culture filtrate concentrations after 24 h of exposure. Duirng the survey of major insect pests of baby corn, the exotic pest fall army worm (*Spodoptera frugiperda*) was recorded with highest larval population (4.23/plant) during 40th SMW. However, no larval incidence was recorded from 1-8th, 20-30th and 47-52nd SMW.

In bio-management of postharvest diseases in major vegetable crops, potential biocontrol agents (*Bacillus* sp., *Stenotrophomonas* sp. *Paenibacillus* sp.) isolated from a soil samples were characterized for nutrient solubilization, IAA and siderophore, HCN and ammonia productions. Antifungal activity of Moringa leaf extracts against three major soil pathogens *viz*., *Sclerotium rolfsii, Fusarium* sp. and *Rhizoctonia solani* was studied. The moringa leaf extract (1000 mg/L of water) showed a negative effect on the growth of *Fusarium* sp. Gas chromatographic method for estimation of Chlorantraniliprole residue in cowpea and its safety evaluation in cowpea pod and leaf was standardized.

कार्यकारी सारांश

भा.कृ.अनु.प.–भारतीय सब्जी अनुसंधान संस्थान, वाराणसी द्वारा वर्ष 2022 की शोध एवं प्रसार गतिविधियों द्वारा सब्जियों की नई किस्में, उत्पादन एवं फसल सुरक्षा की नई प्रौद्योगिकी विकसित करने से उत्पादकता एवं गुणवत्ता में वृद्धि हुई है साथ–साथ किसानों के प्रक्षेत्र पर प्रौद्योगिकी हस्तांतरण का कार्य सफलतापूर्वक किया गया।

फसल उन्नयन सम्भाग: मटेरियल ट्रांसफर एग्रीमेन्ट के तहत वर्ष 2022 में कुल 14 सब्जियों के 1183 परिग्रहणों एवं एक जीवाणु संवर्ध की 35 संगठनों को आपूर्ति की गयी। संस्थान के वैज्ञानिकों ने भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवांशिक संसाधन ब्यूरो के साथ मिलकर देश के विभिन्न भागों से नये जननद्रव्यों का अन्वेशण कर जननद्रव्य की संख्या में वृद्धि किया।

इस वर्ष सब्जियों की 2 किस्में एवं 1 संकर किस्म को विकसित किया गया जिसे अखिल भारतीय सब्जी अनुसंधान परियोजना (सब्जी फसल) द्वारा देश के विभिन्न जोनों के लिए चिन्हित किया गया जैसे–सेम की वी.आर.वी. सेम–207, भिण्डी की वी. आर.ओ.–119 एवं बैंगन की संकर लम्बा–आइ.वी.बी.एच.एल.–22। संस्थान द्वारा विकसित 8 किस्मों जैसे–बैंगन की काशी ब्रिंजल ग्रीन राउण्ड, फ्राशबीन की काशी अग्रिम, गाजर की काशी अरूण, सेम की काशी बौनी सेम–3, काशी बौनी सेम–9, नेनुआ की काशी कल्याणी, कुम्हड़ा की काशी वसंत एवं लोबिया की काशी विषान तथा बैगन का एक संकर काशी मनोहर भारत सरकार द्वारा गजट में अधिसूचित किया गया जिसका नोटीफिकेशन सं. 3254 (ई) दिनांक 20.07.2022 है। इसके अतिरिक्त 15 किस्में एवं 4 संकरों को उ.प्र. राज्य किस्म विमोचन समिति द्वारा अधिसूचना के लिए संस्तुत किया गया।

एकीकृत जीन प्रबंधन के लिए वृहद कार्यक्रम के अन्तर्गत टमाटर वर्गीय फसलों में टमाटर की 57 विदेशी लाइनें संसाधन के लिये आयात की गयी। संकर जैसे–वी.आर.एन.टी.एच.–20131, वी.आर.एन.टी.एच.–20122, वी.आर.एन.टी.एच.–20149, वी.आर.एन.टी.एच.–20133 एवं वी. आर.एन.टी.एच.–20141 गर्मी के मौसम में उगाने के लिए उत्कृष्ट पाये गये एवं जिनकी उपज 43.5–57.5 टन प्रति हेक्टेयर पायी गयी। जननद्रव्य एच 88–78–1 (आइ.एन.जी.आर.–22049) को रूट नॉट निमेटोड, कालर रॉट, टी.ओ.एल.सी.वी. तथा उच्च तापमान हेतु पंजीकृत किया गया। टी.वाई.–2, टी.वाई.–5 एवं टी.वाई.–6 जीन की एम.ए. एस.–लेड पिरामीडिंग काशी अमन किस्म में की गयी। इस कार्यक्रम में विभिन्न उद्देश्यों की पूर्ति के लिये संकर विक. सित किये गये जैसे– सी.आर.पी.वी.आर.टी.एच.–20–10 पूरे वर्ष खेती के लिए उपयुक्त, वी.आर.टी.एच.–22–24 प्रसंकरण के लिए (ब्रिक्स 5.08) एवं वी.आर.टी.–67 (ब्रिक्स 5.36) एवं वी.आर.टी.–59 (जोड़ रहित) चेरी टमाटर (वी.आर.सी.वाइ.टी.–3), बीटा कैरोटिन रिच (वी.आर.के.वी.–17)। पन्द्रह प्रभेदों को आइ सी नम्बर प्राप्त हुआ।

बैंगन में कुल 114 जनन द्रव्य जिसमें 23 परिग्रहण जो 8 जंगली प्रजातियों से सम्बन्धित थे का अनुरक्षण एवं मूल्यांकन किया गया। संकरों के मूल्यांकन में आइ.वी.बी. आर.–18–1 (36.8 टन/हे.) (गोल) एवं आइ.वी.बी.एच.एल.–25 (45 टन/हे.) (लम्बा) अच्छे पाये गये। प्रभेद/संकरों आइ.वी.बी.एच.एल.–22 (31.8 टन/हे.) एवं आइ.वी.बी.एच.एल.–24 (31.6 टन/हे.) ने उच्च तापमान (35–40^{0}से.) पर अच्छा उत्पादन दिया। मिर्च में 410 परिग्रहण एवं 223 उन्नत प्रभेदों का रख रखाव किया गया। 11 नये परिग्रहण एवं 28 नये संकरों का मूल्यांकन किया गया। प्रभेद काशी अनमोल x आइ.आइ.वी.आर.सी.–452 पी.टी.–1; पूसा ज्वाला x ईसी 519636–पी.टी. 2–1–4; पूसा ज्वाला x एन.जी.–3–पी. टी.–1–3–1 उपज एवं पर्ण कुंचन प्रतिरोध के लिए अच्छे पाये गये।

सब्जी मटर में एफिला मटर प्रभेद अगेती समूह (वी.आर.पी.ई–921 एवं 933) सहित कुल 289 जननद्रव्यों का अनुरक्षण किया गया। 102 प्रभेदों का मूल्यांकन किया गया एवं बहुत अगेती (फूलने मे औसतन 32 दिन) (आइ.एन.जी.

आर.–22087) तथा 7 प्रभेदों को आइ.सी. नम्बर प्राप्त हुआ। लोबिया में 9 एफ–1 क्रास युग्म बनाये गये एवं 268 प्रभेदों का अनुरक्षण किया गया। दो अभिजात प्रभेद (वी.आर.सी. पी.–65–8 एवं वी.आर.सी.पी.–167–3) को अखिल भारतीय सब्जी अनुसंधान परियोजना (सब्जी फसल) के ए.वी.टी.–2 परीक्षण में है। सेम में 136 प्रभेदों का अनुरक्षण किया गया। बुश टाइप के 140 प्रभेदों से उपज, मोजैक वायरस प्रतिरोधीता एवं उच्च तापमान सहनशीलता के आधार पर 76 प्रभेदों का चयन किया गया। फ्राशबीन में 37 (बुश टाइप) एवं 30 (पोल टाइप) प्रभेदों का अनुरक्षण किया गया एवं 30 प्रभेदों को उन्नत करके अगली पीढ़ी में रखा गया।

करेले में 156 प्रभेदों का अनुरक्षण किया गया तथा 12 उन्नत प्रभेदों का मूल्यांकन किया गया। उपज के आधार पर उच्चकोटि के संकर वी.आर.बी.टी.जी.एच–10 (3.65 किग्रा./पौधा) एवं वी.आर.बी.टी.जी.एच–22 (3.51 किग्रा./पौधा) विकसित किये गये एवं गाइनोसियस संकर वी.आर. बी.टी.जी.वाइ.एच–6 (3.81 किग्रा./पौधा) विकसित किया गया। 148 जननद्रव्यों का चूर्णिल आसिता बीमारी के लिए अध्ययन किया गया तथा छः लाइनों में आंशिक प्रतिरोधिता पायी गयी। लौकी में 94 प्रभेदों का मूल्यांकन किया गया तथा उन्नत प्रभेद वी.आर. वी.जी.–7 एवं संकर वी.आर.वी. जी.एच.–15 एवं वी.आर.वी. जी.एच.–11 उपज के आधार पर चयनित किये गये। पेठा में 61 प्रभेदों का अनुरक्षण किया गया एवं 20 उन्नत प्रभेदों का मूल्यांकन किया गया। चिकनी तोरी में उत्कृष्ट प्रभेद वी.आर.एस.जी.–7–17 (1.47 किग्रा./पौधा) एवं संकर (वी.आर.एस.जी.–17–3 x वी.आर. एस.जी.–2–21) (1.58 किग्रा/पौधा) चिन्हित किये गये। जनन द्रव्य वीआरएसजी 17–10 (1.57 किग्रा/पौधा) एवं काशी रक्षिता (1.57 किग्रा/पौधा) खेत स्तर पर मृदुरोमिल आसिता के प्रति मध्यम सहनशील पायी गयी। नसदार तोरी में 11 जननद्रव्य एवं 5 संकर औधानिक गुणों के आधार पर अच्छे पाये गये। सतपुतिया में 6 प्रभेद उत्कृष्ट पाये गये एवं 15 प्रभेदों को उन्नत किया गया।

खीरा में 62 जनन द्रव्यों (पार्थेनोकार्पी प्रभेद वी.आर.सी. यू.पी.–20–2 सहित) का औधानिक गुणों के आधार पर मूल्यांकन किया गया एवं दो अच्छे प्रभेद वी.आर.सी. यू.–19–9 एवं वी.आर.सी. यू.–2240 को चिन्हित किया गया। 58 प्रभेदों को उन्नत किया गया एवं 60 प्रभेदों की छंटनी विषाणु टी.ओ.एल.सी.एन.डी.वी. के लिए किया गया एवं वी.आर.सी.यू.–सी.सी.–7 प्रतिरोधी पाया गया। कुम्हड़ा में 50 जननद्रव्य एवं 11 उन्नत प्रभेदों का मूल्यांकन किया गया एवं प्रभेद वी.आर.पी.के.–05 उत्कृष्ट पाया गया। छप्पन कद्दू में 65 जननद्रव्यों एवं 25 उन्नत प्रभेदों का मूल्यांकन किया गया। तरबूज में 76 जननद्रव्य एवं 17 उन्नत प्रभेदों का मूल्यांकन किया गया एवं वी.आर.डब्ल्यू.–10, वी.आर.डब्ल्यू.–514 एवं वी.आर.डब्ल्यू.–54–2 उत्कृष्ट पाये गये। खरबूजा में 195 प्रभेदों का अनुरक्षण किया गया एवं एकलिंगी इनब्रेड वी.आर.एम.एम.–140 में एक लिंगी सेक्स एक्सप्रेशन स्थिर पाया गया। 85 प्रभेदों का मूल्यांकन विषाणु प्रतिरोद्यिता के लिए किया गया जिसमें वी.आर.एम. एम.–160, 161 एवं 171 प्रतिरोधी पाये गये।

भिण्डी में 780 परिग्रहणों का अनुरक्षण किया गया एवं 115 संकरों (हरे फल) में वी.आर.ओ.–236 x वी.आर.ओ.–219 को बढ़िया संकर (उपज 595 ग्राम/पौधा) पाया गया। चार लाल फली वाले संकर पीतशिरा मोजैक एवं ई.एल.सी.वी. के प्रति सहनशील पाये गये। लाइनें वी.आर. ओ.–219, वी. आर.ओ.–236, वी.आर.डब्ल्यू..–220, वी.आर. डब्ल्यू..–235, वी.आर.ओ.आर.–160, वी.आर.ओ.आर.–165 एवं वी.आर.ओ. आर.–167 उत्कृष्ट संयोजक पाई गयी। बौने जननद्रव्य के रूप में वी.आर.ओ.–416–10–1 चिन्हित किया गया। भिण्डी की जंगली सम्बन्धी आर.सी.एम./ पी.के./63 का मूल्यांकन पीत शिरा मोजैक एवं ई.एल.सी. वी. के प्रति प्रतिरोद्यिता एवं विकसित किस्मों से संयोजन के लिये किया गया।

फूलगोभी में 23 प्रतीप संकरण से कोशिका द्रव्यी नरबंध्यता वाले प्रभेदों का उन्नतिकरण किया गया एवं 5 प्रभेद जैसे–वी.आर.सी.एफ.–41 (28–30 डिग्री सेल्सियस) वी. आर.सी.एफ.–131 एवं वी.आर.सी.एफ.–132 (24–28 डिग्री सेल्सियस) वी.आर.सी.एफ.–110 (22–25 डिग्री सेल्सियस) एवं वी.आर.सी.एफ.–212 (20–23 डिग्री सेल्सियस) स्थायी पाये गये। अगेती एवं मध्यम परिपक्वता वाले संकर (वी. आर.सी.एफ.–131 x वी.आर.सी.एफ.–75–1, वी.आर.सी. एफ.–131 x वी.आर.सी.एफ.–86 एवं वी.आर.सी.एफ.–222 x वी.आर.सी.एफ.–77) (225–275 कु./हे.) को बहुस्थलीय परीक्षण के लिए पेश किया गया। फूलगोभी प्रभेद (वी.आर. सी.एफ.–75–1) में उच्च ताप सहनशीलता के लिए सूक्ष्म प्रवर्धन की शुरूआत की गयी। गाजर में कोशिका द्रव्यी नर बन्ध्यता आधारित संकरों (वी.आर.सी.ए.आर.–211 x वी.आर.सी.ए.आर.–86 एवं वी.आर.सी.ए.आर–211 x काशी

अरूण) तथा 1 मुक्त परागित जनन द्रव्य वी.आर.सी.ए. आर.–85 का बहुस्थलीय परीक्षण किया गया। गाजर के कुल 84 प्रभेदों (49 मुक्त परागित एवं 35 संकर) का अनुरक्षण किया गया। काले एंव लाल नर बन्ध्य गाजर (वी.आर.सी.ए.आर.–214 एवं वी.आर.सी.ए.आर.–252) का पंजीकरण अद्वितीय जनन द्रव्य के रूप में किया गया।

जैव प्रौद्योगिकी परियोजना के अन्तर्गत बैंगन की ट्रांसजेनिक लाइन (जीन क्राई1 एए3 एवं क्राई 1एसी), टमाटर (क्राई1एसी) एवं बहुसहनशील (सूखा, साल्ट एवं ठण्डी) ट्रांसजेनिक लाइन (ए.टी.डी.आर.बी. 1 ए एवं बी.सी. जेड ए. टी. 12) का अनुरक्षण किया गया। टमाटर में नर बन्ध्यता रूपांतरण क्षमता बढ़ाने के लिए क्रिस्पर/कैस 9 जीनोम एडिटिंग प्रौद्योगिकी का प्रयोग किया गया। टमाटर में बहुरोग प्रति. रोधिता जीन (एस.आइ.डी.एम.आर.–6 एवं एस.आइ.पी.एल.), उच्च टी.एस.एस. (एस.आइ.आई.एन.वी.आइ.एन.एच.आई.) एवं (एस.आइ.वी.पी.इ.एस.) का प्रयोग किया गया।

अल्पदोहित सब्जियों में पंखिया सेम की 266 लाइनों को मूल्यांकन किया गया। 79 लाइनों का उन्नतिकरण किया गया एवं फली उपज के आधार पर उत्कृष्ट लाइनों जैसे–वी. आर.डब्लू.बी.एच.–3–17, वी.आर.डब्लू.बी.एच.–12–18, वी. आर.डब्लू.बी.एच.–29–18 का चिन्हीकरण किया गया। सब्जी सोयाबीन की 45, सिंघाड़ा 36 एवं कमल की 6 लाइनों का अनुरक्षण किया गया। कलमी साग की 20 लाइनों का मूल्यांकन किया गया जिसमें वी.आर.डब्लू. एस.–1, वी.आर.डब्लू.एस.–28, वी.आर.डब्लू.एस.–31 एवं वी.आर.डब्लू.एस.–32 उत्कृष्ट पाये गये। पालक की 16 लाइनों का मूल्यांकन किया गया जिसमें से वी.आरपी.एल. के.–2 का पंजीकरण यूनिक जनन द्रव्य के रूप में किया गया। इसके साथ–साथ वलवेटबीन, बेबीकार्न, लाइपत्ता एवं चौलाई पर कार्य किया गया।

वनस्पतिक प्रवर्धित एवं बहुवर्षी सब्जी फसलों के अन्तर्गत परवल की 82 मादा लाइनों का मूल्यांकन किया गया जिसमें वी.आर.पी.जी.–217, वी. आर.पी.जी.–219 एवं वी. आर.पी.जी.–188 मिठाई बनाने के लिए उपयुक्त पायी गयी। ककोड़ा की 59 लाइनों का अनुरक्षण किया गया। फल उपज के आधार पर वी.आर.एस. टी.जी.–22 (1.85 किग्रा.) सबसे अच्छी पायी गयी। स्पाइन गार्ड की 38 लाइनों का मूल्यांकन किया गया एवं वी.आर.एस.ई.जी.–20 एवं वी.आर.एस.ई. जी.–22 (2.04 किग्रा.) फल उत्पादन के आधार पर सबसे अच्छी पायी गयी। कुन्दरू की 28 लाइनों का मूल्यांकन किया गया एवं वी.आर.आई.जी.–17 (8.94 किग्रा.) उत्कृष्ट पाई गई। पोई की 39 लाइनों में वी.आर.बी.–48 उत्कृष्ट पाई गई जबकि सहजन की 22 लाइनों के मूल्यांकन में सबसे अधिक फलत (1290 फल) वी.आर.एन.ओ.–9 में पाए गए।

सब्जी बीज उन्नयन के वृहद कार्यक्रम के अन्तर्गत संस्थान की किस्मों का 20197 किग्रा. बीज पैदा किया गया। विभिन्न सब्जी फसलों जैसे–टमाटर, बैंगन, मिर्च, भिण डी, लोबिया, मटर, फ्राशबीन, सेम, लौकी, नेनुआ, करेला, कुम्हड़ा, खीरा, तोरी, सतपुतिया, पेठा, मूली, गाजर, फूलगोभी, पालक आदि की किस्मों का बीज उत्पादन किया गया। कुल उत्पादित बीज में 17041.20 किग्रा. सत्य प्रमाणित, 3120.2 किग्रा. जनक बीज एवं 35.5 किग्रा. संकर बीज उत्पादन किया गया। इसके अतिरिक्त संस्थान के क्षेत्रीय शोध केन्द्र, कुशीनगर में सब्जी, धान, गेहूँ, हल्दी, मसूर, अरहर एवं सरसों का कुल 65707 किग्रा. सत्यप्रमाणित बीज पैदा किया गया एवं 189.50 किग्रा. संकर बीज पैदा किया गया। गाजर एवं सब्जी सायोबीन बीज को सुखाने एवं भण्डारित करने का मानकीकरण किया गया एवं करेला में सुषुप्तावस्था एवं पेठा बीज में कटाई उपरान्त परिपक्वता पर शोध कार्य किया गया।

सब्जी उत्पादन सम्भागः संरक्षित दशा में सब्जी उत्पादन प्रौद्योगिकी के अन्तर्गत विभिन्न ट्रेनिंग सिस्टम (ड्रेप, पिन्च, अम्ब्रेला, 2 स्टेम, 4 स्टेम, 3 जी., अनप्रुन्ड) का परीक्षण किया गया। परीक्षण में अम्ब्रेला सिस्टम करेला (काशी प्रतिष्ठा) के लिए पाली हाउस में उपयुक्त पाया गया। टमाटर में वृद्धि अवस्था आधारित पोषक तत्व निर्धारण जो कि ऊतक विशलेषण पर आधारित थी, किया गया। परीक्षण में पाया गया कि टमाटर 357 किग्रा. नत्रजन, 85 किग्रा. फास्फोरस एवं 527 किग्रा. पोटैशियम प्रति हेक्टेयर मृदा से ग्रहण करता है। खबरूजा काशी मधु में पादप वृद्धि नियामक जी.ए.–3, पुट्रेसीन एवं मेलाटोनिन के संयोजन के छिड़काव से बीज रहित फलों का विकास हुआ। प्राकृतिक हवादार संरक्षित दशा में टमाटर संकर (वी.आर.एन.टी.एच.–19083) एवं करेला (काशी प्रतिष्ठा) खेती के लिए उपयुक्त पाये गये। टमाटर में उर्वरक की अनुमानित मात्राओं 75% ईडीएफ, 100% ईडीएफ, 125% ईडीएफ, 150% ईडीएफ एवं 175% ईडीएफ को ग्रहणशीलता के मूल्यांकन के लिए आधार

बनाया गया। उर्वरक की पाँच मात्राओं में ईडीएफ @ 125% सबसे अच्छा पाया गया एवं उपज (11.06 किग्रा./पौधा) पायी गयी तथा अधिकतर उपज सम्बन्धित गुण जैसे गुच्छे की संख्या, फल वजन एवं संख्या बेहतर पाये गये। सब्जियों में एग्रोनामिक बायो–फोर्टिफिकेशन अध्ययन में पाया गया कि रबी मौसम में सब्जी मटर (काशी नन्दिनी) में सबसे अधिक उपज (105.5 कुन्तल प्रति हेक्टेयर) माइक्रोमिक्स सी के छिड़काव से प्राप्त हुई उसके बाद (104.7 कुन्तल प्रति हेक्टेयर) माइक्रोमिक्स बी से प्राप्त हुई।

कार्बनिक उत्पादन के अन्तर्गत खरपतवार मैट के साथ पलवार एवं 200 किग्रा. नत्रजन के प्रयोग द्वारा फूलगोभी में सबसे अधिक उपज (297.74 कु./हे.) पायी गयी। कार्बनिक खेती में पीले गूदे वाली संकर चेरी टमाटर–1 की उपज (176 कु./हे.) चेरी टमाटर–2 लाल गूदे वाली संकर की अपेक्षा अधिक पायी गयी। जायद मौसम में नेनुआ तथा कुम्हड़ा एवं खरीफ मौसम में लौकी, भिण्डी, नेनुआ एवं बोड़ा कार्बनिक खेती में अच्छे पाए गए। चेरी टमाटर में एस्कार्बिक अम्ल, लाइकोपीन तथा एण्टीऑक्सीडेन्ट कार्बनिक खेती में अकार्बनिक की अपेक्षा बेहतर पाए गए। ड्रिप सिंचाई एवं पलवार का परीक्षण टमाटर एवं भिण्डी में किया गया। टमाटर में सबसे अधिक उपज (544.97 कु./हे.) एवं जल प्रयोग क्षमता (26.55 कु./हे./सेमी.) ब्लैक सिल्वर पालीथीन मल्च के प्रयोग द्वारा पायी गयी। भिण्डी में सबसे अधिक उपज 466. 2 ग्रा./पौध एवं 121.96 कु/हे. 50% ईटी के साथ ब्लैकसिल्वर मल्च के द्वारा पायी गयी।

बैंगन संकर काशी संदेश में उत्पादकता बढ़ाने एवं जैविक व अजैविक तनावों के प्रति सहनशीलता विकसित करने के लिए ग्राफ्टिंग प्रौद्योगिकी प्रयोग किया गया एवं इसके लिए 6 मूलवृंतो (आइसी 111056, 35455, सूर्या, सोलेनम लेसीनेटम, सोलेनम गिलो एवं सोलेनम टारवम) का परीक्षण किया गया। परीक्षण के परिणामों से ज्ञात हुआ की सबसे अधिक फल संख्या प्रति पौध (43.6) एवं फल उपज (8.17 किग्रा./ पौध) सबसे कम कालर राट संक्रमण (2.5 प्रतिशत) सूर्या मूलवृंत प्रयोग से पाया गया। खीरे काशी नूतन में अधिकतम फल (15.1/पौधा) फल उपज 2०835 किग्रा./ पौधा एवं 168.78 कु./हे. पाया गया जब अन्तर प्रजाति ग्राफ्टिंग में समरफिट (एसीड मेलन x स्नैप मेलन) मूल वृंत उपयोग किया गया। कद्दूवर्गीय सब्जियों में लवणता के प्रति सहनशीलता मूल्यांकन में कुम्हड़ा एवं पेठा अन्य कद्दूवर्गीय सब्जियों की तुलना में बेहतर पाए गए। इसी प्रकार टमाटर में ग्राफ्ट संयोजन बैंगन आई.वी.बी.आर.–17 मूलवृन्त पर टमाटर काशी चयन सबसे उपयुक्त पाया गया जिसमें न्यूनतम उपज घटाव (25.39%) अधिक लवणता तनाव (8 डीएसएम$^{-1}$) में देखा गया। इसके बाद आई.वी. बी.आर.–17 पर टमाटर काशी चयन एवं आई.सी.–111056 बैंगन मूलवृन्त पर टमाटर काशी चयन उपयुक्त पाए गए।

सूखा तनाव में भिण्डी वी.आर.ओ.–110, वी.आर.ओ.–106 एवं पूसा मखमली जनन द्रव्य सहनशील पाये गये जब भिण्डी में 24 जनन द्रव्यों का मूल्यांकन सूखा सहनशीलता के लिए किया गया। फसल बुआई के 55 दिन बाद सिंचाई रोक दी गयी एवं पाया गया कि वी.आर.ओ.–128 एवं वी. आर.ओ.–160 में सूखा सहनशीलता अच्छी पायी गयी।

उच्च मूल्य वाली सब्जियों की तुड़ाई उपरान्त जीर्णता एवं गुणवत्ता पर पालीएमीन के प्रभाव को ज्ञात करने के लिए स्परमाइन 1.5 मिली मोल, सिटोसन (1%) का लेपन एवं सी.एम.सी. (0.5%) लेपन से भार में सबसे कम कमी हुई एवं भण्डारण के दौरान गुणवत्ता बनी रही। शिमला मिर्च एवं चेरी टमाटर में स्वजीवन बढ़ाने के लिए शीत भण्डारण में क्रमशः 60 एवं 40 दिन रख सकते हैं। गाजर जनन द्रव्यों की ग्रहणशीलता लाल गाजर में सबसे अधिक दिन उसके बाद पीला गाजर एवं सबसे कम सफेद गाजर में पायी गयी। लौकी काशी गंगा का छिलका जैवसक्रिय तत्वों एवं प्रतिआक्सीकारक का अच्छा स्रोत है।

ग्रामीण परिवारों (5–8 सदस्य) के लिए पोषण वाटिका के विकास एवं उन्नति के मोड्यूल द्वारा ज्ञात हुआ कि 100–150 वर्गमीटर क्षेत्र से उपभोग के लिए हरी सब्जियाँ पर्याप्त मात्रा में मिल जाती है। किचेन गार्डेन का ये मोड्यूल 398 परिवारों में प्रचलित हुआ। पूरे वर्ष के दौरान 15 प्रशिक्षण कार्यक्रम उद्यमिता विकास हेतु किये गये जो 3–15 दिनों की अवधि के थे, जिसमें कुल 466 लोग लाभान्वित हुए। आर्थिक प्रभाव मूल्यांकन के लिए टमाटर की काशी अमन किस्म का चयन किया गया जिसका बीसी अनुपात 62.91 रहा। अतः किसान परिवारों के लिए उपयुक्त पाया गया।

संस्थान में तीन आउटरीच कार्यक्रम किए गए। टी.एस.पी. कार्यक्रम के अन्तर्गत 1512 जनजाति परिवारों को लिया गया। एस.सी.एस.पी. कार्यक्रम के अन्तर्गत 2400 से अधिक अनुसूचित जाति के परिवारों को प्रार्द्यागिकी सहायता दी गयी। एन.ई.एच. कार्यक्रम के अन्तर्गत प्राद्यौगिकी प्रदर्शन 10 हजार से अधिक लाभार्थियों के यहाँ किया गया जिसमें

उपज में 62% वृद्धि हुई एवं प्रत्येक परिवार को रूपये 20000 से 25000 तक बचत हुई।

सब्जी सुरक्षा सम्भागः सब्जियों के मुख्य नुकसानदायक कीटों का परिवर्तनशील जलवायु में जैव सघनता प्रबंधन परियोजना के अन्तर्गत टमाटर में रासायनिक कीट प्रबंधन माड्यूल (एम–2) जिसमें इमिडाक्लोप्रिड 17.8 एस.एल. @ 0.35 मिली./लीटर 30 दिन रोपण के बाद स्पायरोमेसीफन 22.9 एस.सी. @ 12.5 मिली./ली. रोपण कों 50 दिन लाए एवं इण्डोक्साकार्ब 14.5 एस.सी. @ 1 मिली./लीटर 70 दिन रोपण के बाद सबसे अधिक प्रभावी पाया गया। विषालुता के लिए अध्ययन में नये एवं वानस्पतिक कीटनाशकों के प्रयोग में लोबिया के पाड बोरर के लिए पाया गया कि क्लोरानट्रानिलीप्रोल 18.5 एससी/60 ग्राम स.त./हे. वातावरण मित्रवत है एवं सबसे अच्छा नियंत्रण करता है। पत्तागोभी में कीट नियंत्रण के लिए वानस्पतिक कीटनाशी एजादीरैक्टिन 2मिली/लीटर एवं लहसुन तेल 2मिली/लीटर वातावरण मित्रवत है एवं लागत भी कम आती है। मुख्य सब्जियों के जैविक कीट नियंत्रण के लिए नियोनिकोटिनाएड्स संयोजन (इमिडाक्लोप्रिड 17.8 एसएल थायोमेथाक्जाम 25 डब्ल्यू जी एवं एसीटामप्रिड 20 एसपी) एवं 3 इण्टेमोपैथोजेनिक फंजाई (बेवेरिया बैसियाना, मेटाराइजियम एनिसोप्ली तथा लिकैनीसिलियम लिकैनाई) के साथ कम घातक सांद्रता में ब्लैक बीन एफिड कीटों के नियंत्रण के लिए वातावरण मित्रवत है। कद्दूवर्गीय सब्जियों में फल मक्खी वितरण एवं संख्या का अध्ययन किया गया। सब्जियों में कवक से होने वाली बीमारियों का एकीकृत प्रबंधन पैकेज के अंतर्गत बैंगन में बीज उपचार टी. एस्परिलम 0.5% + सी.आर.बी.–7 0.5% से 91.6% पौध स्थापन मिला।

सब्जियों से सम्बन्धित सूक्ष्मजीवों के जैव पूर्वेक्षण में पाया गया कि पत्तागोभी के पौध का उपचार ट्राइकोडर्मा एस्परलम से करने पर सबसे अधिक उपज (167.78 कु./हे.) पायी गयी। मटर में जैविक फार्मुलेशन एक्टिनोमाइसेज प्रजाति स्ट्रेन एन 1–2 का प्रयोग करने पर सबसे कम विल्ट/रूट राट का संक्रमण होता है। सब्जियों में जीवाणु से होने वाली बीमारियों के प्रबंधन में पाया गया कि जीवाणु साफ्ट राट का सबसे कम संक्रमण छप्पन कद्दू की लाइन वी.आर.एस. एस.–65 में (1.6 प्रतिशत) पाया गया। जीवाणु गलन (आर. सोलेनेसेरम) एवं जीवाणु झुलसा (एक्स. काम्पेस्ट्रीज) के शुद्ध सम्वर्ध की स्थापना की गयी। सोलेनेसियस सब्जियों में प्रतिरोधी जनन द्रव्य की छटनी की प्लाण्टा तकनीकी का मानकीकरण किया गया एवं टमाटर में (वीआरटी–50) रसायनिक एवं जैविक मॉड्यूल सबसे अधिक प्रभावी पाया गया (उपज 46.6 टन/हे.) एवं सबसे कम अगेती झुलसा संक्रमण (33% पीडीआई)।

सब्जी फसलों में विषाणु संक्रमण का विशेशीकरण एवं प्रबंधन के अन्तर्गत 102 कद्दूवर्गीय सब्जियों के नमूनों में 16 में क्रीनी विषाणु एवं 23 में पोलेरो विषाणु पाया गया। करेला, सतपुतिया, खरबूजा एवं नेनुआ में दोनो विषाणुओं का मिश्रित संक्रमण पाया गया। कद्दूवर्गीय क्लोरिटिक येलो विषाणु आइसोलेट (ओ.क्यू.–285908–11) के सिक्वेंश विश्लेषण में पाया गया कि आइसोलेट में 94.48 प्रतिशत न्यूक्लियोटाइड आपस में एक समान थे। फिलोजेनेटिक विश्लेषण में भारतीय आइसोलेट एवं जीनोमिक क्षेत्र के उपलब्ध सी.सी.वाइ.वी., सी. वाइ.एस.डी.वी., सी.ए.बी.वाइ. वी. एवं एल.ए.बी.वाइ.बी. का उपयाग किया गया। टमाटर में नई निक्रोसिस बीमारी के विषाणु के गुण तरबूज के बड निक्रोसिस विषाणु के गुण से सम्बन्धित है। सब्जियों में पौध परजीवी, सूत्रकृमि संक्रमण के प्रबंधन के अन्तर्गत जड़ सूत्रकृमि (एम.इनकागनिटा) के शुद्ध सम्वर्ध की पहचान एवं अनुरक्षण किया गया। सबसे अधिक जुवेनाइल मोर्टेलिटी (100 प्रतिशत) ट्राइकोडर्मा आइसोलेट टी.टी.बी.–1, टी.टी. बी.–2 एवं टास्प का 50 प्रतिशत सम्वर्ध फिल्ट्रेट 24 घंटे एक्सपोजर के बाद प्रयोग करने से पायी गयी । बेबीकार्न में सबसे अधिक आर्मीवार्म सूण्डी/पौध की संख्या 40 वें एस.एम.डब्लू में (4.23 सूण्डी/पौध) अक्टूबर, 2022 के प्रथम सप्ताह में पायी गयी। 1 से 8 वें एस.एम.डब्लू., 20 वें से 30 वें एस.एम.डब्लू एवं 47 वें से 52 वें एस.एम.डब्लू. के अन्तर्गत सूण्डी नहीं पायी गयी।

सब्जियों में कटाई उपरानत रोग प्रबंधन में प्रभावी जैव नियंत्रक एजेन्ट (बैसिलस स्टेनोट्राफोमोनास प्रजाति पेनि. कवैसिलस) को मृदा सैम्पल से अलग किया गया एवं इसका चिन्हन तत्वों के घुलनशीलता इण्डोल एसीटिक एसीड एवं साइडरफोर, एच.सी.एन. तथा अमोनिया उत्पादन के लिए किया गया। सहजन की पत्तियों के सत् की प्रतिकवकीय सक्रियता का अध्ययन मृदा रोगजनक स्क्लेरोशियम रोल्फसी, फ्यूजेरियम प्रजाति एवं राइजोक्टोनिया सोलेनाई के लिए किया गया। सहजन की पत्ती सत् फ्यूजेरियम की वृद्धि पर ऋणात्मक प्रभाव डालता है। लोबिया की पत्ती एवं फली में क्लोरानट्रानीलीप्रोल अवशेष के आंकलन के लिए क्रोमेटोग्राफिक गैस विधि का मानकीकरण किया गया।

Abbreviations

a.i.	Active Ingredient
AICRP(VC)	All India Coordinated Research Project (Vegetable Crop)
AIR	All India Radio
ASCI	Agriculture Skill Council of India
ATIC	Agricultural Technology Information Centre
ATMA	Agricultural Technology Management Agency
AU	Astronomical Unit
BOLD	Barcode of Life Database
B-S PE	Black-Silver Polyethylene Mulch
CAPS	Cleaved Amplified Polymorphic Sequences
CD	Critical Difference
CDD	Conserved Domain Database
CMS	Cytoplasmic Male Sterile
CMS	Cytoplasmic Male Sterility
CT	Conservation Tillage
CTC	Co-toxicity Coefficient
CV	Coefficient of Variation
DAI	Days After Inoculation
DAS	Days After Sowing
DAT	Days After Transplanting
DDG	Deputy Director General
DFF	Days Required to First Flowering
DNA	Deoxyribonucleic Acid
DS	Drought Stress
DSI	Drought Sensitivity Index
DTPA	Diethylene Triamine Pentaacetic Acid
DW	Dry Weight
DWR	Directorate of Weed Research
EC	Emulsifiable Concentrate
EDTA	Ethylene Diamine Tetraacetic Acid
EPN	Entomopathogenic Nematodes
FD	Fruit Diameter
FL	Fruit Length
FLD	Front Line Demonstration
FSB	Fruit & Shoot Borer
FW	Fresh Weight
GDD	Growing Degree Days
GDP	Gross Domestic Product
GMS	Genetic Male Sterility
GMV	Golden Mosaic Virus
HAT	Hours After the Treatment
IAA	Indole Acetic Acid
IC Numbers	Indigenous Collection Numbers
ICAR	Indian Council of Agricultural Research
IIVR	Indian Institute of Vegetable Research
INLFH	Inter Node Length at First Harvest
IRM	Insecticide Resistance Management
KVK	Krishi Vigyan Kendra
LC_{50}	Lethal Concentration 50
MI	Mycelial Growth Inhibition
MTA	Material Transfer Agreement

MtCOI	Mitochondrial Cytochrome Oxidase I
NAIP	National Agricultural Innovation Project
NBAIR	National Bureau of Agricultural Insect Resources
NFP	Number of Fruits per Plant
NNFH	Number of Node at First Harvest
NPTC	Network Project on Transgenic CROP
NT	Not Tested
NUE	Nutrient Use Efficiency
OC	Organic Carbon
OD	Optical Density
OFT	On Farm Trials
PBNV	Peanut Bud Necrosis Virus
PCR	Polymerase Chain Reaction
PDI	Per cent Disease Index
PHI	Pre Harvest Interval
PLW	Physiological Loss in Weight
PPM	Parts Per Million
PPOC	Per cent Protection Over Control
PPP	Public Private Partenership
PR	Percent Reduction
PRP	Proline Rich Protein
PTC	Pre-Treatment Count
QTL	Quantitative Trait Loci
R&D	Research and Development
RAPD	Random Amplified Polymorphic DNA
RBD	Randomized Block Design
RH	Relative Humidity
RILs	Recombinant Inbred Lines
RNA	Ribonucleic Acid
RT	Reduced Tillage
Sc	Number of Sclerotia
SD	Standard Deviation
SDI	Sub-surface Drip Irrigation
SEM	Standard Error Mean
SNPs	Single Nucleotide Polymorphism
SPS	Single Plant Selection
SR	Survival Rate
SSDI	Sub Surface Drip Irrigation
SSR	Simple Sequence Repeat
TI	Tolerance Index
ToLCV	Tomato Leaf Curl Virus
TSS	Total Soluble Solids
WBNV	Watermelon Bud Necrosis Virus
WEY	Wheat Equivalent Yield
WFPP	Weight of Fruit Per Plant
WG	Water Dispersible Granules
WUE	Water Use Efficiency
YVMV	Yellow Vein Mosaic Virus
ZT	Zero Tillage


भा.कृ.अनु.प. - भारतीय सब्जी अनुसंधान संस्थान
ICAR-Indian Institute of Vegetable Research

DIVISION OF VEGETABLE IMPROVEMENT

MEGA PROGRAMME 1: INTEGRATED GENE MANAGEMENT

Project 1.1: Genetic improvement of tomato

Germplasm augmentation and maintenance: Imported nine tomato genotypes from World Vegetable Centre, Taiwan, eight tomato genotypes from World Vegetable Centre**,** Hyderabad office, India and forty tomato genotypes from Tomato Genetics Resource Centre (TGRC), University of California, Davis, USA. Maintained twelve tomato wild accessions and 344 cultivated tomato genotypes.

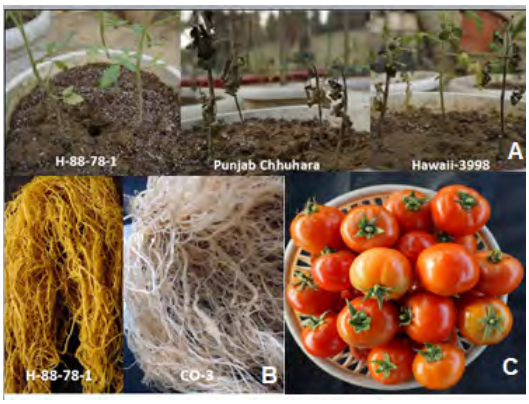


Fig. 1: H-88-78-1 (INGR 22049) A. Resistance to *Alternaria solani* in comparison to Punjab Chhuhara and Hawaii-3398 B. Resistance to root knot nematode in comparison to CO-3 C. Fruits of H-88-78-1

Germplasm registered at ICAR-NBPGR

H-88-78-1 (INGR 22049): The line has been found resistance to early blight (*Alternaria solani*), root knot nematode & ToLCV, and tolerance to high temperature up to day temperature of $38^0C \pm 2$. The line H-88-78-1 has slightly flattened shaped fruits, with an average fruit weight of 35-40g (Fig. 1).

Development and evaluation of hybrids: Total thirty nine hybrids carrying atleast *Ty*-2 or *Ty*-3 from any of the parents evaluated in main tomato growing seasons. Transplanting (September) alongwith five hybrids of commercial companies and Arka Rakshak of public sector hybrid as commercial checks. Yield wise test, hybrids VRTH810, VRTH1218, VRTH105, VRTH418, VRTH113, VRTH218, VRTH210, and VRTH518 were performed high yield. The hybrid VRTH1218 yielded highest (76 tonnes/ha) with good firmness, avg. per fruit weight of 80-85 g and free from ToLCV disease in the last two years trials. The hybrid Kashi ToLCV Hybrid-4 has been submitted for multi-location testing under AICRP-VC. In addition to the above hybrids, 14 tomato hybrids having ToLCV resistance genes (*Ty-2* or *Ty*-3) and late blight resistance genes (*Ph-2* or *Ph-3*) from any of the parents were evaluated. Yield wise test hybrids *viz.* VRTH515, VRTH1819, VRTH115, VRTH219, VRTH415, VRTH119, VRTH1119, VRTH1815 and VRTH419 performed well.

Pyramiding of genes for multiple disease (ToLCV and LB) resistance in tomato: Twenty advanced breeding with *Ty2*, *Ty3, Ph2* and *Ph3* in different combinations were evaluated for ToLCV resistance with the help of agro-inoculation using infectious clones of tomato leaf curl Palampur virus (ToLCPalV), a bipartite begomovirus along with parental lines, C-8-6-1 a *Ty-2* containing line and susceptible checks (Punjab Chhuhara and Money Maker). Lines namely *Ty3* VRT45-3, VRT45-4, VRT20-10, VRT20-13, VRT20-21, VRT20-22, VRT20-23, VRT20-24, VRT20-25, VRT20-26, VRT20-27 and VRT20-28 carrying only *Ty3* and *Ty3* in combination with *Ty2* lines are VRT20-4, VRT20-5, VRT20-9, VRT20-14 and VRT20-17 which recorded < 1 disease severity index (Fig. 2).

Fig. 2: Reaction of tomato genotypes with different combinations of *Ty2* and *Ty3* genes for agro inoculation with Palampur virus (ToLCPalV)

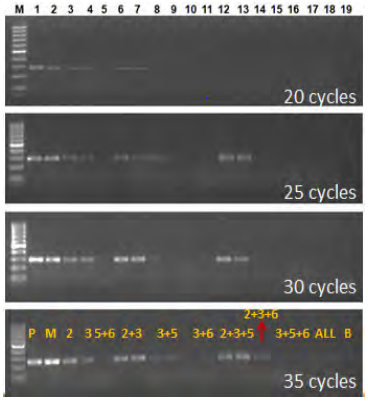


Fig. 3: Semi-quntitative estimation of viral cocentration in 40 dpi plants

Pyramiding of *Ty* genes in Kashi Aman background: In this, through repeated backcross breeding programme along with marker assisted foreground selection, *Ty-2*, *Ty-5* and *ty-6* genes were pyramided in Kashi Aman background which carries *Ty-3*. Phenotypic selection for horticultural characters of Kashi Aman was followed in every cycle of back crossing. In the

process we developed different genotypes with all combination of *Ty-2*, *Ty-5* and *Ty-6* with *Ty-3* in the background of Kashi Aman. In the present year, the response of these lines was assessed two times by agro-inoculation using infectious clones of tomato leaf curl Palampur virus (ToLCPalV), a bipartite begomovirus. In Kashi Aman disease severity index (DSI) was 0.78 and *Ty-2* donor parent produced DSI of 1.69. In all the lines with *Ty-3* in combination with other *Ty* genes, disease severity index (DSI) was <1. Further, virus concentration in inoculated plants was analysed with semi-quantitative PCR using the virus specific primers in tomato plants 40 days post inoculation (dpi) and the viral load was also compared (Fig. 3).

Development of inter-specific populations and phenotyping for biotic stresses (*Alternaria solani*): F_1, F_2 and reciprocal back cross populations of collar rot (caused by *A. solani*) susceptible Hawaii 3998 and collar rot resistant yellow fruited wild species (WIR-3928) were developed. These populations along with the parents were challenged with *A. solani* (ITCC-4632) and were scored for collar rot symptoms. QTL-Seq approach was used to identify the putative genomic regions using the sequencing data at ICAR-IASRI, New Delhi. The publicly available gold standard genome assembly of tomato genome version SL3.0 was used as reference. Following data processing and after developing resistant parent assembly, the reads from both resistant and susceptible bulks were aligned onto resistant parent reference assembly. The variants (SNP index) were then called for both the bulks. Only those SNP positions which passed the criteria of having ΔSNP index of -1 are considered as the putative causal SNPs. ΔSNP index of -1 indicate that the allele called in resistant bulk was same as that of resistant parent while alternate SNP base in susceptible bulk. The preliminary analysis performed showed the presence of genomic region on chromosome 09 defined based on confidence of interval under null hypothesis of no QTLs ($P < 0.05$).

Fig.4: Promising rainy season tomato hybrids

Tomato for rainy season (Tropical tomato): Total 58 hybrids, 53 open-pollinated lines and 3 private hybrids were evaluated in the rainy season (DoT: 03.08.2022). Among them, 25 hybrids produced > 50 t/ha yield. Promising hybrids were VRTH-

Table 1: Performance of improved lines of tomato for horticultural traits (Average of three years yield)

S.N.	Genotype	Avg. fruit wt.(g)	Fruit length (cm)	Fruit dia. (cm)	TSS (°Brix)	Yield/ plant (kg)	ToLCV (index)	Fruit shape	Other trait
1	VRT-01	86.00	5.27	4.94	3.79	1.41	1.50	Round	Elite line
2	VRT-02	18.43	3.17	2.80	4.89	1.77	1.03	Round	Dwarf, suitable for pot culture
3	VRT-06	127.26	6.18	5.93	4.47	1.69	0.10	Oval	Elite line
4	VRT-16-1	50.35	4.06	4.09	4.26	1.15	2.27	Round	Elite line
5	VRT-19	111.37	4.90	5.80	4.29	1.89	0	Flat-Round	Elite line
6	VRT-30	52.57	4.09	4.19	4.36	0.95	0.10	Round	Elite line
7	VRT-34	62.75	4.75	4.27	4.71	1.94	0.07	Oval	Elite line
8	VRT-50	84.84	4.81	5.29	4.50	1.94	0	Round	Elite line
9	VRT-51	105.51	5.14	5.41	4.11	1.78	0.10	Round	Elite line
10	VRT-67	29.95	3.57	3.42	5.36	1.53	0.07	Round	Elite line
11	VRT-69	79.57	4.97	4.42	4.52	2.50	1.17	Pear shape	Jointless
12	ToLCV-16	54.42	4.73	4.57	3.62	1.35	0.50	Round	Elite line
13	ToLCV-28	68.67	4.69	5.09	4.04	2.12	0.50	Flat	Elite line
14	ToLCV-32	75.82	5.75	4.66	4.22	1.96	0.0	Oval	Elite line
15	H-88-78-1	36.20	3.52	3.86	4.07	1.44	0	Round	Elite line
16	H-88-78-2	188.20	5.32	6.60	5.11	1.50	0	Flat- Round	Non-ripen fruit
C.D. (5%)		6.70	6.89	6.35	0.52	2.61	0.53		
C.V.		7.90	8.52	8.50	8.32	9.43	6.23		

D: Determinate; SD: Semi-Determinate

16-90 (94.99 t/ha), VRTH-22-12 (89.99 t/ha), VRTH-18-28 (88.88 t/ha) and VRTH-22-14 (83.33 t/ha). Based on the first fruit picking started in October, four were early hybrids *viz*., VRTH-16-4 (63.66 t/ha) followed by VRTH-22-22 (57.33 t/ha) and VRTH-19-18 (56.99 t/ha). Hybrids VRTH-22-06 and VRTH-22-14 had very tough fruit, whereas VRTH-20-29, VRTH-22-12, VRTH-22-19, VRTH-22-22, VRTH-22-24 and VRTH-22-26 had tough fruit firmness (Fig. 4).

Identification of processing tomato hybrids: Four hybrids had high TSS (> 4.5° Brix) *viz*., VRTH-22-24 (TSS 5.08° Brix, yield 67.99 t/ha, tough firmness, and medium maturity type), VRTH-16-75 (TSS 4.92° Brix, yield 42.66 t/ha, medium firmness and medium maturity type), VRTH-22-22 (TSS 4.92° Brix, yield 57.33 t/ha, tough firmness, and early to medium maturity type), and VRTH-22-19 (TSS 4.52° Brix, yield 65.66 t/ha, tough firmness, and medium maturity type) (Fig 5).

Fig. 5: Promising processing tomato hybrids

Development of improved tomato lines: Sixteen improved tomato lines were evaluated during three years 2020-23. Among which, VRT-02 is suitable for pot culture, VRT-67 had maximum TSS (5.36 °Brix), VRT-69 was jointless and H-88-78-2 had non-ripened fruit (yellow-green).

Cherry Tomato and beta carotene rich tomato lines: Thirty-three tomato advance lines comprising of different colors like red (21) and yellow (12) were evaluated. Under open field conditions, cherry tomato advance line VRCYT-3 produced highest yield (23.5t/ha) with TSS (8.1-8.4 °Brix) and average fruit weight 7-8 g, while another line VRVRT-14 produced 21.8 t/ha with TSS 7-7.5 °Brix and fruit weight 9-10g (Fig. 6-7). Further, 22 beta-carotene rich tomatoes were evaluated and the promising lines were, VRKB-17 (7.9 mg/100g) followed by VRTKB-14(6.75 mg/100g) and free from ToLCV. VRKB-17 carries *Ty3* gene and yielded 30.3 t/ha with average fruit weight of 72.82 g.

Jointless tomato lines: Ten Jointless genotypes were evaluated for agro–horticultural characters. EC-695037 recorded the highest yield 66.89 t/ha with average fruit weight of 88 g and 4.28 ^{0}Brix TSS followed by VRT-69 with 62.29 t/ha yield, average fruit weight of 82 g and TSS of 4.4 ^{0}Brix.

Fig. 6: Cherry tomato VRCYT-3

Fig. 7: Cherry tomato VRCRT-14

Generation Advancement: A total 193 SPS of different generations comprising of F_2 (17), F_3 (26), F_4 (35), F_5 (18) F_6 (25) and F_8 (17) were advanced. Also, 33 advance lines of cherry tomato of red (21) and yellow (12), and 22 beta carotene rich advance lines were advanced to next generation.

Seed Multiplication: The seeds of 16 varieties/lines namely Kashi Tamatar-8 (5 kg), VRToLCV-16 (300 g), VRT-19 (300 g),VRT-1 (200 g),VRT-ToLCV-32 (100 g), VRT-06 (200 g), VRT-13 (100 g), VRT-50 (300 g), VRT-51 (300 g), VRTToLCV-28 (500 g), VRT—30 (50 g), CRPVRTH-16-3 (60 g), CRPVRTH-16-70 (85 g), CRPVRTH-16-5 (40 g), CRPVRTH-16-4 (60 g) and CRPVRTH-16-8 (60 g) were produced.

IC No. Allotment: IC No. were allotted by ICAR-NBPGR, New Delhi for 15 tomato lines/hybrids *viz*., VRTH16-3 (IC-0647733), VRTH16-4 (IC-0647734), VRTH16-8 (IC-0647735), VRCY-3 (IC-0647736), VRCY-14 (IC-0647737), VRKB-1 (IC-0647738), VRKB-2 (IC-0647739), VRKB-3 (IC-0647740), VRKB-4 (IC-0647741), VRKB-11 (IC-0647742), VRKB-14 (IC-0647743), VRKB-17 (IC-0647744), VRNTH-19067 (IC-0647745), VRNTH-19083 (IC-0647746) and VRNTH-20122 (IC-0647747).

AICRP (VC) Trials: Three trials each of tomato hybrid determinate and tomato (ToLCV) hybrid determinate, two tomato varietal determinate trial, and one each of tomato (ToLCV) varietal, tomato varietal indeterminate and cherry tomato were conducted.

Project 1.2: Genetic Improvement of Brinjal

Germplasm exploration: A 10 days exploration trip during 11-20 October, 2022 was planned and undertaken in collaboration with ICAR-NBPGR, New Delhi for the collection of Wild relatives of *Momordica*, *Luffa*, *Trichosanthes*, *Corchorus*, *Sesamum*, *Solanum*, *Vigna* and *Cajanus* species and their cultivated forms from Banaskantha, Kutch and Patan districts of Gujarat. A total of 93 germplasm accessions covering 42 species of different crops including 30 species of

crop wild relatives and other economic species were collected and Herbarium specimen (20 Nos) also deposited in NHCP at ICAR-NBPGR, New Delhi (Fig. 8).

Fig. 8: Variability in fruit of *Solanum coagulans, S. incanum* & *S. virginianum* and their seeds

Maintainance and evaluation of germplasm: A total 114 germplasm including 23 accessions of 8 related (e.g. *Solanum torvum, S. sisymbriifolium, S. gilo, S. virum, S. incanum, S. trilobatum, S. virginianum* and *S. aethiopicum)* wild species of brinjal were maintained and evaluated for further use in crop improvement programme.

Evaluation of accessions for resistance to bacterial wilt: The bacterial wilt (*Ralstonia solanacearum*) incidence were recorded in brinjal (*Solanum melongena*) hybrid cv. Kashi Sandesh (100%) at Bangalipur (Varanasi). However, Kashi Sandesh, Kashi Taru, Kashi Himani, Kashi Manohar and Kashi Brinjal Green Round were found free from bacterial wilt under front line demonstration in farmer's fields at Kusi Dour location in Sonebhadra.

Screening of brinjal germplasm against Phomopsis blight/ fruit rot: One hundred and fifty accessions (germplasm/varieties/ hybrids) of brinjal were screened and scored against phomopsis fruit rot/blight. Among tested advance lines/hybrids of brinjal namely Ramnagar Giant, Kashi Uttam, IVBHL-23, PR-5, Kashi Sandesh, IVBL-23, IVBR-17, IVBR-18, IVBR-19, IVBR-20, IVBHR-19, IVBL-24, IVBL-25, IVBL-26, IVBL-28, IVBHL-20, IVBHL-21, IVBHL-22, IVBHR-16, IVBHR-17, IVBHR-18, IVBHR-19, Kashi Prakash, Kashi Taru, Kashi Komal, IVBL-28, IVBHL-20, IVBHL-21, IVBHL-22, IVBL-27 were found moderately resistant to *Phomopsis vexans* fruit blight. Pathogenicity test of isolates of *P. vexans* were performed under detached fruit method.

Screening of Brinjal Genotypes for resistance against Brinjal shoot and fruit borer (Leucinodes orbonalis): A field screening experiment is in progress to find the sources of resistance against BSFB, *Leucinodes orbonalis*, which could be used in the crop improvement programme. Screening of advance lines/ genotypes is done to identify the elite sources of resistance. Several plant attributes such as shoot and fruit infestation parameters are selected to screen the genotypes. Based on our earlier findings, Punjab Sadabahar and Pant Rituraj are used as susceptible checks whereas CHBR-2 and IVBL Selection 10 were used as resistant checks. Kashi Manohar, Kashi Modak and IVBHL-23 were found moderately resistant to BFSB. *In vitro* screening of the different genotypes under choice and no-choice tests are also in progress.

Development of new crosses and Evaluation of hybrids: Total 40 F_1 hybrids (17 round fruited and 23 long fruited types) developed in last season, targeting various market segments were evaluated for fruit quality and yield parameters along with standard checks. Based on the fruit colour, shape and yield, among round fruited types, IVBHR-23 and IVBHR-17-1 performed better over checks, while among long fruited types IVBHL-25 and IVBHL-21-1 performed better over other genotypes and checks and were selected for multi-location testing under AICRP (VC) trials.

IVBHL-21-1

IVBHL-25

IVBHR-17-1

IVBHR-23

Evaluation of advance lines and generation advancement: Among advance lines evaluated for fruit type, colour, shape and yield, BCB 3-1X PR-5 (IVBR-23) and Baramasi X PR-5 (IVBR-18) in round fruited type and SLW X Green Long (IVBL-31) & JB-7X UTTARA (IVBL-25) in long fruited type were evaluated from two years and identified as promising for multi-location testing through AICRP (VC) trials. Further, 506 segregating populations (40: F1 to F2; 56: F2 to F3; 58: F3 to F4; 52: F4 to F5; 69: F5 to F6; 111: F6 to F7; 51: F7 to F8; 33: F8 to F9; 36: F9 to F10) were advanced.

Evaluation of brinjal for performance in high temperature conditions: A total of 31 genotypes including 19 OP and 12 hybrids were evaluated for tolerance to high temperature during summer season in 2022. Of these, IVBHL-22, IVBHL-24, IVBHR-16, Kashi Sandesh, IVBR-20, IVBR-19, Kashi Vijay, Kashi Himani and IVBL-27 were found to have potential for flowering and fruiting at day temperature 42 $\pm$ 2^0C..

IVBHL-22

IVBHL-24

IVBHR-16

IVBR-20

Maintenance breeding: Seeds of Kashi Sandesh (600g), Kashi Taru (500g), Kashi Komal (400g), Kashi Prakash (300g), Kashi

Himani (800g), Kashi Vijay (250g), Kashi Manohar (500g), Kashi Brinjal Green Round (450g), Kashi Modak (250g) and Kashi Uttam (600g) being multiplied for distribution and multi-location demonstration. Seeds of the parental lines of the hybrids were also maintained.

Project 1.3: Genetic Improvement of Chilli

Germplasm Management: A total of 410 accessions of chillies were maintained during 2021-22. Besides, 223 stable advanced lines and three sets of RILs were also maintained. The germplasm pool included eight sets of CMS, one GMS, and 12 wild, indigenous and exotic collections. The nucleus seeds of IIVR developed varieties along with parental lines were also multiplied. The fruit length ranged from 9.78 cm (DC/SKT-03) to 2.42 cm (KP/DRB-21-60) while the fruit width was found maximum in KP/DRB -21-76 (2.12 cm) and minimum in DC/SKT-20 (0.7 cm). Two lines namely KP/DRB -21-76 and KP/DRB-21-60 were almost round type. The fresh fruit colour of the newly collected lines varied from light green to dark green and except DC/SKT-20, all the lines were pendant in fruiting behaviour.

Augmentation of Chilli germplasm: Eleven accessions of three wild species viz. Capsicum *chinense* (7; IIHR-4637, IIHR-4638, IIHR-4639, IIHR-B-HP143, IIHR-B-HP144, IIHR-B-HP145 and IIHR-B-HP119); *Capsicum baccatum* (2; IIHR-3240 and IIHR-4442) and *Capsicum frutescens* (2; IIHR-4640 and IIHR-4641) were obtained from ICAR-IIHR, Bengaluru for utilization in genetic improvement of chillies for different traits after seed multiplication. From SASRD, Nagaland 23 genotypes (NUKC-1 to NUKC-23) of Bhut Jolokia and other local collections were collected for further multiplication and characterization.

Documentation of Chilli germplasm: Thirty two advanced lines were submitted to ICAR-NBPGR for IC numbers which were obtained. These included genotypes derived from either resistant to chilli leaf curl virus and anthracnose or with good combiners (Fig. 9).

IIVRC-18223

IIVRC-19006

Fig. 9: Advanced lines of chilli registered with ICAR-NBPGR, New delhi

A1 x Kashi Abha

A3 x Kashi Abha

Fig. 10: Superior chilli hybrids for yield and disease resistance

Evaluation and development of F_1 hybrids in chilli: A total of 28 new F_1 hybrids were evaluated along with 13 released or commercial hybrids. The fruit length ranged from 2.42 – 10.10 cm while fruit width varied from 0.74-1.96 cm. Green fruit yield ranged from 11.70 – 250.0 q/ha (Fig 10).

Heterobeltiosis for green fruit yield ranged from -83 to 336.33 percent while standard heterosis over hybrid VNR-305 ranged from -87 to 156.76 percent; and over Indu ranged from -89 to 127.18 percent. During the year 2021-22, thirty-five new combinations were developed using CMS lines and other better combiners for evaluation and characterization of hybrids. These hybrids have been planted and the data observation is pursued.

Line Development: To develop inbred lines for use as parental combinations or for developing open pollinated varieties, various population were advanced to the subsequent generation during the reporting period. Twenty three selections were made from F_2 generation of various combinations and F_3 seeds harvested, similarly 19 families in F_4, 16 in F_5, five in F_7 and 10 selections in F_9 generation were made for generation advancements. Three RIL population for different traits were grown and multiplied for further characterization for various morphological, quality, yield and disease reactions. Advanced lines of F_9 generations were evaluated for different yield traits. The estimated green fruit yield ranged from 62.23 to 144.90q/ha. The fruit length and width ranged from 6.60 -9.84 cm and 1.18-2.32 cm, respectively. The lines Kashi Anmol X IIVRC-452 PT-1; Pusa Jwala X EC-519636-PT-2-1-4; Pusa Jwala X NG-3-PT-1-3-1; Pusa Jwala X NG-4-PT-1-2; Pusa Jwala X Kashi Gaurav; Kashi Sinduri X NG-4-PT-3; PBC-473 x Punjab Lal; Kashi Abha X Kashi Gaurav-Pt-3-2-1; Kashi Abha X IIVRC-452-Pt-23-2 were found better with respect to yield and resistance to leaf curling under field condition.

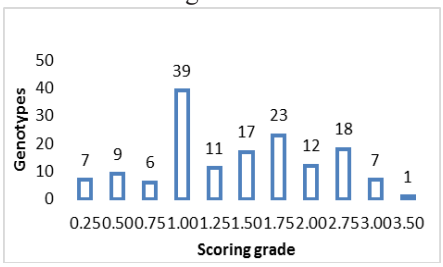


Fig. 11: Screening of chilli for thrips tolerance

Screening for thrips tolerance in chillies: A population of 150 genotypes of chillies were screened for thrips tolerance/resistance under field condition following the standard screening protocol based on symptoms appeared. The population was screened for the four times and during each screening 0-4 grade was given based on leaf curling symptoms in the lines. The average of all the score were calculated and it was found that 61 lines showed 25% or less infection (Fig 11).

New Entry for AICRP trial

IIVRC-19001 (IC No. 0642200): Plants are semi-upright, spreading with higher number of fruit, green foliage, medium sized, solitary bearing and drooping (first harvest approx. 60 days after transplanting), fruits highly pungent, long (8.1-9.2 cm), medium thick (0.9-1.1 cm), slightly curved, acute shaped at base end and fruit end.

AICRP (VC) trials: A total of eight trials of chilli/capsicum varieties and hybrids were allotted during 2021-22. All the trials were planted, however, the trial on Capsicum IET was not successful due to water logging at the early stage of the crop.

Apart from this, total five entries (one in IET, 3 in AVT-I and one in AVT-II) of chilli are at different stages of testing in trials of AICRP (VC).

Project 1.4: Genetic improvement of Pea

Hybridization for introgression of important genes: A total of 38 crosses (including selected backcrosses) were made during the year 2021-22 by targeting the trait of earliness, multi-flowering, edible podded and powdery mildew resistance.

Evaluation of promising early peas genotypes under varying sowing dates: Based upon the last year screening (2020-21), a set of 29 advance breeding lines belonging to early maturity group were grown for four consecutive date of sowing (28th Sept., 10th Oct., 2nd Nov., 2021 and 25th Jan., 2022) to evaluate these lines for various horticultural traits under open field conditions. The objectives of these trails were to evaluate yield potential and suitability of these genotypes for October and January sowing (slightly high temperature than the normal) compared to normal date of sowing (November). Poor seed germination was noted for October sown crop. Two genotypes 'VRPE-29' and 'VRPE-30' were found promising for October as well as for January sowing in which picking is ready in 50-55 days with uniform pods and seed filling, having on average 7.5-8.5 seeds/pod.

Breeding for edible podded peas: A total of nine cross combinations (bred for edible pods) viz., VRPD-2 × VRPD-3, VRPD-3× VRP-7, VRPD-3 ×AP-3, Sampoorna × VRPD-3, VRPD-2 × Mithi Phali, VRPD-2 ×VRP-6, VRPD-3 ×VRP-5, VRPD-3 × AP-3, Sampoorna × VRPD-2 were advanced to next higher generation through Single Plant Selection approach. The superior plants having longer, broader pods that were free from the parchment layers with higher number of pods/plant were selected. Rest cross materials (advance breeding lines) were rejected.

Development of *afila* pea genotypes in early group: In peas, *afila* (leafless) trait is characterized with many advantages viz., bush-type ten drilled architecture with low-leaf biomasses, self-stacking habit, reduced foliar disease pressure, high water use efficiency and drought and heat tolerance. The trait is found to be linked with late flowering habit. With the long-term objective of introgression of leafless or semi-leafless trait into early vegetable pea cultivars, crosses including the *afila* types with early vegetable pea cultivars were attempted long back. We selected two cross populations (VRPE-921 and VRPE-933) having segregation of plants for the *afila* type plants with early flowering habit. Both the lines took 35-38 for days to first flower; having plant height between 55-66 cm; 10 pod weight varying from 88-100 g; 8-10 pod/plant with average yield of 65-80 g/plant.

Fig. 12: A field view of newly developed *afila* pea genotypes VRPE-921 and VRPE-933 in early group

Characterization of pea germplasm lines: A total of 102 germplasm lines of peas were characterized for various horticultural traits. Pod length in these accessions vary from 3.7-10.7 cm; pod width 0.5-2.2 cm; seeds/pod 3.7-8.7; pods/plant 8-42; 10 pod weight 16-61; plant height 30-156 cm; pod yield 20-150 gm; seeds yield 8.3-17.5 g/plant. The disease data in these genotypes could not be recorded due to sharp rise in temperature during March month with limited time for diseases spread like rust and powdery mildew, which otherwise noticed in some of germplasm with minor inoculum.

Inheritance of powdery mildew resistance: Based upon our 2-3 years screening for powdery mildew, we have identified two resistant lines *viz*., BHU-57 (EC865975) and BHU-26 (EC865944). The inheritance of powdery mildew was worked out by utilizing the five cross combination *viz*., BHU-57×VRP-6; BHU -26 × (PC-531× VRP-270); Ageti × BHU 26; BHU 26 × Kashi Nandini and BHU-57× Kashi Shakti. All the parents, F_1s and their F_2s populations were grown in plastic protrays and 25 days old plants were then artificially screened for the disease reaction. The inoculum collected from the field was uniformly dusted for 2-3 days and disease score was recorded after one week when plants showed the disease symptoms. Each plant was scored on 0-9 scale. The data showed that inheritance of powdery mildew in these two accessions was governed by single recessive gene.

Inheritance of *Afila* Trait in the accessions*:* With the aim of introgression of leafless or semi-leafless trait from the genotypes EC865944 and HUPD-15, a total of 11 crosses were attempted by utilizing the high yielding genotypes of vegetable peas. Further, the inheritance of leaf types was studied in the F_2 generation. Chi-square test confirmed monohybrid model of inheritance 3:1.

Germplasm documentation and distribution: A total of 07 genotypes of peas were documented with NBPGR, New Delhi *viz*., VRPE-29 (IC0642307), VRPE-30 (IC0642308), VRPE-105 (IC0642309), VRPE-111 (IC0642310), VRPE-115 (IC0642311), VRPE-25-3 (IC0642312), and VRPE-29 (IC0642313). Further, a total of 101 genotypes of peas were distributed to various organization of the nation.

Maintenance of germplasm lines including released varieties: In addition to advanced breeding material, a total of 289 germplasm lines were grown and maintained during the cropping season. The pea varieties *viz*. Kashi Uday, Kashi Nandini, Kashi Ageti, Kashi Mukti, Kashi Samrath, Kashi Shakti, and Kashi Samridhi were also maintained.

Generation advancement of breeding material: Among total 360 (F_2 to F_7) advanced lines grown, 25 lines were advanced to F_2 population, 70 lines to F_3, 135 lines to F_4, 40 lines to F_5,

16 lines to $F_{6,}$ and 74 lines to F_7 so on with targeted traits of earliness, high yield, resistant to powdery mildew and rust.

AICRP and trials conducted: Total 06 AICRP (VC) trials were also carried out during the season as detailed viz., Early (IET-1)/2021; Mid (IET-1/2021); edible podded IET/2021; Early (AVT-II)/2019, Mid (AVT-II)/2019, Powdery Mildew, AVT-II/2019.

Advancement of the *RIL* population in Peas: Two RIL populations *viz*., VRP–386 ×VRP–500 (MF–01P) and VRPSel–17 ×VRPM–901–5 (MF–02W) that consists of 217 and 142 individuals, respectively. The genotypes viz., VRPSel–17, VRP–500, VRPM–901–5 are of white colour, while VRP–386 produces purple flowers. Both the RIL populations were developed using single seed descent to the F_6.

Registration of unique germplasm: The genotype 'VRPE-29' (INGR22087) has been registered as unique material with NBPGR New Delhi as an extra early accession of vegetable pea. VRPE-29 (IC0642307) is an extra early vegetable pea genotype (Days to flower ≤32 days) in which pods are ready for picking in 60-65 days with average pod yield of 70g/plant. The plants are determinate, with shorter internodal length; 1st flower appeared on 8th to 9th node onward. The pods are very attractive and slightly curved in shape (Fig.13a) having on average 8 seeds/pod. Plant bears 10-12 dark green pods of 8-8.5cm long, having pod width of 1.5cm, average pod weight of 8-9.5 g, 100-green seed weight of 54g, shelling percentage of 50% and pod yield potential of 90-100 q/ha. It has additional advantage of synchronous maturity (single picking) and can easily fit for multiple cropping and high intensity cropping systems. Additionally, it could be a potential parent for breeding early maturing cultivars in peas.

Fig. 13: (a) Pod bearing and (b) seed filling in VRPE-29 (IC0642307) under normal field

Project 1.5: Genetic improvement of Cowpea

Salient achievements: During the year 2021, a total of 8F2, 10F4, 5BC1F6, 2BC1F7, 14 F7, 8 F8, 15 F9 were advanced to next filial generation by single plant selection. Apart from this, stable advanced lines were maintained and characterized. During Kharif, 2021 a total of 9 F1 cross combinations were done based on yield, quality and resistance to cowpea golden mosaic disease resistance.

Maintenance breeding: Two hundred and sixty eight genotypes of cowpea were grown and maintained. IIVR released varieties Kashi Kanchan, Kashi Nidhi, Kashi Gauri, Kashi Unnati, Kashi Shyamal and Kashi Vishan were also maintained.

Entries in AICRP (VC) trials: Two elite lines of vegetable cowpea VRCP-65-8 and VRCP-167-3 were in AVT-II stage of AICRP (VC) trials.

Project 1.6: Genetic improvement of Indian bean and French bean

Indian Bean (Dolichos Bean)

Generation Advancement: A total 76 superior segregates of bush type were selected from 140 single plant selection (SPS) in different generations viz; F_{6-7}(20), F_{8-9}(23), F_{9-10}(16), and F_{10-11}(17). These segregates were categorized for high yield with DYMV tolerant & high temperature tolerant for vegetable purposes, use for pulse purposes, and cultivation for terrace farming (pot culture).

AICRP (VC) Trials: Conducted and submitted report of three trials IET, AVT-I, AVT-II on pole type.

Seed Multiplication: Ten entries were sown in the field for seed multiplication and produced seeds of respective entries *viz*. Kashi Bouni Sem-3 (19.50kg), Kashi Bouni Sem-9 (13.75kg), Kashi Bouni Sem-14 (8.20kg), Kashi Bouni Sem-18 (34.40kg), Kashi Bouni Sem-207 (28kg), Kashi Haritima (8.50kg), Kashi Khushaal (9.8kg) and Kashi Sheetal (22.90kg).

Entries under AICRP (VC): One entry VRPSEM-186 of pole type is under AICRP(VC) trials for multilocation testing.

French Bean

Germplasm management: Thirty seven bush type genotypes of French bean and 30 pole type genotypes of French bean were grown and maintained. Besides, of IIVR developed varieties Kashi Agrim, Kashi Baingani, Kashi Rajhans, Kashi Sampann were grown and also maintained.

Generation Advancement: During the year 2022, a total of 10 F1, 2F2, 5F3, 5F4, 5F6, 3F7 populations of bush type French bean were advanced to next filial generation by single plant selection, similarly in pole type 7 F6 combinations were advanced to next filial generation by single plant selection.

Project: 1.7: Genetic improvement of seed propagated gourds

Bitter Gourd

Germplasm maintenance and augmentation: A total of 156 accessions were characterized for different horticultural traits viz. fruit colour, fruit shape/size (small/medium/large), protubrenant /non-protuberent rind etc. and their seed multiplied. Eleven new bitter gourd accessions i.e. KP/DRB/21-60, KP/DRB/21-57, KP/DRB/21-32, KP/DRB/MB-25, KP/DRB/MISC-21-9, KP/DRB/21-85, KP/DRB/21-62, KP/DRB/MISC-21-19, KP/DRB/MISC-21-41, KP/DRB/MISC-21-34, KP/DRB/MISC-21-8 were received from ICAR-NBPGR, New Delhi but out of these only seven accessions germinated. New genetic stocks were grouped as medium long (KP/DRB/21-32, KP/DRB/MB-25, KP/DRB/MISC-21-9, KP/DRB/21-85, KP/DRB/21-62) and long (KP/DRB/MISC-21-19 & KP/DRB/MISC-21-34). Maximum yield per plant was found in KP/DRB/21-32 (2.52 kg/plant) followed by KP/DRB/MISC-21-9 (1.78 kg/plant) and KP/DRB/MISC-21-19 (1.45

kg/plant) respectively. All the germplasm were characterized, selfed and multiplied for seed enhancement.

Evaluation of advance lines: Twelve advanced lines were evaluated for yield and yield related traits during Summer and Kharif season, 2022. Maximum yield per plant was recorded in VRBTG-2-1 (2.74 kg) followed by VRBTG-71 (2.68 kg) and VRBTG-47 (2.61 kg). Maximum number of fruits observed in VRBTG-47 (36.33 fruits/plant) followed by DVBTG-3 (35.67 fruits /plant) and VRBTG-15 (31.33 fruits/plant). For individual fruit weight, the maximum value recorded in VRBTG-71 (106.00 g) followed by VRBTG-8 (98.33 g) and VRBTG-2-1 (90.00 g) at the edible stage. Some promising genotypes like VRBTG-71, VRBTG-23, VRBTG-20, VRBTG-47, DVBTG-3, VRBTG-15, VRBTG-29, VRBTG-2-1, VRBTG-8, VRBTG-70, DVBTG-4 and VRBTG-64 were observed for yield.

Development and Evaluation of Hybrids: In summer and rainy season of 2021, thirty two hybrids were developed and evaluated in 2022. Developed hybrids were long (15), medium (10) and small (7). The hybrid VRBTGH-10 gave highest yield (3.65 kg/ plant) followed by VRBTGH-22 (3.51 kg / plant) and VRBTGH-12 (3.44 kg / plant) (Fig.14).

Development and evaluation of gynoecious based hybrids: Eleven gynoecious base hybrids were developed by using one female parent (gynoecious) and eleven diverse male parents (monoecious) during Rainy Season, 2021. These hybrids were evaluated along with parents in summer and *kharif* season 2022. The hybrids VRBTGYH-6 gave highest yield (3.87 kg/ plant) followed by VRBTGYH-5 (3.45 kg / plant) and VRBTGYH-7 (3.21 kg / plant). Maximum number of fruits per plant was recorded in VRBTGYH-11(43.33) followed by VRBTGYH-6 (39.67) and VRBTGYH-5 (32.89). On the basis of overall performance VRBTGYH-2, VRBTGYH-3, VRBTGYH-4, VRBTGYH-7 in long, VRBTGYH-6, VRBTGYH-8, VRBTGYH-11, VRBTGYH-12, VRBTGYH-10 in medium and VRBTGYH-5, VRBTGYH-9 in small were selected.

VRBTGYH-7 VRBTGYH-11 VRBTGYH-6

Fig. 15: Promising gynoecious based hybrids

Field screening of bitter gourd against powdery mildew: A total of 148 germplasm were screened against powdery mildew in the open field condition. Six germplasm DVBTG-3, DVBTG-4, DVBTG-5, VRBTG-5-2, VRBTG-47 and VBT-3 expressed partial resistance (<20%).

Advancement of generation: Total 30 F_2, 16 F_3, 12 F_4 and 10 F_5 cross combinations were advanced to next generation.

Seed enhancement: Released varieties and promising lines of IIVR viz. Kashi Mayuri, Kashi Pratishtha, VRBTG-47 and VRBTG-2-1, DVBTG-3 and VRBTG-23 were maintained and multiplied for multi-location demonstration.

Entries in AICRP (VC) trial for multi-location testing: One F_1 hybrid VRBTGH-5 was included in IET of AICRP (VC) trial.

Bottle gourd

Germplasm maintenance and augmentation: Total 94 genotypes were evaluated for different horticultural traits and seed enhanced. Nine new bottle gourd germplasm (DC/SKT-77, DC/SKT-82, DC/SKT-35, KP/DRB/MUS-21-36, KP/DRB/MUS-21-37, KP/DRB/MUS-21-56, KP/DRB/MUS-21-88, KP/DRB/MUS-21-112, KP/DRB/MUS-21-54) were received from ICAR-NBPGR, New Delhi and their seeds are being multiplied. Newly augmented genetic stocks were grouped under long (DC/SKT-82, KP/DRB/MUS-21-56, KP/DRB/MUS-21-88,), round (KP/DRB/MUS-21-36, KP/DRB/MUS-21-54), oblong (DC/SKT-35, DC/SKT-77, KP/DRB/MUS-21-37, KP/DRB/MUS-21-112) category (Fig. 16).

VRBTGH-15 VRBTGH-16 VRBTGH-17 VRBTGH-19

VRBTGH-20 VRBTGH-23 VRBTGH-24 VRBTGH-25

Fig. 14: Promising Hybrids in bitter gourd


DC/SKT-35


KP/DRB/MUS-21-37

Fig. 16: New genetic stock of bottle gourd

Lines submitted to NBPGR: Fourteen advance lines of bottle gourd. i.e. IC0642347, IC0642348, IC0642349, IC0642350, IC0642351, IC0642352, IC0642353, IC0642354, IC0642355, IC0642356, IC0642357, IC0642358, IC0642359, IC0642360 (VRBG-3, VRBG-15-1, VRBG-59, VRBG-18, VRBG-61, VRBG-6, VRBG-67, VRBG-47-1, VRBG-14, VRBG-47-2, VRBG-2017, VRBG-71, VRBG-66 and VRBG-34) have been deposited to ICAR-NBPGR, New Delhi.

Evaluation of advanced lines: Twelve advanced lines were evaluated for different horticultural traits during summer and Kharif, 2022. Maximum yield per plant was recorded in VRBG-7 (9.42 kg) followed by VRBG-18 (8.98 kg) and VRBG-11 (8.54 kg). Maximum number of fruits observed in VRBG-18 (12.44 fruits/plant) followed by VRBG-17 (12.44 fruits /plant) and VRBG-7 (11.19 fruits/plant). For individual fruit weight, the maximum value recorded in VRBG-11 (958.33 g) followed by check variety of Sarita (932.33 g) and VRBG-7 (841.67 g) at the edible stage.

Development and evaluation of hybrids: A total of 27 F_1 hybrids in different segments (long=5, medium long=6, round=9 and oblong=7) were developed during the Summer and Rainy season of 2021. These hybrids were evaluated of 2022, for various horticultural traits. Maximum yield per plant was recorded VRBGH-15 (10.26 kg/plant) in oblong shape, followed by VRBGH-11 (9.87 kg/plant) round shape, VRBGH-5 (9.00 kg/plant) medium long, against the check variety Kashi Bahar (7.75 kg/plant) and NDBGH-4 (6.53 kg/plant). Maximum no. of fruits observed in VRBGH-24 (11.95) followed by VRBGH-19 (11.50) and VRBGH-5 (10.56). For individual fruit weight, maximum value was recorded in VRBGH-16 (1010.00 g) followed by VRBGH-11 (975.00 g) and VRBGH-6 (950.00 g) respectively (Fig. 17).


VRBGH-24 (Round)


VRBGH-11 (Round)


VRBGH-5 (Long)


VRBGH-16 (Pear shape)


VRBGH-18 (Round)


VRBGH-19 (Pear shape)

Fig. 17: Promising F_{1s} of bottle gourd

Field screening of bottle gourd against powdery mildew: Ninety Four genotypes were screened for powdery mildew under natural condition. Twelve i.e. VRBG-61, VRBG-47, VRBG-47-1, VRBG-47-3 VRBG- 9-1-1, VRBG-67, SBC/DRB-151, SBC/DRB-12, SBC/DRB-179, SBC/DRB-150, SBC/DRB-205 and SBC/DRB-125 were showed <20% incidence indicating partially resistant.

Advancement of generation: Total of 26 F_2, 13 F_3, 10 F_4 and 7 F_5 cross combinations were advanced.

Seed enhancement: Released varieties and promising lines of IIVR viz. Kashi Ganga, Kashi Kiran, Kashi Bahar (Hybrid), Kashi Shubhra, VRBG-67 and VRBG-7 were maintained and multiplied for multi-location demonstration.

Multiplication and maintenance of seeds of Kashi Kundal and Kashi Kirti: Three kg seeds of Kashi Kundal and 1.5 kg seeds of Kashi Kirti were produced. Single plant selection was performed for maintenance of both the variety. The 30 SPS in Kashi Kirti and 25 SPS in Kashi Kundal was done for further maintenance.

Ash Gourd

Maintenance of germplasm lines: A total of 61 lines including identified/released varieties from different universities and ICAR institute were maintained as active collections.

Evaluation of advance lines: Twenty advance breeding lines including waxy and non-waxy have been evaluated for important horticultural traits. Maximum number of fruits/plant was observed in VRAG- RIL 49 (4.5) followed by VRAG-RIL-51 (2.60) and VRAG-21-01 (2.40). On the basis of overall performance VRAG-RIL 49 was found promising.

Multiplication and maintenance of seeds of released varieties of ash gourd: One kg seeds of Kashi Dhawal, Kashi Ujwal and Kashi Surbhi were produced and SPS were selected for maintenance of the variety.

Project 1.8: Genetic Improvement of *Luffa*

Sponge Gourd

Germplasm maintenance: A total of 25 germplasm of sponge gourd were evaluated. Out of 25 germplasms of sponge gourd, VRSG-136, VRSG-9, VRSG-171, VRSG-1-21, VRSG-2-21 and VRSG-3-21 including one aromatic line i.e. VRSG-7-17 were found promising for horticultural traits. These lines showed tolerance against the sponge gourd mosaic disease under field conditions except VRSG-7-17.

Promising advance breeding lines: Among the 50 advanced breeding lines of sponge gourd VRSG-17-21, VRSG-19-5, VRSG-19-6, VRSG-21-8, VRSG-21-16, VRSG-17-5, VRSG-17-14, VRSG-17-16, VRSG-17-10, VRSG-17-31, VRSG-18-2, VRSG-18-10, VRSG-19-1, VRSG-19-3 and VRSG-19-24 were found promising for various horticultural traits. The five lines i.e. VRSG-17-21, VRSG-19-5, VRSG-19-6, VRSG-21-8 and VRSG-21-16 and were moderately resistant to ToLCNDV and rest lines were moderately susceptible to ToLCNDV under field conditions. The downy mildew disease severity was minimum (25%) in VRSG-17-10 and therefore categorized as moderately resistant under the field conditions.


VRSG-17-5


VRSG-17-10


VRSG-17-14


VRSG-17-16

Development and evaluation of F_1 genotypes: A total of 32 F_1 cross combinations were developed by using the 8 Lines × 4 Testers. Among the 32 F_1(s) of sponge gourd, VRSG-17-3 x VRSG-2-21, VRSG-17-11 x VRSG-1-21, Kashi Jyoti x VRSG-17-27, VRSG-171 × VRSG 1-21, Kashi Shreya × VRSG-1-21, VRSG-17-3 x VRSG-1-21, VRSG-17-3 x VRSG-3-21, VRSG-17-5 x VRSG-3-21 were found promising for various horticultural traits over the checks i.e. Kashi Rakshita, Garima (Nirmal Seeds), KSP-1125 (Kalash Seeds), Alok (VNR Seeds), Vinay (Indus Seeds) and Chikani F_1 (Semillas). The F_1(s) VRSG-17-3 x VRSG-2-21, VRSG-17-11 x VRSG-1-21, Kashi Jyoti x VRSG-17-27 were moderately resistant to ToLCNDV and rest F_1(s) were moderately susceptible to ToLCNDV under field conditions. The downy mildew disease severity was minimum (25%) in Kashi Rakshita and therefore categorized as moderately resistant under the field conditions.


VRSG-171 × VRSG-1-21


Kashi Shreya × VRSG-1-21


VRSG-17-5 × VRSG-3-21


VRSG-17-3 × VRSG-2-21

Generation advancement: Under the generation advancement program, 2 populations were advanced from F_2 to F_3. One RILs population of Kashi Shreya x VRSG-7-17 (Aromatic line) advanced from F_5 to F_6 (250 plants).

Promising genotypes/hybrids under multi-location testing of AICRP (VC): A total of 4 OP improved genotypes i.e. VRSG-19-3 in IET, VRSG-18-10 & VRSG-17-17 in AVT-I and VRSG-17-5 in AVT-II, and 3 F_1 hybrids namely, VRSGH-8 & VRSGH-9 in AVT-I and VRSGH-7 in AVT-II are under multi-location testing of AICRP (VC) trials.

Varietal screening of sponge gourd genotypes against its major insect pests: A total of 26 genotypes of sponge gourd were screened against leaf miner incidence under field condition. Among theses, the lowest leaf miner population (number of leaf miner affected leaves/ plant) was observed in the cultivar Kashi Kalyani,VRSG-21-16 and VRSG-19-1 whereas the genotype VRSG-17-10 and VRSG-17-14 had harboured maximum leaf miner population during kharif season, 2022.

Field screening of sponge gourd against downey mildew and virus diseases: 105 germplasm/advanced lines/varieties of sponge gourd screened under natural field condition during October, 2022 against downey mildew and virus diseases. Symptoms of virus diseases complex mostly comprised of Cucurbit aphid-borne yellow virus (Polerovirus) and ToLCNDV in sponge gourd during the screening period. Screening was done on 0-5-point rating scale.

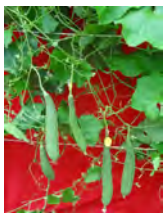
The downy mildew disease severity was minimum (25%) in VRSG-17-10 and Kashi Raakshita and therefore categorized as moderately resistant under the field conditions. Kashi Jyoti x 17-3, 17-3 x SG-6, 195 x Pusa Suriya, Vinay and VRSG-20-9 were grouped under susceptible to downy mildew. Remaining all the germplasm lines were under moderately susceptible category.

Total eight germplasm lines were moderately resistant to the yellow mosaic virus disease complex. The three F_1 were VRSG -17-3 x VRSG-2-21, VRSG-17-11 x VRSG-1-21, Kashi Jyoti x VRSG-17-27, and five lines VRSG-19-5, VRSG-19-6, VRSG-21-8, VRSG-21-16 and VRSG-17-21 recorded in kharif season. Remaining all the germplasm lines were moderately susceptible to yellow mosaic virus disease complex.

Maintenance breeding and nucleus seeds production of sponge gourd varieties/hybrids developed from the Institute: Maintenance breeding: Four varieties i.e. Kashi Shreya, Kashi Jyoti, Kashi Kalyani and Kashi Vandana are being maintained by producing nucleus seed (1.0 kg each) and parental lines of two hybrids i.e. Kashi Rakshita and Kashi Saumya are being maintained by producing nucleus seed of each 450g (F) and 250g (M)).

Ridge Gourd

Germplasm Collection and Evaluation of Ridge gourd: Out of 54 germplasms (52 old and 2 new collection) of ridge gourd 11 i.e. VRRG-26, VRRG-7-2, VRRG-1-17, VRRG-4-10, VRRG-5A, VRRG-110, VRRG-75-2016, VRRG-35, VRRG-1-16, VRRG-42-2016 and VRRG-23 were found promising for horticultural traits and showed tolerance against sponge gourd mosaic and downy mildew disease symptoms under field conditions.


VRRG-26


VRRG-7-2


VRRG-1-17


VRRG-4-10

Development and evaluation of F_1 genotypes: A total of 28 F_1 cross combinations were developed by using the 8 lines in HDMD. Among the 28 F_1(s) of ridge gourd VRRG-7-2016 X VRRG-6A, Kashi Shivani x VRRG-75-2016, Kashi Shivani x VRRG-6A, VRRG-75-2016 x VRRG-5A, VRRG-75-2016 x VRRG-26 and VRRG- 5A ×VRRG-6A were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downy Mildew disease under field conditions.

AICRP (VC) trials: OP improved genotype VRRG-1-2016 in AVT-I, and two F_1 hybrids namely, VRRGH-7 in IET and VRRGH-6 in AVT-I are under multi-location testing of AICRP (VC) trials.

Generation advancement of ridge gourd: Under the generation advancement program, 15 populations of ridge gourd were advanced from F_6 to F_7.

Maintenance breeding and nucleus seeds production: One variety i.e. Kashi Shivani of ridge gourd was being maintained by producing nucleus seed (1.25.0 kg).

AICRP-VC Trials Conducted: A total of 10 trials i.e. Sponge gourd Varietal IET, Sponge gourd Varietal AVT-I, Sponge gourd Varietal AVT- II, Sponge gourd Hybrid IET, Sponge gourd Hybrid AVT-I, Sponge gourd Hybrid AVT-II, Ridge gourd Varietal IET, Ridge gourd Varietal AVT-II, and Ridge gourd Hybrid IET, Ridge gourd Hybrid AVT-II were conducted during the summer, 2022. Results of these trials have been submitted in PC cell as per technical Programme of AICRP (VC) and compilation is in progress.

Satputia

Out of 38 germplasm of Satputia, Six i.e. VRS-11, VRS-24-1, VRS-28, VRS-3-17, VRS-3-10, and VRS-25, were found promising for horticultural traits and showed tolerance against downy mildew and virus disease under field condition.


VRS-11


VRS-24-1


VRS-28

Generation advancement: Under the generation advancement program, 15 populations were advanced from F_4 to F_5.

Maintenance breeding and nucleus seeds production: One variety i.e. Kashi Khushi of satputia is being maintained by producing nucleus seed (1.0 kg).

Project 1.9: Genetic improvement of pumpkin and cucumber

Cucumber

Germplasm evaluation and maintenance

Enhancement, maintenance and evaluation of germplasm lines: A total of 62 germplasm/genotypes of cucumber were evaluated for flowering, yield and related traits. The variability among the evaluated genotypes were observed for all horticultural traits. Among the new collection genotype SBC/DRB-91, SBC/DRB-38, KKG/VKS/SKT-274 and KKG/VKS/SKT-313 were found promising for number of fruits and resistance. Selfed-seeds of all genotypes were harvested. A total of 185 germplasm were maintained as active germplasm.

Development of F_1 combination: A total of 28 cross combinations were developed utilizing 10 parents selected on the basis of variability and desirability. The seeds were obtained only in 12 cross combinations due to poor seed set. These crosses will be evaluated with the check during next season.

Advancement of segregating generation: Selected individuals/ crosses were advanced to subsequent generation from the segregating lines, i.e. 12 combinations in F_3 generation, 18 in F_4, 17 in F_5, 7 in F_6 and 4 families in F_7 generations were advanced.

Evaluation of advance lines: A total of 18 advance lines along with check PCUC-09 have been evaluated for yield and its contributing traits in green/mottle green segment. The best performing lines based on the fruit colour, appearance and yield were VRCU-19-19 followed VRCU-2240. Fruits of these lines were non-bitter in taste.

Maintenance of parental lines: The parental lines of hybrid Kashi Nutan were maintained through selfing and sufficient amount of seeds were produced.

Evaluation of advance parthenocarpic cucumber lines under protected condition: The advance parthenocarpic line VRCUP-20-2 was evaluated for horticultural characteristics with KPCH-1 as check. The yield of VRCUP-20-02 was at par with the public sector hybrid KPCH-1 and it can be grown in a protected structure both during the off season as well as the main season. The fruit colour of this genotype was green with a length and diameter of 14.52 and 3.40 cm, respectively (Fig. 18). The VRCUP-20-02 can be released as an open pollinated variety suitable for cultivation under protected structures.


Fig. 18: Plants and fruits of Parthenocarpic line VRCUP 20-02

Maintenance of parthenocarpic lines: The plants were treated with silver thio-sulphate at 3-4 leaf stage and repeated four times at 4 days interval to induce the male flowers. The seed of targeted lines were obtained by selfing for further advancement. For getting the better-quality seeds, each plant was allowed to set maximum 3 selfed fruit.

Screening of lines against the ToLCNDV disease: A total of 60 germplasm / advanced breeding lines of cucumber with three checks (CUCU-7, Cucumber-1 and Japanese Long Green) were screened against ToLCNDV. Analyzed the disease incidence on 0-4 scale (Todd and Kommedahl, 1994) (0 = immune, 0.01-1 = resistant, 1.01-2 = mild resistant, 2.01-3 = susceptible 3.01- 4 = highly susceptible). The disease score was recorded 6 times at weekly intervals starting at 30 days after sowing. Among the 60 accessions, a total of 9 lines were found resistant, 17 mild resistant and others susceptible to this disease. Lowest PDI found in the VRCU-C-C-7 line (18.333) which is most resistant to ToLCNDV. Moreover, the highest PDI was expressed in the Japanese Long Green that indicate the most susceptible line to this virus.

Pumpkin

Enhancement, maintenance and evaluation of germplasm lines: A total of 50 germplasm evaluated for flowering, yield and related traits and maintained through selfing.

Hybridization and advancement of segregating generation: A total of 24 F_1 combinations were developed by utilizing divergent inbred lines. Selected individuals/crosses were advanced to subsequent generation from the segregating lines, i.e. 04 combinations in F_4 generation developed using butternut squash, were advanced.

Evaluation of advance lines: Eleven advance breeding lines selected during last year have been evaluated for important horticultural traits. Maximum number of fruits/plant were observed in VRPK-05 (4.28) followed by VRPK-63 (4.20) and VRPK-222-02-01 (4.10). The fruit shape of VRPK-18-01 and VRPK-11-6-5 sel-2-1 was oval round, while other lines have flat round shape. On the basis of overall performance and phenotypic acceptability VRPK-63, was found promising and selected for multi-location testing.

Development of high carotene inbred lines: During 2021 two single crosses were made between VRPK -19-03 x VRPK-09-01 and VRPK -19-04 x VRPK-11-06-05sel-02-01. VRPK -19-03 and VRPK -19-04 are having high carotenoid content, pear-shaped fruit, and less number of fruits per plant while VRPK-09-01 and VRPK-11-06-05sel-02-01 are having less carotenoid content, flat round fruit shape and more number of fruits per plant. In 2022 backcrosses (BC_1F_1) were made between F_1 (VRPK -19-03 x VRPK-09-01) x VRPK-09-01 and F_1 (VRPK -19-04 x VRPK-11-06-05sel-02-01) x VRPK-11-06-05sel-02-01. The seeds of these F_1s were harvested and will be evaluated for carotenoid content during next season.

Multiplication and maintenance of seeds of Kashi Harit and parental lines of Kashi Shishir: One kg seeds of Kashi Harit variety of pumpkin were produced and SPS were selected for maintenance of the Kashi Harit and both the parents of Kashi Shishir.

Summer Squash (*Cucurbita pepo*)

Maintenance of germplasm: Among the germplasm, only 65 germplasm/genotypes of summer squash were evaluated for yield and contributing traits. The number of fruits per plant ranged from 8.0 (VRSS-20-324) to 12.0 (VRSS sel-20-65), while average fruit weight ranged from 675.0 g (VRSS sel -20-65) to 1250.0 g (VRSS sel-20-357). The fruit length ranged from 7.5 cm to 32.8 cm and diameter is 6.9 and 14.7 cm.

Evaluation of advance lines: A total of 25 advance lines have been evaluated for yield and its contributing traits in different segment. The best performing lines based on the fruit colour, appearance and yield were VRSS-20-158 followed VRSS-20-166. Maximum number of female flower was recorded in VRSS-20-131.

Project 1.10: Genetic Improvement of Melons

Watermelon

Germplasm Maintenance: Seventy-six germplasm accessions, including wild (*C. lanatus* var. *citroides*), diverse in shape size and colour, are being maintained in the field.

Hybrid development and generation advancement: The hybrids were done during the spring summer season of 2022. Based on the total yield and TSS of the hybrid fruits, VRW-511 x VRW-14-1 (VRWH-5) was found promising followed by VRW-54-2 x VRW-514 DG (VRWH-8) and VRW-516 x VRW-929 (VRWH-4). These hybrids have TSS 10.13-11.33 ◦Brix and a yield potential of 590-460 q/ha.

Maintenance and evaluation of advance lines for various economic traits: During the summer season, 2022, 17 promising lines having various shape, size, and flesh colour (red, scarlet red, canary yellow, salmon yellow, orange, and white) were evaluated for several economic traits. The maximum yield per plant along with high TSS was observed in VRW-10 (7.58 kg/plant & 10.57 ◦Brix %) followed by VRW-514 (6.82 kg/plant & 13.77 ◦Brix %) and VRW-54-2 (5.75 kg/plant & 11.57 ◦Brix %). The first node for the first female flower was observed in VRW-53-1 (11.33) followed by VRW-9-1 (11.67) and VRW-66 (13.00). In the present study, the genotypes VRW-10, VRW-514, and VRW-54-2 were found to be superior for yield and quality attributes. The segregating populations are being advanced to the next higher generation, and promising advanced lines shall be identified for station trials.

VRW-10 VRW-514 VRW-54-2

Fig. 19: Promising watermelon genotypes

Evaluation of segregating lines for various economic traits at RRS, Sargatia: Twenty-two lines were evaluated. The maximum yield per plant along with a high TSS was observed in VRW-927 (4.29 kg/plant & 13.24 % TSS) followed by VRW-57 (3.69 kg/plant & 13.79% TSS), VRW-509-3 (3.68 kg/plant & 12.93 % TSS), VRW-73 (3.55 kg/plant & 12.63 % TSS), VRW-76 (3.45 kg/plant & 12.12 % TSS) and VRW-34 (3.39 kg/plant & 12.53 % TSS). The VRW-927, VRW-57, VRW-509-3, VRW-73, VRW-76, and VRW-34 were found to be promising for yield and quality attributes.

VRW-927 VRW-57 VRW-509-3

Fig. 20: Promising watermelon genotypes

Round Melon

Twelve advance lines were evaluated in augmented design with check during summer 2022 for yield and horticultural traits. All genotypes were characterised for traits such as early horticulture maturity, high yield, and fruit quality. The maximum yield per plant was found in VRM-20-1 (1.16 kg/plant) followed by VRM-11-1 (1.14 kg/plant), VRM-12-6 (0.94 kg/plant) and VRM-5-2 (0.85 kg/plant). The maximum number of fruits per plant were found in VRM-5-2 (6.77) followed by VRM-11-1 (6.16) and VRM-20-1 (5.84). Maximum individual fruit weight was recorded in VRM-20-1 (204.00g) followed by VRM-17 (192.33g) and VRM-11-1 (186.33) at the edible stage. Some promising an overall the VRM-20-1, VRM-11-1, VRM-12-6 and VRM-5-2 were superior in both yield and quality point of view (Fig. 21).

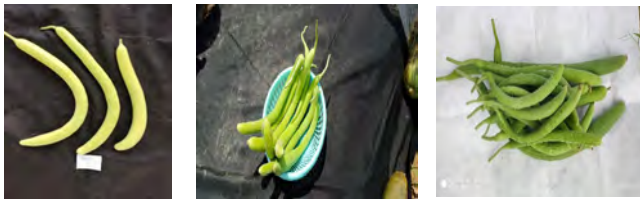
VRM-20-1 VRM-11-1 VRM-12-6

Fig. 21: Promising genotypes of round melon

Long Melon

Hybrid development: Evaluated 10 hybrids during the rainy season, 2022 for yield and other economic traits. Based on yield and fruit quality characters, the hybrid VRLM-24-1 x VRLM-1 was found promising with fruit yield of 1.53 kg/plant followed by VRLM-1 x VRLM-39 (1.37 kg/plant) and VRLM-3 x VRLM-1 (1.19 kg/plant).

Maintenance and evaluation of advance lines for various economic traits: Forty germplasm accessions were maintained including a segregation population with snap melon. Eighteen lines were evaluated in augmented design during summer, 2022 for yield and horticultural traits. All genotypes were characterized for traits like early harvest, high yield and fruit quality. Maximum yield per plant was found in VRLM-102 (1.64 kg/plant) followed by VRLM-101 (1.60 kg/plant) and VRLM-1 (1.12 kg / plant). The number of fruits per plant was found to be higher in VRLM-1 (8.05) followed by VRLM-40-1 (7.85) and VRLM-24-1 (7.64). The maximum weight of the individual fruit was recorded maximum in VRLM-102(363.33g) followed by VRLM-101 (351.00g) and VRLM-17-5 (321.33g) at the edible stage. Based on overall performance, VRLM-101, VRLM-102, VRLM-1, VRLM-24-1 and VRLM-3 were found to be superior for yield and quality attributes.



VRLM-40-1 VRLM-102 VRLM-24-1

Fig. 22: Promising genotypes of Long melon

Muskmelon

Status of germplasm: A total of 195 accessions of muskmelon which include genotypes of various fruit shapes *i.e.*, round, oval, flaty round, and oblong and flesh colour i.e., orange, yellow, white, and green flesh and 65 accessions of *C. melo* var *agrestris* and *C. callosus* were maintained at IIVR. Ten accessions of muskmelon and 5 accessions of *C. melo* var *agrestris* augmented.

Monoecious inbred VRMM-170: VRMM-170 was isolated from a segregating population of a cross of andromonoecious and monoecious parents in 2016-17 and is characterized for its stable monoecious sex expression with round fruit; and stability of sex expression had also been confirmed though continuous evaluation for five years from 2017-18 to 2021-22. This is an early flowering genotype and first productive flower appears at 7-8 nodes and 40-45 DAS. It produces 3-4 fruits/plant with an average fruit weight of 750-850gm, having light orange colour flesh which is crispy in nature with a TSS of 11-12^{o}Brix (Fig. 23).

Fig. 23: VRMM-170

Screening of germplasm for ToLCNDV and melon yellowing disease resistance: A total of 85 genotypes of muskmelon screened for the ToLCNDV and melon yellowing disease resistance for two seasons (spring-summer & rainy seasons) of 2022. Out of 85 genotypes, only 6 (B-159, VRMM-170, VRMM-160, VRMM-161, VRMM-305, VRMM-225-1) genotypes exhibited resistance with pooled average score 0-0.78 and rest were either moderately susceptible or susceptible. With respect to melon yellowing disease only 3 genotypes (VRMM-160, VRMM-161 & VRMM-171) showed resistance with pooled average score 0-1 and rest were designated as susceptible to highly susceptible.

Development of mapping population and identification of polymorphic SSR for fruit shape: For this study round fruited andromonoecious variety Kashi Madhu, round fruited monoecious line VRMM-170 and oblong fruited monoecious line B-159 used for polymorphism survey and development of mapping population. B-159 is crossed with both round fruited parents Kashi Madhu and VRMM-170 to developed two mapping population monoecious × monoecious and andromonoecious × monoecious. A total of 570 SSR primer used for polymorphism survey and 115 identified as polymorphic for fruit shape (Fig. 24).

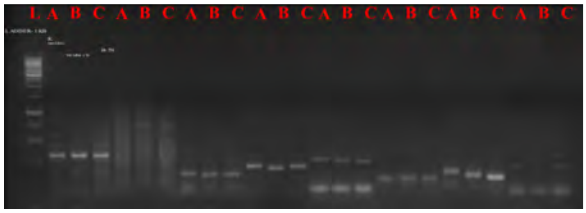


Fig. 24: SSR polymorphism for fruit shape morphology (A= Kashi Madhu, B=VRMM-170, C=B-159)

Project 1.11: Genetic Improvement of Okra

Status of germplasm: A total of 780 accessions of diverse germplasm of cultivated okra maintained at ICAR-IIVR, which embody the considerable genetic variability for morphological, horticultural and biotic stress tolerance traits viz., bush type, plant with short internodal length, thin fruited, ridge less, five to nine ridged, red fruited, cut leaf, YVMV and ELCV tolerance in the primary gene pool. Additionally, 167 accessions of various wild relatives like *Abelmoschus caillei, A. tuberculatus, A. ficulneus, A. tetraphyllus, A. moschatus, A.enbeepeegearense, A. crinitus, A. angulosus, A. manihot, A. angulosus* var. *grandiflorus* and *A. moschatus* subsp. *tuberosus* and 30 accessions of wild derived stable amphidiploids lines were also maintained and multiplied at our institute. During 2022, 15 new germplasm *viz*., 6 accession of cultivated okra, 3 accessions of *A.tetraphyllus*,1 accessions of *A. palianus* and 5 accessions of *A. crinitus* augmented from Odisha, Uttar Pradesh, Bihar, West Bengal and Jharkhand.

Development and evaluation of F_1 hybrids: During spring summer season of 2022 a total of 115 F_1hybrids in the green fruited segment were developed using 35 diverse parents of newly developed VRO-200 series genotypes along with the genotypes from VRO-100 series These 115 F_1 hybrids were evaluated during Kharif season for yield, dark green uniform fruit colour free from seed bulging and spine, faster fruit growth, easy to picking including other morpho-horticultural traits, and reaction to YVMV and ELCV diseases using Kashi Shristi (Public sector hybrid) and SF044, SF007, Navya and Radhika (Private sector hybrids) as check. Out of these 115 experimental hybrids, 30 promising F_1 s identified as promising for fruit yield potential, quality, earliness and viral disease tolerance. Out of these 30 promising hybrids, the 10 best performing F_1s which outperformed the popular commercial hybrids in all respect were VRO-236× VRO-219, VRO-235× VRO-219, VRO-200× VRO-219, VRO-200 × VRO-236, VRO-201×VRO-236, VRO-235×VRO-236, VRO236 × VRO-220, VRO-146 × VRO-236, VRO-235 × VRO-220 and VRO-236× VRO-221.

In red fruited segment 20 F_1 hybrids were developed utilizing VRO-120, VRO-125, VROR-154, VROR-155,Kashi Lalima, VROR-160, VROR-156, VROR-166, VROR-165 & VROR-167 and evaluated for morpho-horticultural traits like plant architectural traits, redish purple fruit colur, fruit quality and tolerance to viral diseases. Among these 20 evaluated red fruited hybrids, VROR-165×VROR-166 (fruit yield: 500g/plant), VROR-160×VROR-166 (fruit yield: 475g/plant), VROR-160×VROR-167 (fruit yield: 460g/plant) and VROR-160×VROR-165 (fruit yield: 455g/plant) found most promising. Moreover, these 4 hybrids also expressed high degree of tolerance to YVMV (PDI: 00%) and ELCV (PDI :<1%).

Identification of best combiners in green and red fruited segments: Based on the data recorded from 8×8 half diallel and 10×2 line× tester matting design in green and red fruited segment respectively, it had been observed that hybrid combinations performed better and expressed significant amounts of standard heterosis (16-30%) where ever the VRO-219, VRO-236, VRO-220, VRO-235 (green fruited), VROR-160, VROR-165 and VROR-167 (red fruited) involved as one of the parents. These parents were also responsible for better plant architectural traits, fruit quality and viral disease tolerance. Thus, based on the performance of hybrids and trait expression VRO-219, VRO-236, VRO-220, VRO-235, VROR-160, VROR-165 and VROR-167 can be recognized as best combiner for hybrid breeding in okra.

Evaluation of advance lines in green fruited segment: A total of 70 advance lines were evaluated during kharif season for morpho-horticultural traits including yield, fruit quality (uniform dark green fruit, devoid of seed bulging, spine), ease to harvest and tolerance to YVMV and ELCV diseases. In addition to the advance lines VRO-146, VRO-147, VRO-200, VRO-201, VRO-209, VRO-127-1-18, VRO-204, VRO-212 which were also identified as promising lines during 2021; in the newly identified advance lines VRO-236, VRO-219, VRO-235, VRO-220, VRO-218,VRO-217, VRO-221, VRO-226, VRO-227, and VRO-228 found as most promising genotypes for fruit yield, fruit quality and disease resistance during field evaluation of advance lines of okra.

Evaluation of red fruited okra genotypes: In the red fruited segment twenty five genotypes including VROR-158, VROR-159, VROR-160, VROR-161, VROR-162, VROR-165, VROR-166, VROR-167 and VROR-170 were evaluated along with Kashi Lalima for growth habit, branching pattern, uniform red fruit colour, fruit quality, yield, total anthocyanin content and tolerance to viral diseases. In the evaluated genotypes fruit colour ranges from reddish purple to dark purple, fruit length ranges from 12-15 cm, fruit diameter varies from 1.45-2.30 cm, number of fruits per plant ranges from 18-32 fruits and yield per plant varies from 210g-380g. Among the evaluated red fruited genotypes VROR-166 (fruit yield: 380 g/plant, total anthocyanin: 4.23 mg/100g), VROR-167 (fruit yield: 375g/plant; 5.24 mg/100g), VROR-165 (fruit yield: 360g/plant; 4.47 mg/100g) and VRO-160 (fruit yield: 360g/plant; 4.68 mg/100g) identified as most promising red fruited genotypes for yield, quality and disease resistance. Besides, these genotypes also had short and compact internodes.

Validation of okra genotypes for ease to harvest: Performance of selected advance lines with ease to harvesting also validated in spring-summer and rainy season of 2022. In modern day okra breeding it considered as an important trait. In some genotypes fruits were harvested only by single down ward bending the fruits while others required jerk with various force. As like 2021 the genotypes VRO-145, VRO-146, VRO-147, VRO-112-1, VRO-200, VRO-201, VRO-202, VRO-203, VRO-204, VRO-205, VRO-208, VRO-209, VRO-210, VRO-219 and VRO-236 were consistent with respect to ease to harvest in both the seasons and can be utilized as potential donor to breed easy to harvest okra hybrid.

Dwarf okra genotype VRO-416-10-1: VRO-416-10-1 was isolated from a segregating population which is an ultra-dwarf genotype (45-50cm) in the five ridge segment with earliness (Days to first flowering: 36 DAS, short and very compact internodes (1.50-1.80 cm), 1-2 effective branches, high yield potential (160-170q/h), resistance to YVMV & ELCV, tolerance to jassid (3-5 jassid/leaf) and produced green fruit. This genotype was 10-12 cm shorter and more yield potential than the check No-315. Besides, F_1 hybrids having VRO-416-10-1 as one of the parents both in direct and reciprocal crosses also produce dwarf plant with short and compact internodes.

Validation of nutritional quality of previously evaluated red okra lines: The nutritional parameters such as total anthocyanin content, total carotenoids, total phenolics, and total chlorophyll content of 4 red okra lines genotypes Kashi Lalima, VROR-156, VROR-158, VROR-160 were analysed during the rainy season of 2022 to validated performance of 2020 along with one green fruited genotype Kashi Chaman and no significant deviation was observed for various parameter studied from the previous season performance signifies the stability of these traits.

Colorimetric analysis fruit surface colour of red fruited okra genotypes: Colorimetric analysis of fruit surface colour of 15 red fruited okra genotypes (Kashi Lalima, VROR-152, VROR-153, VROR-154, VROR-155, VROR-156, VROR-158, VROR-159, VROR-160, VROR-161, VROR-162, VROR-165, VROR-166, VROR-167 and VROR-170) was carried out based on CIE Lab parameters (L*, a* and b*) utilizing Hunter Color Lab spectrophotometer. Based on the value of L*, a* and b*, the hue angle (h^o) and chroma (C*) computed for all the 15 genotypes. In red fruited okra value of L*, a* and b* ranged from 20.44-30.24, 1.42-9.08 and 1.52-8.45, respectively. Considerable variation for hue angle and chroma also observed among the red fruited genotypes.

Transfer of Genetic Male sterility (GMS) in desirable background: BC_4F_1 generation in the background of VRO-109, VRO-110, VRO-112-1, Kashi Lalima, VRO-120, VRO-125 and No.315 were grown during the summer season of 2022 and plants were selfed and BC_4F_2 seeds were harvested in the respective background. BC_4F_2 seeds were sown during the rainy season and all the plants segregated for male sterility were again back crossed with the respective recurrent parent and seeds harvested as BC_5F_1which will be grown during summer season of 2023.

Evaluation of advance lines of okra for red spider mite tolerance: A total of 40 advance lines (VRO-110, VRO-111, VRO-112, VRO-112-1, VRO-113, VRO-114, VRO-115, VRO-117, VRO-119, VRO-120, VRO-124, VRO-125, VRO-126, VRO-127, VRO-128, VRO-145, VROB- 178, VROB-178-1, 416-10-1, VRO-146, VRO-234, VRO-200, VRO-201, VRO-209, VRO-127-1-18, VRO-204, VRO-212, VRO-236, VRO-219, VRO-235, VRO-220, VRO-218, VRO-217, VRO-221, VRO-226, VRO-227, VRO-228, VROR-165, VROR-166 and VROR-167) along with Kashi Pragati, Kashi Kranti and Kashi Chaman were evaluated for reaction to red spider mite infestation based on the damage grading index. The genotypes VRO-112-1, VRO-145, VRO-217, VRO-227, VRO-234, VRO-235 and VRO-236 found to be tolerant and VRO-120, VRO-219, VRO-220 and VRO-125 as moderately tolerant, while other genotypes found to be susceptible to red spider mite on the basis of damage grading index.

Evaluation of scarlet red flowered interspecific hybrid *A. moschatus* × *A. moschatus* subsp. *tuberosus* and its segregating population: The interspecific hybrid of *A. moschatus* × *A. moschatus* subsp. tuberosus has immense potential to be used as ornamental plant. Unlike *A. moschatus* the F_1 plants capable of produce showy scarlet flower throughout the year and management of plant architecture made this plant to bear more than 100 flowers/day. In 2022 about 150 F_2 plant were grown and morphologically characterized. The flower colour of these plants ranged from, scarlet red, pink, peach colour, orange, yellow to light yellow and also having ornamental significance (Fig. 25). These plants showed very high degree of resistance to YVMV and ELCV diseases and can be utilized for introgression of resistant gene into cultivated okra.

Fig. 25: F_2 population of *A. moschatus* × *A. moschatus* subsp. *tuberosus*

Evaluation of RCM/PK/63 a novel wild relative of okra for YVMV & ELCV resistance and cross-ability with cultivated okra: In 2022 also, RCM/PK/63 the unidentified and non-characterized wild relative of okra screened for YVMV and ELCV. Like 2020 and 2021, this novel accession exhibited very high degree of resistance under natural epiphytic condition in 2022 (Fig. 34). The resistance was confirmed through artificial screening using begomo virus specific primers. There was no amplification reported from the sample from RCM/PK/63 which showed high degree of resistance continuously for 3 years. Besides, cross- ability with the cultivated also studied. When this accession was used as male parent then there is no problem of fruit and seed setting. The F_1 hybrid of cultivated okra and RCM/PK/63 was found to be sterile and set fruits parthenocarpically. Colchicine treatment is essential to restore fertility in this combination for further utilization in the breeding program.

Fig. 26: RCM/PK/63 novel wild relatives of okra

Maintenance breeding of IIVR released varieties and parental lines of the hybrid: ICAR-IIVR developed varieties *viz*. Kashi Kranti, Kashi Pragati, Kashi Sathdhari, Kashi Lila, Kashi Vibhuti, Kashi Vardaan, Kashi Chaman and Kashi Lalima were maintained by producing nucleus seed (1.5 kg each). Parental lines of the hybrid Kashi Bhairov and Kashi Shristi were also maintained by self pollination.

Project 1.12: Genetic improvement of cole and root crops

Cole Crops

CMS lines and F_1 hybrids in tropical cauliflower: Twenty-three back cross CMS population of BC_1F_1-BC_7F_1 stage for various traits i.e. plant type (Semi-spreading/Semi-erect), maturity (Early/Mid/Mid-late), curd colour (White/Orange) and flower colour (Yellow/White) were advanced/maintained. Among these, five CMS lines of various curding temperature were found to be stable and robust namely VRCF-41 for 28-30˚C; VRCF-131 & VRCF-132 for 24-28˚C; VRCF-110 for 22-25˚C; and VRCF-212 for 20-23˚C. The best six hybrids expressing 8-16% heterosis for yield at different maturity are VRCF-41×VRCF-75-1 and VRCF-131×VRCF-35 during 2nd fortnight of October (28-30°C); VRCF-110×VRCF-50 and VRCF-131×VRCF-86 during 1st fortnight of November (24-28°C); VRCF-132×VRCF-111 during 2nd fortnight of November (22-26 °C) and VRCF-212×VRCF-77 during 1st fortnight of December (20-24°C).

Fig. 27: Curding in VRCF-11 during first fortnight of November

Evaluation of tropical cauliflower: Seventy-six genotypes, including forty-one OP lines (advance lines and germplasm) and thirty-five hybrids were evaluated during different maturity time for yield and quality traits. The following OP genotypes were found to be promising namely VRCF-25, VRCF-74 & VRCF-35 during 2nd fortnight of October (28-30 °C); VRCF-25, VRCF-11, Kashi Gobhi-25, & VRCF-127 during 1st fortnight of November (24-28 °C) [Fig. 27]; and VRCF-77 & VRCF-192 during 1st fortnight of December (20-23 °C). Additionally, in the early segment (24-30 °C), the population of 2nd selection cycle are being improved for self-blanched plant type and compact curds. Seven entries, including 2 OP genotypes (VRCF-77 & VRCF-118), and 5 F_1 hybrids (VRCF-131×VRCF-75-1, VRCF-131×VRCF-86, VRCF-222×VRCF-77, VRCF-212×VRCF-77 & VRCF-132×VRCF-120) are in multi-location testing for early- and mid-season maturity under varietal/hybrid trials of AICRP-VC. The maintenance breeding of a notified variety Kashi Gobhi-25, and 5 CMS lines & their maintainers are being done by producing nucleus seed (50-500 g of each) in flexible nylon-net cage.

Micro-propagation of heat tolerant cauliflower genotype: With objective to establish uniformity in segregating heat tolerant cauliflower genotype VRCF-75-1 (curding at temperature of 38-43 °C) during summer 2022, in vitro propagation using curd explant, Murashige and Skoog nutrient media with modified vitamins was carried out. The plants surviving in glass house were transferred to main field in September 2022. Survival of ~ 50% was observed from lab to main field. Plants established in main field were uniform in terms of plant type, curd initiation time (26th October) with curd weight of 350-450 g and creamish white curd colour (Fig. 28). Bud pollination was carried on individual plants for obtaining selfed seeds.

Green and orange cauliflower: A green curd genotype (good source of glucosinolates) with very late maturity (110-120 days), poor in harvest index (<20%) and inferior in seed setting have been crossed using a genotype of tropical cauliflower with objective to transfer green colour trait in mid maturity group, reduce the maturity period (70-80 days) and increase the harvest index (≈40%). The F_1 has been evaluated (85-90 days maturity) and advanced in next generation for getting F_2, BCP_1 and BCP_2 population and to study inheritance pattern and develop green coloured mid-maturing genotype of Indian cauliflower. Moreover, the β-carotene rich lines with orange coloured curd have been grouped in four categories depending upon curd colour intensity and β-carotene content (0.75-1.50 mg/100g FW); and the segregating population have been advanced.

Tropical cabbage and broccoli: The CMS-based backcrossing has been done in five genotypes to transfer male sterility cabbage/broccoli (BC_2F_1 to BC_4F_1). Eleven genotypes of tropical cabbage have been evaluated for yield and compactness, and the population advanced to next generation. Three cabbage genotypes such as VRCAB-112 and VRCAB-116 were found promising.

Conservation and maintenance of cole crops: Augmented four early cauliflower germplasm (IC632601, IC632602, IC 632604 and IC 632605) from NBPGR, New Delhi. A sum of 82 genotypes (accesions, germplasm, advance lines, variety, etc), including 67 of cauliflower, 8 of cabbage, 5 of broccoli and 2 of kale are being conserved & maintained.

Radish

CMS lines and F_1 hybrids of radish: Twenty-two back-cross population of Ogura CMS in the backgrounds of leaf

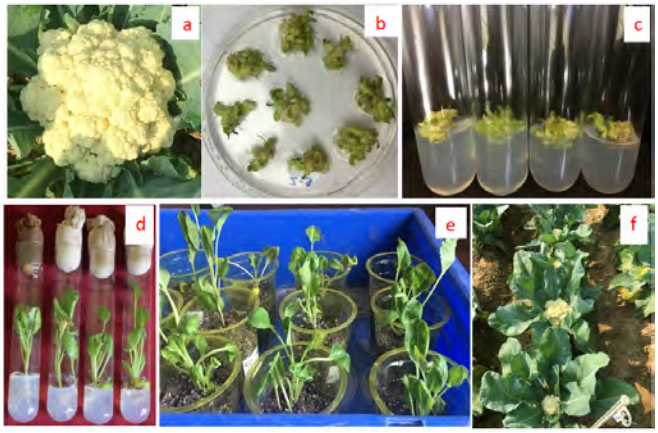


Fig. 28: Micro-propagation of heat tolerant cauliflower genotype VRCF 75-1. a: curd of VRCF 75-1 during May 2022 used as explant; b: callus formed from curd; c: sub-culture of callus for shoot and root differentiation; d: in vitro rooted plants; e: hardening in vitro grown plants in soilless mixture and glass house; f: field establishment of micro-propagated plants during November 2022.

Fig. 29: Performance of Kashi Rituraj during summer (35-43 ˚C)

morphology (lyrate, sinuate, entire), root shape (tapering, blunt), root colour (white, red, purple) and adaptability (winter, summer) were advanced to various stages (BC_1F_1-BC_7F_1) for harnessing the hybrid vigour and economize the seed production of F_1 hybrids in radish. The following six CMS lines are found to be robust, stable and uniform such as VRRAD-11 & VRRAD-12 (lyrate leaf); VRRAD-41, VRRAD-198 & VRRAD-201 (sinuate leaf); and VRRAD-275 (purple root). Among forty-two cross-combinations evaluated, nine hybrids were found to be most promising for various economically important traits such as VRRAD-11×VRRAD-213 & VRRAD-12×VRRAD-213 (lyrate leaf, less tapering root, winter season); VRRAD-201×VRRAD-213 & VRRAD-201×Kashi Mooli-40 (lyrate leaf, tapering root, winter season); VRRAD-45×VRRAD-216 & VRRAD-41×VRRAD-216 (entire leaf, less tapering root, autumn/winter/spring season); and VRRAD-201×VRRAD-200, VRRAD-45×VRRAD-202 & VRRAD-41×VRRAD-200 (sinuate leaf, tapering root, autumn/winter/spring/summer season). First CMS-based F_1 hybrid of radish from Public sector in India i.e. Kasha Rituraj (VRRAD-201×VRRAD-200) has been released in October 2022.

Evaluation and Population improvement in radish: A sum of 80 genotypes, including 38 OP lines and 42 CMS-based hybrids has been evaluated for yield, leaf morphology, root shape, maturity and heat tolerance. The following genotypes & varieties were found to be promising namely VRRAD-204, Kashi Mooli-40, VRRAD-202, VRRAD-200 and Kashi Aardra for white root; Kashi Lohit, VRRAD-170 & VRRAD-173 for red root; and VRRAD-134 and VRRAD-131 for purple root. The maintenance breeding to retain genetic purity of six varieties/hybrid (Kashi Sweta, Kashi Hans, Kashi Lohit, Kashi Mooli-40, Kashi Aardra & Kashi Rituraj), and six CMS lines & their maintainers (VRRAD-11, VRRAD-12, VRRAD-41, VRRAD-198, VRRAD-201 & VRRAD-275) are being done by producing nucleus seed (100-2000 g of each) in flexible nylon-net cage. Further, total 89 genotypes of white, red, purple, black and yellow coloured radish are being conserved ex situ at istitute.

Carrot

CMS lines and F_1 hybrids of carrot: To harness the hybrid vigour potential in carrot, thirty-five CMS-based cross-combinations were evaluated for various economic traits; and following eight hybrids were found to be promising for yield and quality traits namely VRCAR-214×VRCAR-85, VRCAR-214×VRCAR-201, VRCAR-211×Kashi Arun & VRCAR-211×VRCAR-86 (red root, 13.8% heterosis); VRCAR-252×VRCAR-125 & VRCAR-252×VRCAR-89-1 (black root, 11.5% heterosis); VRCAR-241×VRCAR-135 (orange root, 15.6% heterosis); and VRCAR-252×VRCAR-107-2 (rainbow, 21.4% heterosis). The most promising 4 CMS-based F_1 hybrids (VRCAR-211×VRCAR-86 & VRCAR-211×Kashi Arun, VRCAR-214×VRCAR-85 & VRCAR-214× VRCAR-201) and 1 OP genotype VRCAR-85 are in multi-location testing under tropical carrot hybrid trial of AICRP-VC.

Fig. 30: Eye-catching coloured carrots received attention of Hon'ble Union Minister for Agriculture and Framers Welfare, Sh. Narendra Singh Tomar

Evaluation and population improvement in carrot: A total of 84 genotypes of red, black, orange, yellow, cream, white and rainbow carrots, including 49 OP genotypes and 35 hybrids have been evaluated for yield and quality traits. Among various eye-catching tropical carrots, the following were found to be promising for root yield & quality namely VRCAR-86, VRCAR-201 & Kashi Arun for red root; VRCAR-125, Kashi

Krishna & VRCAR-89-1 for black root; VRCAR-135, VRCAR-132 & VRCAR-44 for orange root; VRCAR-154, VRCAR-153 & VRCAR-203 for yellow root; VRCAR-171-1 & VRCAR-107-2 for rainbow-type root; and VRCAR-161 for white root (Fig. 30). Further, the black carrot variety/genotypes (Kashi Krishna, VRCAR-125 & VRCAR-252) have prospective to be used for many preparations and could be a potential source of plant-derived pigment by the pharmaceutical industries as it is one of the richest source of anthocyanins (250-300 mg/100 g FW), having higher antioxidant ability (25 to 30-times more than carotenoid carrots) and able to produce anthocyanins to the tune of 65-75 kg/ha.

Fig. 31: Male sterile and Male fertile umbellate/flowers of a unique germplasm, VRCAR-214 (INGR22160)

Documentation, conservation and maintenance of carrot: Two CMS lines namely VRCAR-252 (INGR22088, black carrot) and VRCAR-214 (INGR22160, red carrot) with better combining ability and heterotic potential have been registered as unique germplasm by the PGRC, ICAR-NBPGR, New Delhi on 8th July and 8th December 2022, respectively (Fig. 31). Further, IC number was allotted for 13 genotypes of carrot i.e. IC0642950 (VRCAR-81), IC0642951 (VRCAR-85), IC0642952 (VRCAR-86), IC0642953 (VRCAR-101), IC0642954 (VRCAR-125), IC0642955 (VRCAR-211), IC0642956 (VRCAR-212), IC0642957 (VRCAR-213), IC0642958 (VRCAR-214), IC0642959 (VRCAR-231), IC0642960 (VRCAR-251), IC0642961 (VRCAR-252) and IC0642962 (VRCAR-272). A total of 83 genotypes (varieties, promising lines, accessions and germplasm) of 7 different coloured carrots (red, black, orange, yellow, rainbow, cream & white) are being conserved at this institute

Project 1.13: Biotechnological interventions including transgenics for managing stresses in vegetables

Fruit and shoot borer resistant transgenic brinjal –*Cry1Aa3* gene*:* Homozygous T10 generation plants of three cry1Aa3 transgenic brinjal (cv. Kashi Taru) events (A2, A3, and A7) developed earlier were grown in a glass house.

Fruit and shoot borer resistant transgenic brinjal – *Cry1Ac* gene: Generation advancement of *Bt*-brinjal lines (*viz*. Pant Rituraj, Uttara, Punjab Barsati, VR-14, IVBL-9, VR-5, EV-1 and EV-4) with high protein expression and similar to recurrent parent were selected and further selfing was repeated in this season again. Plants were again raised for seed multiplication. *Bt*-brinjal seeds were sown in pots in containment proof insect house. After 20 days of germination, six successive kanamycin sprays (200 mg/l) were applied to find any escape of transgenic or low expression on the transgene. All the seedlings survived after kanamycin sprays showing optimum expression of the transgene. Further, the positive plants of each line were transplanted in net house.

Fruit borer resistant transgenic tomato – *Cry1Ac* gene: Eight events of transgenic tomato plants *cv.* Kashi Vishesh carrying *Cry1Ac* gene were advanced to T14 generation. Seeds of the best events IVTT-5 and all other events were germinated in a glass house. After 30 days of germination, six successive sprays of kanamycin (200 mg/l) were applied to find any escape of transgenic or low expression of the transgene. All the seedlings survived after kanamycin spray showing optimum expression of the transgene. Ten seedlings of each event were transplanted in insect-proof net house.

Drought, Salt and Cold stress tolerance transgenic tomato-*AtDREB1A:* Transgenic tomato lines D41, D53, D76 and D86 expressing *AtDREB1A* gene were advanced to T12 generation. The seeds of all events were germinated in a glass house. After 30 days of germination, screening was done with kanamycin sprays (200 mg/l) to find any escape of transgenic or low expression on the transgene. All the seedlings were survived after kanamycin spray showing optimum expression of the transgene. Eight seedlings of each event were transplanted in insect-proof net house.

Drought, Salt and Heat stress tolerance transgenic tomato-*BcZAT12:* Drought, salt and high temperature stress tolerance transgenic tomato lines ZT1, ZT5 and ZT6 expressing *BcZAT12* gene were advanced to T12 generation. The seeds of all events were germinated in a glass house. After 30 days of germination, screening with kanamycin sprays (200 mg/l) was done to find any escape of transgenic or low expression on the transgene. All the seedlings were survived after kanamycin spray showing optimum expression of the transgene. Eight seedlings of each event were transplanted in insect-proof net house.

Pyramiding of *AtDREB1A and BcZAT12* transgenes for abiotic stresses: Pyramiding of *AtDREB1A* and *BcZAT12* transgenes were done by crossing both the transgenic lines in a reciprocal manner. The F7 plants expressing *AtDREB1A* and *BcZAT12* transgenes gene were tested by PCR amplification for both *AtDREB1A* and *BcZAT12* specific primers and scored according to banding patterns. Progenies having both the transgenes were further used for morphological and physiological characterization for generation advancements.

***In-vitro* curd regeneration of heat tolerant cauliflower genotype:** *In-vitro* curd regeneration of a novel heat tolerance cauliflower genotype (75-1) capable of curd formation above 42°C during the month of May studied. The twelve days old curd (150-200 gm weight) were collected from field and thoroughly washed under tape water. Under aseptic condition curds were sterilized with the help of 4% w/v sodium hypochlorite for 10 min. The sterilized curds were cut into small pieces (approximately 1.0 cm) and inoculated on MS medium with or without containing plant growth regulators (PGR) (0,

0.2, 0.5, 1.0 and 2.0 mg/L 6-Benzylaminopurine, kinetin or zeatin). In all the media combination except media without PGR responded 100%. The highest regeneration (87%) and highest number of plantlets per explants 9 was obtained in MS medium supplemented with 1 mg/L zeatin followed by 1mg/L BAP (78% and 6 explant) and 1mg/L kinetin (69% and 5 explant). Fully regenerated (2-5 cm long) plantlets were transferred to root induction medium, MS containing 0.1 mg/L NAA. The well rooted plantlets were removed from the medium, washed with sterile, distilled water, and used for hardening. The rooted plantlets were transferred to a mixture of sterile coco pit and Boro kit (1:1) for acclimatization and irrigated with fungicide solution (Bavistin, 5% w/v). After about two weeks, the acclimatized plants were transferred to pots containing soil for further growth and transfer to open field.

Development of male sterility trait in tomato: The gRNA cassette targeting pollen specific SlCRK1 gene synthesized earlier in pUC57 vector was digested out using BamHI and SacII restriction enzymes and further cloned in the binary vector pORE-O4 containing Cas9 gene governed by CaMV35S promoter. The binary vector after confirmation by digestion and sequencing mobilized in Agrobacterium tumefaciens LBA4404 strain for subsequent tomato transformation. The process of standardization of regeneration protocol for tomato genotype P18 is in progress.

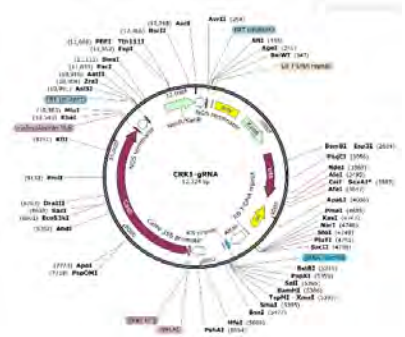


Fig. 32: Representative vector map of binary vector pORE-O4 containing gRNA and Cas9 cassettes for development of male sterility trait in tomato.

Development of multiple disease resistance in tomato: Various diseases in tomato severely affects yield and quality of tomato fruits. Therefore, the work has been initiated to develop multiple disease resistance in tomato using genome editing technology. The downy mildew resistance 6 (SlDMR6) and pectate lyase (SlPL) genes were selected as targets for CRISPR/Cas9 mediated mutagenesis after thorough literature survey. The mutation in these genes will confer resistance against Bacterial speck (*Pseudomonas syringae* pv. Tomato) Phytophthora blight (*Phytophthora capsici*) Powdery mildew (*Pseudoidium neolycopersici*) and grey molds along with firm fruits with longer shelf life. For this purpose, multiplex genome editing gRNA cassette has been synthesized for targeting two sites in each gene for effective mutation. The gRNA cassette is synthesized in pUC57 vector, and it is further cloned in binary vector pORE-O4 containing Cas9 cassette. Kashi Aman cultivar of tomato having Ty genes for resistance against ToLCV is selected for the work. The regeneration protocol for genotype has been standardized.

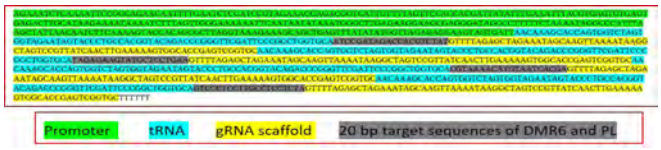


Fig. 33: gRNA cassette sequence for multiplex editing of SlDMR6 and SlPL genes

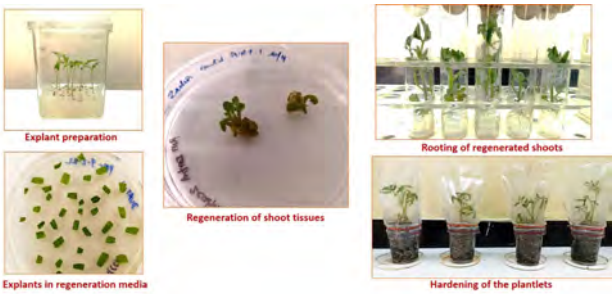


Fig. 34: Regeneration protocol of ToLCV resistant Kashi Aman tomato genotype

Guide RNA designing for increasing high total soluble solid (TSS) content in tomato: Tomato is an important vegetable crop in the world for both fresh consumption and making processing products such as ketchup, sauce, paste etc. In our country, most of tomatoes are consumed as fresh for vegetable purpose, and hardly < 1% is only processed for making processed products compared to the developed countries like Italy (64.02%), Spain (39.41%) and USA (10.34%). Hence, there is a need of suitable varieties for processing purpose for year-round cultivation to sustain the processing industries in the country with suitable growing regions. Earlier some varieties were developed in the country but currently these varieties are not suitable for processing due to lack of processing parameters especially high total soluble solid (TSS) (> 5.5°Brix) required by processing industries. To address these issues, we applied genome editing technology for enhancing TSS content in tomato. We selected two candidate genes namely the vacuolar invertase inhibitor gene *SlINVINH1* (*Solyc12g099200.1*) and the vacuolar processing enzyme *SlVPE5* (*Solyc12g095910.1*) and downloaded the sequences from the tomato genome sequence database. Both the genes negatively regulate the sugar accumulation and involved in enhancing TSS content in tomato. The guide RNAs were designed using CRISPRdirect tool (https://crispr.dbcls.jp) such as *SlVPE5* (TCGGAAGCTTCCAGATTCTT/TGCGTATCAGCTATTGAGAA) and *SlINVINH1* (GCTATGTTGCTAGTAACAAG/CCTCAAGCTTGGAAAGATCC) for further cloning and regeneration of plants.

Impact of *Bacillus*-based microbial inoculants on performance of tomato plants: Three talk-based bioformulations of *Bacillus* species (BV4, BV5 and BV7) were evaluated on tomato (Kashi Aman) in concomitant applications as seed priming followed by seedling root-inoculation prior to transplanting under green-house conditions. After seed priming, seeds of tomato were

Fig. 35: Impact of the bioformulation BV7 and BV4 priming and root-inoculation on tomato

equally germinated with >88% germination. However, the performance of plants primed with BV5 was not satisfactory 8 days after transplantation but bioformulations of BV4 and BV 7 along with the control performed well. Fruit yield in the primed plants was 27.62±1.79 and 29.84±2.23 respectively in BV4 and BV7 compared to 24.76±2.43 in control, suggesting that multiple application of the bioformulations enhanced fruit yield. Tomato fresh wt was 77.8±1.38 g per plant in control but in bioformulation priming, the production was enhanced to 83.4±1.62 and 84.2±2.52 respectively in BV4 and BV7. In bioformulation primed plants, fruit size was also enhanced to almost 6-7% with early fruit and flower bearing compared to control. Protein content of the fruits of BV4 and BV7 treated plants varied from 16.28±0.67 (BV4) and 16.37±0.39 (BV7) compared to control (15.48±0.37) mg/100g FW. Likewise, fat content in the fruit was 0.742±0.043 (BV4) and 0.79±0.022 (BV7) and 0.731±0.018 in control showing a non-significant difference in the fat content in the fruits. Total sugar content in BV4 treated fruit was 2.87±0.078 and in BV7 treatment it was 2.93±0.043 g/100g FW compared to 2.34±0.063g in control. Total soluble sugar (TSS) content (°Brix) was 7.74±0.18 (BV4) and 7.96±0.022 (BV7) g/100g FW in comparison to 6.68±0.038g in control fruits. Likewise, the content of lycopene, ascorbic acid, tocopherol, carotenoids (total), flavonoids (total) and polyphenolics (total) was also substantially enhanced by the treatment of BV4 and BV7 bioformulations separately. Overall, both the *Bacillus* species have primarily shown positive impact on crop performance of tomato in green house conditions. They will be further evaluated in the both the green-house and field conditions on more rigorous biochemical and molecular traits to establish them as bioproducts for field applications.

Project 1.14: Genetic Improvement of Underexploited and Future Vegetables

Winged Bean

Evaluation & characterization of genotypes: A total of 266 germplasm, segregating population and advanced lines of winged bean were characterized for different horticultural traits viz., pod colour (light green, green, dark green, purple-green colour and dark purple colour), average days to anthesis (63-76), days to edible maturity (12-22), pod length (17.5-26.5 cm), pod weight (21.3-23.9 g), pod per cluster (2-3.8), pods per plant (111-198), yield per plant (2260.0-3730.0 g), dry weight per pod (2.2-4.2 g), tuber length (11.0 -15.8 cm), tuber width (1.25 – 2.78 cm), number of tuber per plant (4-7) and tuber yield per plant (220 -1100 g). Varying populations viz., VRWBH 3-17, VRWB12-18, VRWB29-18, VRWBH- 30-18, VRWB -30, VRWB- 43, VRWB-69, VRWB- 94 and VRWB-102 were identified as promising for green pod yield and related traits and genotype VRWB-50 and VRWB-19 were adjudged as promising for tuber yield and associated traits.

Fig. 36: Fruiting in genotype VRWB-102

Fig. 37: Fruiting in genotype VRWB-30

Advancement of generation: Total 35 F_1 lines were advanced to F_2 population. 18 F_2 lines were advanced to F_3, 15F_4 to F_5 and 11 F_5 to F_6 generations.

Vegetable Soybean

Maintenance of soybean germplasm: A total of 45 genotypes of soybean were maintained, including the commercial released varieties, indigenous and exotic collections.

Fig. 38: Newly augmented genotype VRWC-38

Evaluation of advanced breeding lines: A total of four advanced breeding lines *viz.*, AGS-110 × *Swarna Vasundhara*, *Swarna Vasundhara* × AGS-406, *Swarna Vasundhara* × SLV and *Swarna Vasundhara* × *Kala Bhatt* were grown and advanced through single plant selection to F_6 generation. The selection of plants was done on the basis of horticulture parameters as well plant showing resistance to YMV.

Water chestnut

Germplasm augmentation and multiplication: Total 5 new accessions were augmented from different parts of the country. These lines was characterized for and multiplied for next season.

Germplasm characterization: Thirty six genotypes of Water chestnut were grown in water ponds were characterized for different horticultural traits. Average number of leaves per plant varies between (25.8-38.0), number of fruit per plant (2-4.8), Average leaf length (2.6 - 4.6 cm), average leaf width (5.0- 6.5 cm), average fruit pedicel length (4.2 -5.8 cm), number of

spine per fruit (2 - 2.0), average fresh fruit weight (11.0-14.5 g), average shelled fruit weight (5.4 -11.6 g), Dry fruit weight (0.42- 3.0 g), dry matter content (7.2-21.7 %), TSS (4.4- 6.5 ^{0} Brix) and fruit yield per pond (20.5-26.50 kg). Among the genotypes, VRWC-1, VRWC-3, VRWC-23, VRWC-26, VRWC-29 adjudged as promising genotype for dry matter content and fruit yield. Genotype VRWC-4, VRWC-24 was found with green husk colour.

Fig. 39: Genotype VRWC-23

Fig. 40: Genotype -24

Fig. 41: Genotype-29

Lotus

Standaridization of lotus germination in pot culture: Seven genotypes of lotus were evaluated for their germination and plant stand. After scarification, seeds were sown in pots and standard package of practices were followed to raise healthy plants. On the basis of morphological growth pattern of seedlings on the basis root length, number of leaves formed and overall growth of the plants genotype VRL-1 and VRL-3 were found to be promising for direct seed sowing after scarification for raising of healthy plants.

Fig. 42: Raising of healthy seedlings of lotus through direct seed sowing after scarification

Characterization, evaluation & maintenance of different species of lotus: Six genotypes of *Nelumbo nucifera* and one species of *Nelumbo lutea* were characterized for different horticultural traits. VRL-1, VRL-6 and VRL-7 were found to be promising for early flowering and rhizome yield per plant.

Fig. 43: Nelumbo lutea

Fig. 44: Nelumbo nucifera

Water Spinach

Germplasm augmentation: Three new germplasm lines were augmented from Mirzapur, Jaunpur and Ghazipur districts of Uttar Pradesh. These lines were characterized for various horticulture traits and crop plants were multiplied for next season.

Fig. 45: Field view of upland cultivation of different genotypes of water spinach

Germplasm characterization: A total of 20 germplasm lines of water spinach were characterized for different horticultural traits viz., leaf length (4.30-11.5 cm), petiole length (4.2-6.3 cm), leaf width (2.1- 6.5 cm), number of vine/plant (3.0- 4.8), vine length (50.0- 60.0 cm), internodal length (3.2 -7.6 cm), number of nodes / vine (8-14), number of cuttings /month (3-5) and fresh weight of 50 leaves (45.0-95.0g). The genotypes VRWS-1, VRWS-28, VRWS-31 and VRWS-32 were found to be promising for different horticultural traits.

Evaluation of different genotypes of Water spinach in upland field condition: Water spinach is commonly grown in waterlogged areas. However, such cultivation requires cumbersome practices for plant protection measures and harvesting. This also invites water pollutants harmful for human health. Therefore, an attempt was made for evaluation of genotypes viz., Kashi Manu (VRWS-1, seed sown), VRWS-28 (seed sown), VRWS -31 (seed sown) and VRWS-32 (seed sown) and genotypes VRWS-31, VRWS-32 and VRWS-33 were planted through cuttings in upland field condition. On the basis of overall evaluation the genotype VRWS-1 found to be promising for different horticultural traits. Genotypes VRWS-31 and VRWS-32 (planted through cutting) found superior for different horticultural traits. This technology can prove to be simple for cultivation round the year which can serve as boon for the socio-economic upliftment of farmers.

Fig. 46: Kashi Manu - Field view at ICAR-IIVR, Varanasi

Fig. 47: Water spinach - Field view at Farmer's field

Estimation of proximate composition in different genotypes of water spinach: Proximate composition of 4 genotypes viz., VEWS-1, VRWS-28, VRWS-31 and VRWS-32 of water spinach was done. Wide range of variability for Calcium (45.94-141.92 mg/100 g), Iron (3.53-59.67 mg/100 g), Magnesium (139.43-462.22 mg/100g), Zinc (1.06-1.85 mg/100g), Carbohydrates content (59.46-77.29 mg/100g), Ash content (3.04-8.38 %), Fat content (0.31-1.1 %), Calories (5.95-11.95 Kcal), Cadmiun

(0.00-0.02 µg/l) and Vitamin A (133-168 mg /100g) observed and found that water spinach crop could be promoted as one of the potential leafy vegetable crop for round the year availability and nutritional security.

Cultivation of water spinach in pot, suitable for round the year production in vertical gardening: Eight genotypes of water spinach viz., VRWS-1, VRWS-28, VRWS-29, VRWS-30, VRWS-32, VRWS- 33, VRWS-34, VRWS-37 were evaluated for total leaf biomass yield (kg/ month) and duration of the crop for economical yield (months). Water spinach genotype VRWS-1 is found to be one of the potential leafy vegetable crop for round the year cultivation and maximum leafy biomass yield (3.7 kg/month). Hence, genotype VRWS-1 could be promoted as one the suitable crop loaded with nutrients for vertical gardening to ensure regular supply of leafy vegetable particularly for urban dwellers.

Fig. 48: Cultivation of water spinach var Kashi Manu in pot suitable for vertical farming

Spinach beet [*Beta vulgaris* L. subsp. vulgaris (Cicla Group)]

Sixteen genotypes were evaluated for yield/morphological traits during winter season and three during off seasons (spring, summer, rainy & autumn). Biomass yield of best three genotypes namely VRPLK-2, VRPLK-3 and VRPLK-7 ranged from 600-710 q/ha during winter sown crop. The biomass yield of VRPLK-2, VRPLK-3 and All Green was 140, 122 & 63 q/ha in mid-February; 205, 186 & 120 q/ha in mid-May; 450, 461 & 311 q/ha in mid-August; and 650, 689 & 490 q/ha in mid-October sowing which is respectively 122.2 & 93.7%; 70.8 & 55.0%; 44.7 & 48.2%; and 32.7 & 40.6% higher than check variety All Green. Furthermore, VRPLK-31, VRPLK-2 and VRPLK-3 showed delayed bolting habit i.e. 15-40 days as compared to other lines. Two genotypes VRPLK-2 and VRPLK-3 are in multi-location testing under varietal trial of AICRP-VC. VRPLK-2 has been registered as Unique Germplasm (INGR22086) by ICAR-NBPGR, New Delhi in July 2022. IC number was allotted for two genotypes VRPLK-3 (IC0642949) and VRPLK-12 (IC0642948) by ICAR-NBPGR, New Delhi.

Fig. 49: Performance of VRPLK-2 (Kashi Baramasi)

Leafy chenopod (*Chenopodium album*, Bathua)

The genetic purity of two varieties of leafy chenopod i.e. Kashi Bathua-2 (green leaves) and Kashi Bathua-4 (purplish-green leaves) are being maintained by producing 4-5 kg of basic seeds of each variety. The biomass yield potential of both varieties is ranged from 375-400 q/ha in 4-5 cutting. IC number was allotted for a genotype VRCHE-7 (IC0642947) by ICAR-NBPGR, New Delhi.

Velvet Bean

Fig. 50: Velvet bean-genotype-VRVB-1

Characterization & evaluation of genotypes for different horticultural traits: Four genotypes viz., VRVB-1, VRWB-2, 2886/2376 and 2886/2377 of velvet bean were characterized for percentage germination, vigour index, plant habit, stem colour, main leaf petiole length (cm), petiolule length (cm), foliage colour, calyx colour, corolla colour, pod colour, pod length (cm), pod width (cm) and number of pod per peduncle. Germination percentage varied from 89-95 %, medium to vigorous, light green to green stem colour, main leaf petiole length (17.2-36.25 cm), petiolule length (2.6-4.6 cm), foliage colour (green, yellowish green, dark green), calyx colour (light green-green), corolla colour (bluish purple), pod colour (yellowish green, blackish green), pod length (10-15 cm), pod width (1.6-2.7 cm) and number of pod per peduncle (4-21). Genotype VRVB-1 is found to be promising for number of pod, pod yield per plant.

Fig. 51: Field day of Baby corn hybrid IIVRBCH-1927

Baby Corn

Germplasm maintenance: Twenty-Six sweet corn inbred and fifty five baby corn inbred lines were maintained.

Hybrid evaluation: Five baby corn single cross hybrids (selected from 26 hybrids of previous year) namely, BC3 × BC4, SC19 × SC27, BC35 × BC51, BC46 × BC51 and SC16 × BC13 along with popular baby corn hybrid HM-4 were evaluated for yield and quality characters. Finger yield was not critically different among the hybrids ranging from (1.91 to 20.21 MT/ha). BC35 × BC51 was rejected due to its irregular ovule arrangement on the finger. SC16 × BC13 was submitted to AICRP-Maize for multilocation testing. Field demonstration of baby corn hybrid SC19 × SC27 (IIVRBCH-1927) was conducted in three farmer fields of Shahanshahpur in 500 m^2 area each. Prolificacy (cobs per plant) of the hybrid was 3 to 5 cobs. On an average 111 Kg of baby corn was harvested from each field. On 12.12.2022 filed day was organized in the presence Dr. TK Behera, Director of the institute and Dr. PM Singh, I/C Head, Vegetable improvement.

Advancing segregating families for high prolificacy: Thirty eight advanced segregating (F_4 to F_6) families with cob number 3-5 per plant were advanced to the next generation.

Laipatta

Laipatta Breeding Programme: A total of 25 germplasms of Laipatta were grown and maintained by selfing during rabi 2022-23. Data for leaf length, width, colour etc. was recorded for the germplasm. In the segregating generation, 336 F_3 progenies were grown and the single plant selection (SPS) were done for identification of delayed flowering and vigorous growth habit. Based on late flowering a total of 176 genotypes were selected and advanced to F_4 while 160 families were rejected. The genotypes VRLP-33, VRLP-2, VRLP-8, VRLP-16, VRLP-12 VRLP-21 and VRLP-32 were very late in flowering. The genotypes VRLP-33, VRLP-22, VRLP-21, VRLP-16, VRLP-8, VRLP-27 and VRLP-23, VRLP-26 were promising for green yield. The two genotypes VRLP-33 and VRLP-8 were very late in flowering, thus having advantage of green yield harvesting for large number of cuttings. The leaf glucosinolate content was also estimated for the germplasm lines (Fig. 52). The genotypes VRLP-2, VRLP-6 and VRLP-33 were having a high content of glucosinolate.

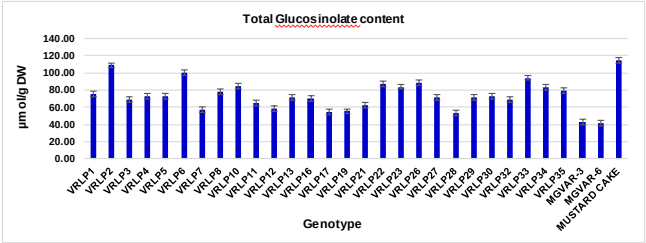


Fig. 52: Glucosinolate content of laipatta genotype estimated from the leaf powder

Amaranthus

The amarathus crop was raised during summer and *kharif* 2022, and a total of 107 and 102 germplasm were evaluated for yield and horticultural trait respectively. Out of the 102 germplasms, eighty-one were of *Amaranthus tricolor*, five each of *A. hypochondriachus, A. dubius,* and *A. mangostanus,* three of *A. lividus,* two of *A. virdis,* and one of *A. caudatus* respectively. Among the promising *A. tricolor* genotypes identified last year, a station trial was conducted for nine genotypes in a block of 5 m × 10 m in two replications with checks Pusa Kirti, Arka Suguna and Kashi Suhaavani. The best performing three genotypes were VRAM-44 (394.52 q/ha), VRAM-45 (377.25 q/ha), VRAM-17 (338.52 q/ha). One genotype VRAM-324 was identified as bushy genotype with large number of branching. This genotype is suitable for planting during summer and *Kharif* seasons with added advantage that the plants does not lodge during seed production. This year, one genotype VRAM-324 has been proposed for AICRP (VC) testing while the two genotypes VRAM-44 (red) and VRAM-308 (green) entered the AVT-II varietal evaluation trials of AICRP(VC). The estimation of leaf betalain content was also done for the promising lines of amaranthus (Fig 53). The genotypes VRAM–343, VRAM–338, VRAM–28, VRAM–45, VRAM–23 and VRAM–44 were having high betalain content (Fig. 53).

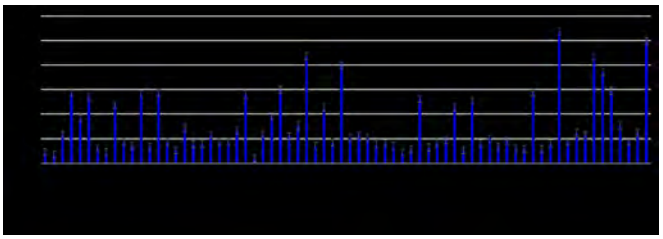


Fig. 53: Betalain content of different genotypes of amaranthus (representative) estimated from leaf

AICRP trials conducted: Two varietal trials relevant to this project were conducted namely in Amaranth (AVT-I), and Laipatta (IET) during the year.

Project 1.15: Genetic Improvement of vegetatively propagated and perennial vegetable crops

Pointed gourd

Status of germplasm: In pointed gourd 82 accessions of diverse female clone showing variability for fruit size, fruit

shapes and colour *i.e.,* round, oval, elliptical and oblong; dark green, green, light green fruit colour; fruits with or without white stripes on the surface and seeded, less seeded or seedless were maintained *in-situ* at IIVR. Additionally, 22 accessions of 4 different species of crops wild relatives (CWRs) of pointed gourd were also maintained at IIVR.

Variability for horticultural traits in pointed gourd germplasm: A total of 80 female clones of pointed gourd were evaluated during summer and rainy season 2022 for various morpho-horticultural characters like days to first flowering after sprouting, first harvesting node, length of the inter node, fruit length, fruit diameter, fruit weight, number of fruits/ plant, yield/ plant and seed per fruit. On the basis of yield/plant and suitability for confectionary purpose VRPG-217, VRPG-219 and VRPG-188 were found to be promising female clones.

Fig. 54: Variability in pointed gourd female clone

Production of planting material and clonal multiplication of selected clones in pointed gourd: About 3000 planting materials of Kashi Alankar, Kashi Suphal, Kashi Parwal-141 and Kashi Amulya were produced and 1500 planting materials distributed to the farmers of Uttar Pradesh and Bihar. All the advance lines of pointed gourd were clonally multiplied to enhance the plant population. Beside this, approximately 100 planting materials were produced for VRPG-103, VRPG-171 and VRPG-173 for farmers field trial.

Teasle Gourd

Germplasm maintenance, evaluation and characterization: A total of 59 lines of teasle gourd were maintained and evaluated for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2022. Significant differences were observed in the germplasm for all the traits studied. For earliness related traits, the genotypes VRSTG-24, VRSTG-32 and VRSTG-56 were found as most promising genotype. Maximum fruit yield per plant was observed in genotype VRSTG-22 (1.85 kg) followed by VRSTG-54 (1.77kg), VRSTG-53 (1.63kg), VRSTG-17 (1.43kg) and VRSTG-10 (1.40kg), while it was recorded minimum in VRSTG-19 (0.52kg) with a population mean of 0.94kg.

VRSTG-22 VRSTG-54 VRSTG-53

Spine Gourd

Germplasm maintenance, evaluation and characterization: Twenty eight genotypes of spine gourd were evaluated and characterized for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2022. Maximum average fruit weight was noted in genotype VRSEG-114 (11.68g) followed by VRSEG-32 (10.53g) and VRSEG-109 (9.32g), while it was recorded minimum in genotype VRSEG-112 (5.23g) with population mean of 7.96g. Fruit yield per plant was observed maximum in genotype VRSEG-20 and VRSEG-22 (2.04kg) followed by VRSEG-118 (1.87), VRSEG-109 (1.82) and VRSEG-114 (1.81), while it was recorded minimum in VRSEG-15 (0.21kg) with a population mean of 0.98kg.

VRSEG-22 VRSEG-20 VRSEG-118

Ivy gourd

Germplasm maintenance, evaluation and characterization: Twenty-eight lines of ivy gourd were evaluated for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2022. The genotype VRIG-4 recorded highest average fruit weight (28.03g) followed by VRIG-15 (26.67g) and VRIG-16 (25.22g). Highest fruit yield per plant was observed in genotype VRIG-17 (8.94kg) followed by VRIG-27 (7.63) and VRIG-18 (6.95), while it was lowest in genotype VRIG-35 (0.41kg) with a population mean of 4.19kg.

VRIG-17 VRIG-27 VRIG-18

Basella

A total of 39 basella genotypes were grown in augmented block design during summer season of 2022, and the ontological cycle of the genotypes continued till winter season. Maximum yield per plant was found to be 1.79 kg in VRB-48, the promising genotypes with good per plant yield were VRB–33, VRB-48-8, VRB–16, VRB–19, VRB–32, VRB-43-1 and VRB-73. The betalain content was estimated in all the genotypes using the protocol of Elbe *et al.* (2001). The highest content of betalain was reported in the genotype VRB-23-1 (Fig. 55).

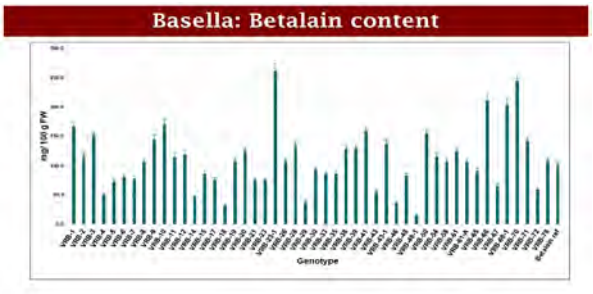


Fig. 55: Betalain content of different genotypes of basella

Moringa

The moringa genotypes were evaluated for flowering and fruiting throughout the year. The 22 moringa selections and two checks (PKM-1 and PKM-2) were evaluated for horticultural traits and fruit yield. The highest fruiting was observed in the genotype VRMO-9 (1290 fruits) followed by VRMO-13 (1040 fruits), VRMO-8 (790 fruits), VRMO-10 (720 fruits), PKM-2 (710 fruits) and PKM-1 (425 fruits). The tissue culture-based regeneration was also tried with the nodal shoots and leaves of the moringa for rapid multiplication. Successful

Table 2: IIVR Varieties (8+1) Notified by Central Gazette Notification (Notification No. 3254(E), 22 July 2022)

Name of Crop & Variety	Important Characters	Recommended Area	Photograph
Brinjal Kashi Brinjal green round (IVBR-17)	Light green, round fruited variety with green calyx. Early fruiting variety bearing 45-55 fruits per plant. Average fruit weight is 275 g and has yield potential of 580-600 q/ha.	Punjab, U.P., Bihar and Jharkhand	
Cowpea Kashi Vishan	Erect and determinate with bushy growth. Pods 34-39 cm long, tender, dark green, parchment free with av. 10 pod weight of 148g. Days to 50% flowering occurs in 46 days after sowing (DAS) and first green tender pod harvest occurs at 55 DAS. Average pod yield 140-160 q/ha. Resistance to cowpea golden mosaic disease	Punjab, U.P., Bihar and Jharkhand	
French bean Kashi Agrim (VRFBB-91)	Bush-type, bears purplish flowers. Pods green & bright in colour, fleshy, tender, straight, cylindrical and free from parchment. It bears 20-25 pods/plant which are 15-16 cm in length, 0.8-0.9 cm in width and 6.5-6.6 g in weight. Tolerant to sclerotinia rot (*Sclerotinia sclerotiorum*) disease. Pod yield potential 125-150 q/ha.	J&K, H.P. and Uttarakhand	
Carrot Kashi Arun (VRCAR-186)	Roots are attractive red in colour, 21-23 cm in length, 110-125 g in weight, 8.5-9.0°B TSS and Danvers (triangular) in shape. Good source of lycopene (7.25-7.50 mg/100 g FW) and beta-carotene (3.5-3.7 mg/100 g FW). Ready to harvest in 90-100 days after sowing. Marketable root yield potential: 250 q/ha.	M.P., Maharashtra, Goa, Karnataka, T.N., Kerala and Puducherry	
Indian bean Kashi Bauni Sem-9	Bush type, plant height 70-75 cm. Days to first picking is 70-75. No staking is required. Pod length 9.66 cm, width 2.22 cm, pod wt. 8.07g. Average yield 26.48 t/ha. Free from Dolichos Yellow vein mosaic virus during cropping period. Has ability to tolerate a day temperature of upto 35 C.	M.P., Maharashtra and Goa	

Indian bean Kashi Bauni Sem-3	Bush Type, plant height 80-85cm. Days to first picking is 80-85. No staking is required. Average yield 28.81 t/ha. Pod length 12.5-14.2cm, pod width +1.8-2.0cm per pod and weight 7.5-80.g. Free from Dolichos Yellow Vein Mosaic Virus during cropping period. Has ability to tolerate a day temperature of upto 35 ^{0}C.	Delhi, Rajasthan, Haryana, Gujarat, M.P., Maharashtra, Goa, Karnataka, T.N., Kerala and Puducherry	
Sponge gourd Kashi Kalyani (VRSG-195)	Fruits are Dark green. Average fruit yield 150-200q/ha. Tolerance against downy mildew and virus disease under field conditions	Punjab, U.P., Bihar and Jharkhand, Rajasthan, Delhi, Haryana and Gujarat	
Pumpkin Kashi Basant (VRPK-230)	Early, flat round, mottle green colour, medium fruit with high yield. Tolerant to pumpkin mosaic virus and downy mildew.	Chhattisgarh, A.P. and Odisha	
Brinjal hybrid Kashi Manohar (IVBHL-20)	Light purple, medium long fruited hybrid with green calyx. Early fruiting hybrid bearing 90-100 fruits per plant. Average fruit weight is 93 g having yield potential of 625-650 q/ha.	M.P., Maharashtra and Goa	

Table 3: IIVR Varieties (15) and Hybrids (4) Recommended for Notification by SVRC of U.P. on 28th October 2022

Name of Crop	Name of Variety	Name of Crop	Name of Variety	Name of Crop	Name of Variety
Varieties		Winged bean	Kashi Annapurna	Water Spinach	Kashi Manu
Amaranth	Kashi Chaulai-1	Longmelon	Kashi Vidhi	Pointed gourd	Kashi Parval-141
Spinach beet (Palak)	Kashi Baramasi	Round melon	Kashi Hari	**Hybrids**	
Bitter gourd	Kashi Pratistha	Watermelon	Kashi Mohini	Chilli hyb.	Kashi Garima
Bottle gourd	Kashi Shubhra	Vegetable Pea	Kashi Purvi	Radish hyb.	Kashi Rituraj
Brinjal	Kashi Uttam	Vegetable Pea	Kashi Tripti	Tomato hyb.	Kashi Adbhut
Faba bean	Kashi Sampada	Okra	Kashi Utkarsh	Tomato hyb.	Kashi Tapas

regeneration was observed with nodal shoots while the leaves were not able to regenerate.

Table 4: IIVR Varieties (2+1) Identified in 40th Group Meeting of AICRP (VC) held at ICAR-IIVR, Varanasi from 15-17 June, 2022

Name of Crop & Variety	Recommended Area
Indian Bean (VRB SEM – 207)	U.P., Bihar, Punjab, Jharkhand, Delhi, Haryana, Rajasthan, Gujarat
Okra Resistant Variety (VRO-119)	Delhi, Haryana, Rajasthan, Gujarat
Brinjal hybrid (IVBHL-22)	M.P., Maharashtra and Goa

Sharing of germplasm through Material Transfer Agreement: During 2022, a total of 1183 accessions in 14 crops and one bacterial culture were supplied to 35 organizations through Material Transfer Agreement (MTA) Table 5.

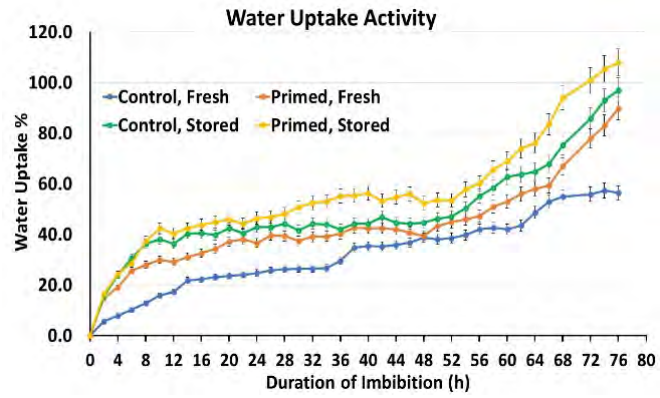
Table 5: Details of the sharing of germplasm through MTA

Crop	*Institutions/Organizations*
Tomato (330)	CSA University of Agriculture and Technology, Kanpur (20); School of Agriculture and Allied Science, Graphic Era Hill University, Dehradun (50); School of Agriculture, ITM University, Sithouli Campus, Gwalior (35); ICAR-Central Coastal Agricultural Research Institute (CCARI), Old Goa (18); College of Horticulture and Forestry, Neri, Hamirpur-177001 (HP) (20); Integral Institute of Agriculture Science and Technology (IIAST),Integral University, Lucknow (30); School of Agriculture, Lovely Professional University, Phagwara (20); Dr. YS. Parmar University of Horticulture and Forestry, Nauni, Solan (15); M/s VNR Seeds Pvt. Ltd, Corporate Centre, Raipur (04); Department of Biotechnology, IIT Kharagpur, Kharagpur (02); College of PG Studies in Agriculture Science, Umiam, Meghalaya (5); BUAT, Banda (40); MJ College Jalgaon, Maharashtra (10); SVPUA&T, Merrut (50), BHU, Varanasi (1); GH Raisoni University, Chindwara (10)
Chilli (106)	CSA University of Agriculture and Technology, Kanpur (16); School of Agriculture, ITM University, Gwalior (20); ICAR-CTRI Research Station, Dinhata, Cooch Behar District, W.B. (25); Sam Higgingbottom University of Agriculture technology and Sciences, Prayagraj, U.P. (20); CCSHAU, Hisar (25)
Brinjal (203)	School of Agriculture, ITM University, Gwalior (15); Rajasthan College of Agriculture, MPUAT, Udaipur (30); College of Agriculture, Vellayani, Thiruvananthapuram, Kerala (50); M/s VNR Seeds Pvt. Ltd, Corporate Centre, Raipur (02); Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P (24); Sam Higgingbottom University of Agriculture technology and Sciences, Prayagraj (25); ICAR-IIHR, Bengaluru (5); Lovely Professional University, Ludhiana (30); Department of Botany, BHU, Varanasi (2); SVPUA&T, Meerut (20)
Okra (195)	Vasant rao Naik Marathwada Krishi Vidyapeeth, Perbhani (25); Moolji Jaitha College, Dept. of Botany, Jalgaon (25); Dr. YS Parmer University of Horticulture and Forestry, Nauni (25); ITM University , School of Agriculture, Gwalior (25); School of Agriculture, Lovely Professional University, Phagwara (20), BRPD College, Deoria (25), CSAUA&T Kanpur (25); Sam Higgingbottom University of Agriculture technology and Sciences, Prayagraj, U.P. (25)
Vegetable pea (157)	School of Agriculture, Graphic Era Hill University, Dehradun (40); School of Agriculture, ITM University, Gwalior (20); COH, BUAT, Banda (15); World Vegetable Center, Guwahati (07); Ramlalit Singh Mahavidyalaya, Kailahat, Chunar, Mirzapur Dist (25); Sri Karan Narendra Agriculture University, Jobner (25); Shri Mukti Manohar town PG College, Ballia (25)
Cowpea (55)	Banda University of Agriculture and Technology, Banda, U.P. (35); Graphic Era hill University, Dehradun (20)
French bean (49)	Banda University of Agriculture and Technology, Banda, U.P. (15); Graphic Era hill University, Dehradun, (15); Lovely Professional University, Ludhiana (15); Shiksha 'O' Anusandhan , Bhubneshwar (4)
Indian bean (11)	ICAR-IARI, Hazaribagh (11)
Radish (24)	College of Horticulture, KSNUAHS, Mudigere, Shivamogga (11); College of Horticulture and Forestry, Neri, Hamirpur, H.P. (11); Babasaheb Bhimrao Ambedkar University, Rae Bareli, Lucknow, U.P. (02)
Cauliflower (1)	Institute of Agriculture Science, BHU, Varanasi (1)
Pointed gourd (02)	Banda University of Agriculture and Technology, Banda (02)
Pumpkin (16)	Banda University of Agriculture and Technology, Banda (16)
Amaranthus (30)	Ramlalit Singh Mahavidyalaya, Chunar, Mirzapur (30)
Basella (3)	Department of Botany, Institute of Science, BHU, Varanasi (3)
Culture of *Phomopsis vexans* (1)	SVPUA&T, Meerut (1)

MEGA PROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES

Project 2.1: Priming, Coating, Ovule Conversion and Seed Enhancement Studies

Studies on seed dormancy in bitter gourd: The seed dormancy or non-germinability of freshly harvested seed of bitter gourd was addressed through after ripening by storing the freshly harvested seed of bitter gourd varieties Kashi Mayuri and VRBTG-10 at room temperature in air tight box. Seed germination was tested at every three-month interval (at 0, 3, 6 month). Results showed drastic increment in seed germination with advancement of storage duration. Physio-biochemical analysis of stored seeds showed significant changes in water uptake activity, ROS, MDA content, hydrolytic enzymes activity (amylase and protease) and antioxidant enzymes (SOD, CAT, POD, APX, GSH, GSSG and total glutathion) activity with advancement of storage duration. This study shows the presence of morpho-physiological dormancy in bitter gourd, which may be due to hard seed (inability of water uptake) and higher internal ABA content in freshly harvested seed (Fig. 56 to 58). Besides, increase in germination after storage may be due to change in physio-biochemical parameters of seed quality.



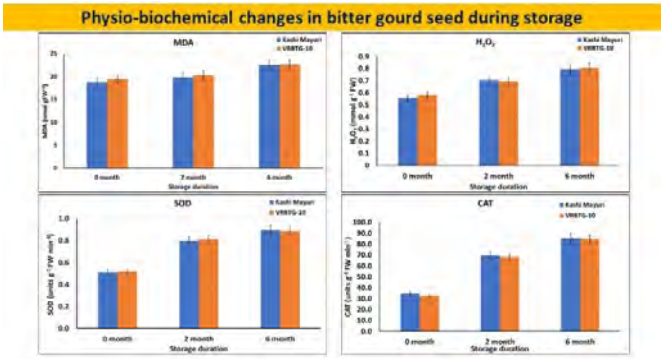


Fig. 56: Water uptake, MDA, ROS, SOD and CAT activity in stored seed

Moreover, differential level of dormancy was observed in seed harvested at different pickings. Seed harvested in early picking showed better seed quality and low level of dormancy as compared to seed harvested in later pickings.

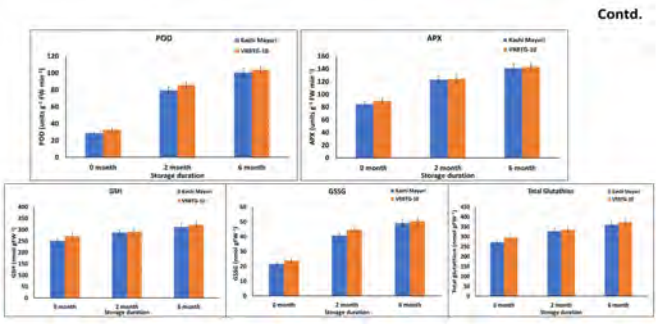
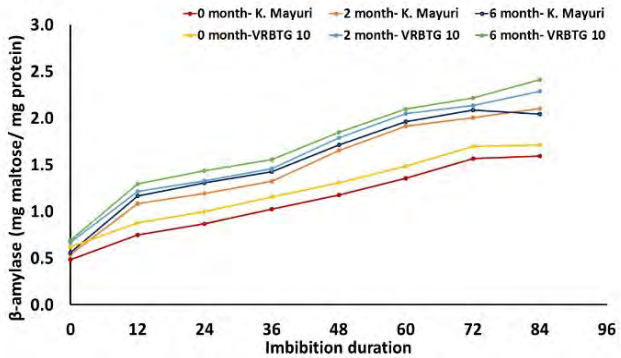


Fig. 57: Antioxidant activity in stored seed of bitter gourd



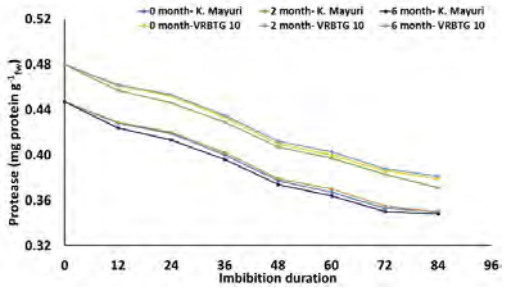


Fig. 58: hydrolytic enzymes activity with attainment of germination in bitter gourd seed during storage at room temperature

Standardization of post-harvest ripening (PHR) duration and seed extraction in ash gourd: Since the manual seed extraction of ash gourd is time and labour intensive, therefore post-harvest ripening duration and seed extraction protocol in ash gourd was standardized. Fruits were cut using cutter and pulp was scooped. Pulp was handled with various treatments i.e. manual extraction, acid, alkaline and fermentation. Like last year, allowing pulp for 24 to 48 hrs to ferment gave the best quality seed as compared to other treatments including manual extraction. Additionally, post-harvest ripening (PHR) of fruit for 20-30 days under room temperature at Varanasi conditions before seed extraction gave the best quality seed as compared to seed obtained from freshly harvested fruits.

The number of seeds per fruit and seed dimensions were consistent among the PHR treatments, whereas, 100-seed weight was significantly increased in 20-day PHR (7.19 g) and 30-day PHR (7.23 g) as compared to non-PHR (0-day) treatment (6.95 g). The seed moisture content (mc %) declined gradually with increment of PHR duration. During the PHR, the seed reserves such as TSS, TSP and total starch significantly varied. Starch, being the major seed storage reserve in ash gourd, increased (1.07-fold) with advancement in PHR periods from 0 to 30 days whereas, TSS decreased (1.16 fold) with PHR period from 0 to 30-days. likewise starch, TSP content increased (1.09-fold) with increasing PHR period, which could be attributed to intracellular interconversion of free amino acids. As a result, it can be deduced that the seed as sink continues to receive accumulations from the fruit as PHR durations advance, resulting in an increase in 100-seed weight and the development of bolder seeds. Further, during PHR, increased dehydrogenase activity, lower EC, and balanced ROS and antioxidant production resulted in improved seed germination and vigour. Further, PHR allows the immature seed to mature within the fruit and prevents drying damage, resulting in reduced ROS generation and, as a result, reduced antioxidants. Thus, 20-30 days PHR in ash gourd is recommended because numerous physio-biochemical changes related to dormancy release and germination enhancement occur during PHR.

Breeder and TL seed production of important vegetable crops: A total of 20197.00 kg vegetable seeds of ICAR-IIVR varieties of tomato, brinjal, chilli, okra, cowpea, pea, bottle gourd, bitter gourd, pumpkin, cucumber, sponge gourd, ridge gourd, ash gourd, radish, French bean, Indian bean, carrot,

Table 6: TL Seed produced during 2022 at ICAR-IIVR, Varanasi

Crop	*Variety*	*Qty TL Seed (Kg)*	*Crop*	*Variety*	*Qty TL Seed (Kg)*
Tomato	Kashi Chayan	1.75	Pumpkin	Kashi Harit	5.70
Tomato	Kashi Aman	64.70	Muskmelon	Kashi Madhu	5.80
Tomato	Kashi Adarsh	44.50	Bottle gourd	Kashi Kirti	5.65
Tomato	Kashi Vishesh	4.80	Bottle gourd	Kashi Ganga	90.00
Tomato	Kashi Amrit	3.10	Satputia	Kashi Khushi	13.00
Tomato	Kashi Anupam	1.70	Summer Squash	Kashi Shubhangi	0.20
Brinjal	Kashi Taru	8.00	Bitter gourd	Kashi Mayuri	6.85
Brinjal	Kashi Uttam	19.50	Cowpea	Kashi Shyamal	6.00
Chilli	KA-2 (Kashi Anmol)	89.20	Cowpea	Kashi Unnati	3.00
Chilli	Kashi Abha	5.80	Cowpea	Kashi Kanchan	315.00
Cauliflower	K. Gobhi-25	6.00	Cowpea	Kashi Nidhi	905.50
Radish	Kashi Mooli-40	4.90	Cowpea	Kashi Vishan	5.00
Radish	Kashi Lohit	6.50	French bean	Kashi Sampann	123.00
Radish	Kashi Aardra	55.70	French bean	Kashi Rajhans	447.00
Carrot	Kashi Krishna	19.50	Dolichos	Kashi Haritima	100.80
Carrot	Kashi Arun	92.50	Pea	Kashi Mukti	655.00
Okra	Kashi Chaman	210.00	Pea	Kashi Ageti	3915.00
Okra	Kashi Lalima	274.60	Pea	Kashi Shakti	50.00
Okra	Kashi Kranti	429.00	Pea	Kashi Samridhi	463.00
Okra	Kashi Pragati	188.60	Pea	Kashi Nandini	1579.00
Ridge gourd	Kashi Shivani	24.80	Pea	Kashi Uday	6229.00
Sponge gourd	Kashi Shreya	252.60	Palak	Kashi Baramasi	170.20
Sponge gourd	Kashi Jyoti	40.40	Palak	Kashi All Green	63.80
				Total	17041.20

Fig. 59: Monitoring of vegetable breeder seed crops by the monitoring team

Table 7: Hybrid seed produced during 2022 at ICAR-IIVR, Varanasi and RRS, Sargatia

Crop	Variety	Location	Qty Hybrid Seed (Kg)
Tomato	Kashi Abhiman	ICAR-IIVR, Varanasi	2.65
Brinjal	Kashi Sandesh	ICAR-IIVR, Varanasi	25.90
Cucumber	Kashi Nutan	ICAR-IIVR, Varanasi	7.00
Sponge gourd	Kashi Rakshita	RRS, Sargatia	70.00
Bottlegourd	Kashi Bahar	RRS, Sargatia	107.00
Cucumber	Kashi Nutan	RRS, Sargatia	12.50
Total			225.05

cauliflower and Palak etc., were produced at Varanasi for the seed indenters and farmers. Among the total seeds, 17041.20 kg was truthfully labelled seeds of the open pollinated varieties of IIVR (Table 6), 35.55 kg F_1 hybrid seeds at IIVR, 189.50 kg F1 hybrid seed at Sargatia (Table 7) and 3120.20 kg breeder seeds (Table 8). Monitoring of breeder seed production plots was carried out by the monitoring team consisting of

Table 8: Breeder seeds produced during 2022 at ICAR-IIVR, Varanasi

Crop	*Variety*	*Qty Breeder Seed (Kg)*		*Crop*	*Variety*	*Qty Breeder Seed (Kg)*
Tomato	Kashi Chayan	0.25		Sponge gourd	Kashi Jyoti	9.00
Tomato	Kashi Aman	3.00		Pumpkin	Kashi Harit	6.00
Tomato	Kashi Adarsh	1.00		Muskmelon	Kashi Madhu	2.00
Tomato	Kashi Vishesh	1.00		Bottle gourd	Kashi Kirti	5.00
Brinjal	Kashi Vijay	0.10		Bottle gourd	Kashi Ganga	10.00
Brinjal	Kashi Taru	1.50		Satputia	Kashi Khushi	5.00
Chilli	KA-2 (Kashi Anmol)	5.00		Longmelon	Kashi Santushti	2.00
Chilli	Kashi Abha	2.00		Summer Squash	Kashi Shubhangi	1.00
Chilli	Kashi Gaurav	0.50		Bitter gourd	Kashi Mayuri	2.00
Chilli	Kashi Sinduri	0.15		Cowpea	Kashi Shyamal	2.00
Cauliflower	K. Gobhi-25	0.20		Cowpea	Kashi Gouri	60.00
Radish	Kashi Hans	10.00		Cowpea	Kashi Unnati	2.00
Radish	Kashi Shweta	12.00		Cowpea	Kashi Kanchan	150.00
Radish	Kashi Mooli-40	12.00		Cowpea	Kashi Nidhi	120.00
Radish	Kashi Lohit	6.00		Cowpea	Kashi Vishan	2.00
Radish	Kashi Aardra	3.00		French bean	Kashi Sampann	7.00
Carrot	Kashi Krishna	5.50		French bean	Kashi Rajhans	10.00
Okra	Kashi Chaman	50.00		French bean	Kashi Baingani	1.00
Okra	Kashi Lalima	70.00		Dolichos	Kashi Haritima	60.00
Okra	Kashi Kranti	100.00		Pea	Kashi Mukti	500.00
Okra	Kashi Pragati	50.00		Pea	Kashi Ageti	500.00
Ash gourd	Kashi Dhawal	4.00		Pea	Kashi Shakti	50.00
Ash gourd	Kashi Surbhi	2.00		Pea	Kashi Samridhi	50.00
Ridge gourd	Kashi Shivani	7.00		Pea	Kashi Nandini	300.00
Sponge gourd	Kashi Shreya	18.00		Pea	Kashi Uday	900.00
					Total	3120.20

Table 9: TL seed and planting material produced during 2022 at RRS, Sargatia

Crop	**Variety**	**Seed yield (kg)**		**Crop**	**Variety**	**Seed yield (kg)**
Cowpea	Kashi Nidhi	408.00		Elephant foot yam	Gajendra	11000.00
Okra	Kashi Chaman	695.00		Turmeric	Megha Turmeric-1	4660.00
Okra	Kashi Kranti	48.00		Lentil	IPL-316	2300.00
Okra	Kashi Lalima	106.00		Arhar	Rajendra Arhar-1	1345.00
Palak	All Green	910.00		Mustard	RH-749	960.00
Radish	Kashi Hans	450.00		Wheat	HD-2967	6240.00
Sponge gourd	Kashi Divya	20.00		Wheat	DBW-187	9480.00
Sponge gourd	Kashi Shreya	107.00		Wheat	DBW-252	14800.00
Satputia	Kashi Khushi	99.00		Paddy	S-52	14340.00 (unprocessed)
Bitter gourd	VRBTG-10	270.00		Paddy	Improved Sambha	11730.00 (unprocessed)
Pumpkin	Kashi Harit	355.00		Paddy	Pusa Basmati-16	1025.00 (unprocessed)
Amaranth	Kashi Suhawani	19.00		Total		3120.20

representatives of State Seed Certification Agency, NSC, seed production scientists and respective breeders. Single plant selection was carried out as a part of maintenance breeding in all the varieties. Seed quality (germination%) of 422 samples were tested at seed testing laboratory for seed quality assurance. A total of 9648 kitchen garden packets of ICAR-IIVR varieties of different vegetables were prepared and distributed among the growers: At the Regional Research Station, Sargatia, a total of 65707.00 kg wheat, paddy, lentil and vegetable seed were produced. In addition to different seeds, 46.6 quintals planting material of turmeric and 110.0 quintals elephant foot yam were also produced at ICAR-IIVR-RRS, Sargatia (Table 9).

Organic seed production of vegetable crops: Organic seed production in cowpea cv. Kashi Nidhi, brinjal cv. Kashi Taru, tomato cv. Kashi Aman, vegetable pea cv. Kashi Uday and French bean cv. Kashi Rajhans was standardized. During seed production, organic inputs such as FYM, vermi-wash, vermi-compost, Trichoderma, Kashi Bio Mix, BC-6, Indo neem, Kashi Jaiv-Shakti, insect traps etc. were applied. The seed yield and quality of organically produced seed was compared with inorganically produced seed as well as control (without any application) after harvesting of seed. Results showed that plant growth, seed yield and quality of organic crop was almost at par with inorganically grown vegetables (Fig. 60). The root growth analysis showed that root length, density and root volume of organically produced vegetables were higher than inorganically produced vegetables (Fig. 61), due to the root promoting activity of BC-6. Similarly, photosynthetic activity, transpiration, stomatal conductance and fv/fm were also superior in organically produced vegetables (Fig. 62).

Fig. 60: Organic seed production of vegetables at ICAR-IIVR, Varanasi

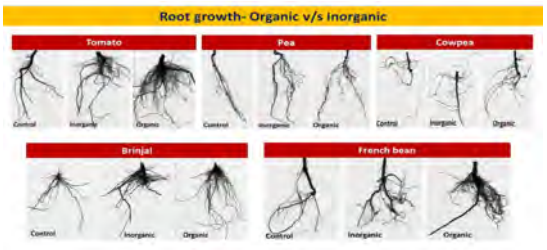


Fig. 61: Root growth of organic and inorganic produced vegetables

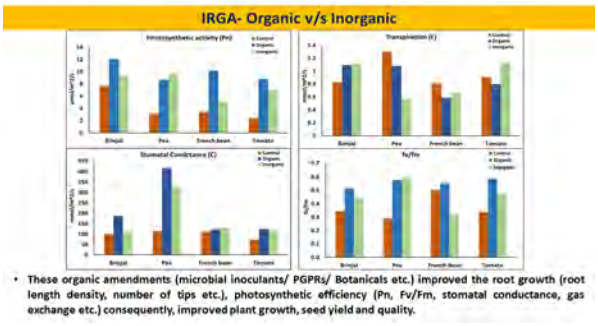


Fig. 62: Photosynthetic activity, transpiration, stomatal conductance and fv/fm of organically and inorganically grown vegetables

Project 2.2: Pollination studies for seed augmentation in vegetables including support of honey bees

Effect on pollination efficiency and seed yield under open field and protected condition with support of honey bee: A study was conducted to observe the effect of honey bees on pollination efficiency and seed yield in radish cv. Kashi Mooli-40 and Kashi Lohit under protected condition, and radish cv. Kashi Aadra and Kashi Hans under open field condition (Fig. 63). Honey bee hives were placed on the onset of 10% flowering in both open field and protected field to ensure the pollination and seed setting. To evaluate the effect of pollinators on the plant productivity, the seed size, seed weight, seed numbers and seed quality of open pollinated plants and caged pollinated plants were compared. It was hypothesized that honeybee *Apis mellifera* play a significant role in the pollination biology of *Raphanus sativus*. Hence, the detailed visitation frequencies and rates of *A. mellifera* on *R. sativus* was studied. Besides, the effectiveness of floral visitors on the yield parameters of *R. sativus* was also studied.

In general, visitation rate and frequency of a floral visitor are important predictor of its pollinating effectiveness. The insect species with high visitation rates and frequencies are considered as effective pollinators. Pollination efficiency was studied in terms of visitation frequency (No. of visits/flower/2 min) and visitation rate (numbers of flower visited/2min) at different time intervals. The flower visitation frequency of *A. mellifera* was highest at 14.00 hrs under both the open (28.75 visits/flower/ 2 min) and protected conditions (31.65 visits/ flower/ 2 min). However, the least flower visitation frequency was noted at 08.00 hrs under both the open (4.78 visits/flower/ 2 min) and protected conditions (5.58 visits/flower/ 2 min). The flower visitation rate of *A. mellifera* was found higher at 14.00 hrs under both open (14.18 flower visited/2min) and protected (16.43 flower visited/2min) conditions (Fig. 64a & b). Whereas it was observed that the flower visitation rate was lower at 08.00 hrs. in both the open (3.83 flower visited/2min) and protected (4.40 flower visited/2min) conditions. Thus, the pollinator *A. mellifera* was effective in pollination at 14.00 hrs which coincides with the maximum temperature during the day when the activity of the pollinator is at its peak. Generally, honeybees were found to prefer a relatively higher

air temperature for nectar collection than for pollen collection. Presence of bee hives significantly enhanced the number of siliqua per plant, siliqua length, number of seed per siliqua, seed yield and quality including seed germination and vigour.

Fig. 63: Effect of honey bees on pollination efficiency and seed yield in radish under open field and protected condition

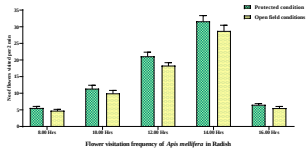


Fig. 64(a): Flower visitation frequency of honey bee in radish

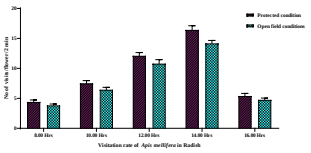


Fig. 64(b): Visitation rate of honey bee in radish

Project 2.3: Drying and Storage Studies on Vegetable Seeds

Seed storage study with and without zeolite beads under room temperature and controlled condition was conducted with the aim of maintaining the viability and vigour of the seed for longer period. Seeds of carrot cv. Kashi Arun, vegetable soybean cv. Swarna Vasundra and moringa cv. PKM-1 were stored with beads, without beads both in room temperature and cold storage in different containers. Initial observation for seed viability and quality were recoded before storage, further periodic (every three month) evaluation of seed viability and quality were recorded. Results showed seed stored under cold storage-maintained seed quality and viability relatively for longer duration. However, irrespective of storage environment, seed stored with zeolite beads in 10:1 ratio (seed:beads) maintained the seed quality and viability upto 15 month (Fig. 66 to 68). Physio-biochemical analysis showed that irrespective of storage environment and crop, significant differences in ROS, antioxidant enzymes and dehydrogenase activity was observed during seed storage. Irrespective of storage container, malondialdehyde (MDA) (lipid peroxidation) and H_2O_2 content was lower and antioxidants was higher as compared to seed stored without beads and in cloth bags (Fig 65). Seed of vegetable soybean stored with zeolite beads for 9 month showed lower fungal infection $1.1X10^4$ cfu/ml. Whereas, seed stored without zeolite beads for 9 month showed higher fungal infection $3.5X10^4$ cfu/ml and no seed germination, which was due to controlled seed moisture during storage with beads (Fig 66). Further, seed quality and physiological analysis will be evaluated at periodic interval.

AICRP (VC) trials: Three seed production AICRP (VC) trials were conducted during 2022, *viz.* (1) Effect of integrated weed management on quality and seed yield in cucumber (2) Fruit load management and post-harvest ripening in cucurbit vegetables for enhancing seed yield and quality (3) Pelleting of vegetable seeds with botanicals and bio control agents for seed enhancement.

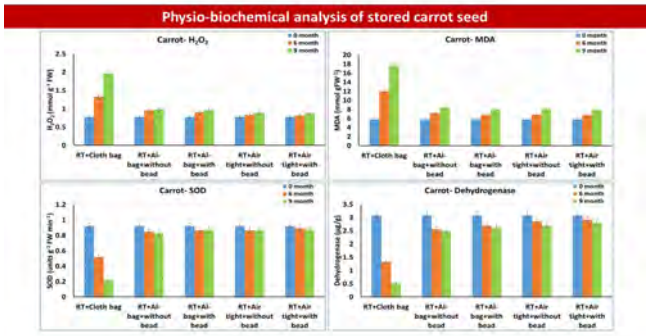


Fig. 65: Physio-biochemical changes associated with carrot seeds during storage

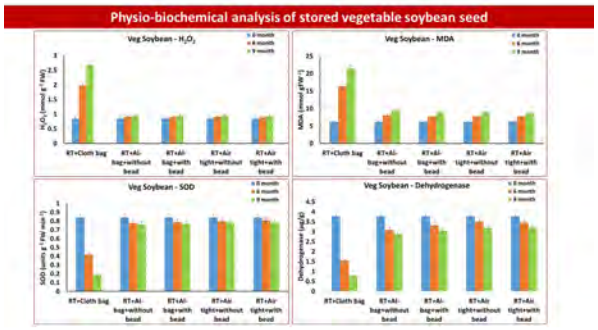


Fig. 66: Physio-biochemical changes associated with vegetable soybean seeds during storage

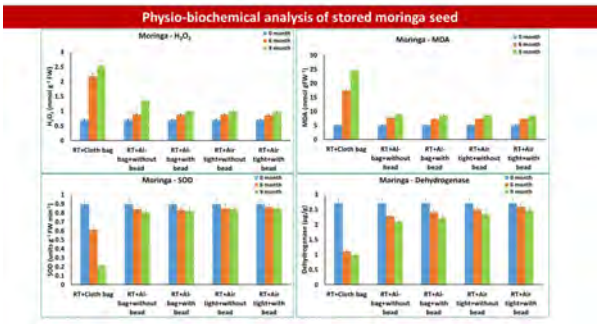


Fig. 67: Physio-biochemical changes associated with moringa seeds during storage

Fig. 68: Vegetable soybean seed after 9-month of storage


भा.कृ.अनु.प.- भारतीय सब्जी अनुसंधान संस्थान
ICAR-Indian Institute of Vegetable Research

Division of Vegetable Production

MEGA PROGRAMME - 3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT

Project 3.1: Technologies for Protected and Offseason Vegetable Production

Evaluation of training system in bitter gourd for greenhouse production: There was a significant variation for yield among the bitter gourd plants trained on different systems under the greenhouse conditions (Table 1 & Fig. 1). Fruit yield, varied among the training systems and ranged from 1.17 kg in var. Pusa Rasdar trained on 3G system to 2.94 kg per plant in Kashi Pratishtha on Umbrella system (Table 1). Irrespective of varieties, among the training systems, the highest yield was noted in Umbrella system (2.68 kg) followed by Pinch system (2.35). Among the varieties, the highest yield was noted in the Kashi Pratishtha (2.44 kg) followed by Kashi Mayuri (2.05). However, no significant differences were noted among the training systems with regard to fruit weight (Table 2). The results indicate towards adopting Umbrella system for var. Kashi Pratishtha under polyhouse conditions.

Fig. 1: Performance evaluation of bitter gourd training systems in polyhouse.

Pheno-phase based nutrient scheduling in tomato: In order to devise pheno-phase based nutrient scheduling in tomato, contents of NPK were estimated during the identified pheno-phases. Highest N content was noticed during the seedling phase. Nitrogen content decreased in plants at subsequent pheno-phases; except at flower opening stage where it increased marginally. Thereafter, N content decreased progressively and was noted to be the lowest at ripe fruit phase. Similar trend was noticed for phosphorus also. However, K content increased progressively from seedling to mature fruit stage but decreased marginally at ripe fruit phase in tomato (Table 3 & 4). Based on the tissue analyses, it was estimated that tomato removes 357.0 kg N /ha, 85.0 kg P /ha and 527.0 kg K / ha.

The uptake dynamics of nutrients shows that the nutrient uptake is initially slow but rapidly increases during fruit development, especially, potassium uptake attains its peak during fruit development. Phosphorus uptake is relatively

Table 1: Bitter gourd yield (kg/plant) as influenced by training systems under naturally ventilated polyhouse conditions

Variety (V)	Training system (T)								
	Drape	Pinch	Umbrella	2-Stem	4-Stem	6-Stem	3G	Unpruned	Mean (V)
Kashi Mayuri	2.41	2.44	2.83	1.69	1.82	1.90	1.24	2.07	2.05
Kashi Pratishtha	2.68	2.88	2.94	1.93	2.30	2.51	2.17	2.11	2.44
Pusa Rasdar	1.61	1.73	2.26	1.24	1.86	1.64	1.17	1.78	1.66
Mean (T)	2.23	2.35	2.68	1.62	1.99	2.02	1.53	1.99	
CD0.05	V: 0.326			T: 0.204			V x T: 0.347		

Table 2: Fruit weight (g) in bitter gourd as influenced by training systems

Variety (V)	Training system (T)								
	Drape	Pinch	Umbrella	2-Stem	4-Stem	6-Stem	3G	Unpruned	Mean (V)
Kashi Mayuri	79.48	69.61	75.82	72.86	66.14	66.57	65.73	71.59	70.98
Kashi Pratishtha	67.75	65.63	58.25	67.81	57.68	70.42	65.38	58.36	63.91
Pusa Rasdar	58.28	64.16	70.10	70.69	74.13	53.96	66.56	63.37	65.16
Mean (T)	68.50	66.47	68.06	70.45	65.98	63.65	65.89	64.44	
CD0.05	V: 15.641			T: 23.476			V x T: 43.275		

Fig. 2: The uptake dynamics of the NPK (kg/ha) by the tomato plant

Table 3: Content of nutrients during different pheno-phases in tomato

Pheno-phase	N (%)	P (%)	K (%)
Seedling	3.3	0.4	2.5
Pre-flowering	3.2	0.7	2.7
Floral emergence	2.8	0.6	2.7
Opening of flower	2.9	0.7	2.8
Marble shape fruits	2.6	0.6	3.0
Mature fruits	2.2	0.5	3.1
Ripe fruits	2.1	0.5	3.1

Table 4: Splits of nutrients as per phenological phase requirement (%) in tomato

Phenophase	N (%)	P (%)	K (%)
Seedling (1-25 d)	0.10	0.05	0.05
Pre-flowering (30-35 DAT)	0.20	0.22	0.12
Floral emergence (35-45 DAT)	1.37	1.23	0.92
Opening of flower (45-60 DAT)	1.23	1.44	0.80
Marble shape fruits (75-80 DAT)	2.14	1.94	2.04
Mature fruits (95-105 DAT)	17.15	16.29	17.24
Ripening to last harvest (120-200 DAT)	77.82	78.82	78.82

Table 5: Splits of nutrients requirement (kg /ha) as per phenophases in tomato

Fertilizer application phase (grouped)	N	P	K
Seedling to transplant establishment and plant development (30-35 DAT)	1.07	0.23	0.90
Floral initiation to fruit formation (35-80 DAT)	16.92	3.92	19.86
Fruit formation to first harvest (80-120 DAT)	67.72	15.24	99.99
First harvest to last harvest (120-200 DAT)	271.29	65.61	406.25
Total	357.0	85.0	527.0

low throughout the growth stages of the tomato plant (Fig. 2).

For the ease in nutrient scheduling, the nutrient requirements of tomato was grouped into four developmental phases as presented in Table 5. This helped in assessing nutrient requirement at major growth stages. Further based on the nutrient use efficiency, the actual nutrient requirement was estimated (Table 6). This was hailed as estimated dose of fertilizers (EDF) i.e. 376.0 kg/ha N, 189.0 kg/ha P and 659.0 kg/ha K. EDF in terms of available fertilizers at different growth phases are presented in Table 7, while their weekly scheduling is being presented in Table 8. Five doses i.e. 75% of estimated

Table 6: Estimated nutrient requirement based on nutrient use efficiency (NUE)

Nutrient	Nutrient uptake (kg/ha)	NUE (%)	Dose (kg/ha)
N	357.0	95	376.0
P	85.0	45	189.0
K	527.0	80	659.0

Table 7: Estimated dose of fertilizers (EDF) (kg/ 1000 sq. m)

Fertilizer application phase (grouped)	18:18:18	MAP (12:61:0)	Urea (46:0:0)	SOP (0:0:50)
Seedling to transplant establishment and plant development (30-35 DAT)	0.3	0.0	0.1	0.0
Floral initiation to fruit formation (35-80 DAT)	4.5	0.1	1.8	0.4
Fruit formation to first harvest (80-120 DAT)	17.8	0.3	7.0	1.6
First harvest to last harvest (120-200 DAT)	71.4	2.8	28.7	6.4

Table 8: Fertigation scheduling in tomato @ 100% EDF

Crop stage	Week	Fertilizers (kg) / 1000 sq. m			
		18-18-18	12-61-0	Urea	SOP
Seedling to transplant establishment and plant development (30-35 DAT)	Week 1				
	Week 2	0.1			
	Week 3	0.1			
	Week 4	0.1			
	Week 5			0.1	
Floral initiation to fruit formation '(35-80 DAT)	Week 6	0.5	0.1	0.3	0.1
	Week 7	0.5		0.3	
	Week 8	0.5		0.3	0.1
	Week 9	1.0		0.3	
	Week 10	1.0		0.3	0.2
	Week 11	1.0		0.3	
Fruit formation to first harvest (80-120 DAT)	Week 12	3.0	0.1	0.5	0.25
	Week 13	3.0		1.0	0.25
	Week 14	3.0	0.1	1.0	0.25
	Week 15	3.0		1.5	0.25
	Week 16	3.0	0.1	1.5	0.25
	Week 17	3.0		1.5	0.25
First harvest to last harvest (120-200 DAT)	Week 18	6.5	0.25	2.5	0.6
	Week 19	6.5	0.25	2.5	0.6
	Week 20	6.5	0.25	2.5	0.6
	Week 21	6.5	0.25	2.5	0.6
	Week 22	6.5	0.25	3.0	0.6
	Week 23	6.5	0.25	3.0	0.6
	Week 24	6.5	0.25	2.5	0.6
	Week 25	6.5	0.25	2.5	0.6
	Week 26	6.5	0.25	2.5	0.6
	Week 27	6.5	0.25	2.5	0.6
	Week 28	6.5	0.25	2.5	0.6

dose of fertilizers (EDF), 100% EDF, 125% EDF, 150% EDF and 175% EDF of fertilizers were made for evaluation in tomato (Table 9). Of five EDF doses, EDF @ 125% was found to be the best in terms of yield and most of the yield associated traits such as number of clusters, fruit weight and size (Table 9). It

Table 9: Yield and attributing traits as affected by fertigation in tomato

Treatment	No. of fruit clusters	No. of fruits/ cluster	Avg. Fruit weight (g)	Avg. Fruit length (cm)	Avg. Fruit width (cm)	Yield/ plant (kg)	Yield/ ha (ton)
EDF @ 75%	18.67	5.7	66.17	4.43	4.71	7.04	137.8
EDF @100%	20.07	6.75	57.4	4.2	4.8	7.75	151.62
EDF@125%	25.33	5.64	70.5	4.47	5.13	10.07	191.88
EDF @150%	20.67	6.31	65.13	4.43	5.04	8.49	166.14
EDF @175%	22.41	5.65	54.1	4.07	4.77	6.85	142.72
CD0.05	3.103	0.699	8.677	0.190	0.217	0.354	2.312

Table 10: Fruit quality attributes as affected by fertigation in tomato

Fertilizer doses	TSS (°Brix)	Phenol (mg 6AE/100g)	Flavonoids (mg (QE/100g)	Lycopene (mg/100 g)	AOX (%)
75% EDF	4.0	101.72	3.47	3.15	81.33
100% EDF	4.2	92.89	3.69	2.69	76.31
125% EDF	4.8	90.17	3.74	2.44	76.18
150% EDF	3.7	89.26	3.21	2.22	76.05
175% EDF	3.6	87.54	2.89	1.73	72.85
CD0.05	1.149	5.326	0.459	0.361	5.925

also registered the highest TSS, while antioxidant activities were higher in 75% EDF (Table 10).

Induction of parthenocarpy using plant growth regulators (PGRs)

Muskmelon

High labor costs are involved in manual pollination of cross-pollinated crops grown under protected cultivation. Exogenous application of PGRs may do away with the need for manual pollination for getting a satisfactory fruit set. At ICAR-IIVR, Varanasi, spray application of PGRs (combination of GA_3, putrescine, melatonin) in muskmelon cv. Kashi Madhu resulted in parthenocarpic fruit development. Application of PGRs resulted in larger and sweeter fruits (1057 g; 12.03ºBrix), more pulp:seed ratio (11.81) and smaller and lesser seeds (6.88 g) as compared to hand pollinated fruits (976g; 11.1°Brix; 6.77; 11.25 g). Further refinement of such techniques will obviate the necessity of cumbersome hand pollination of cross pollinated crops in protected cultivation.

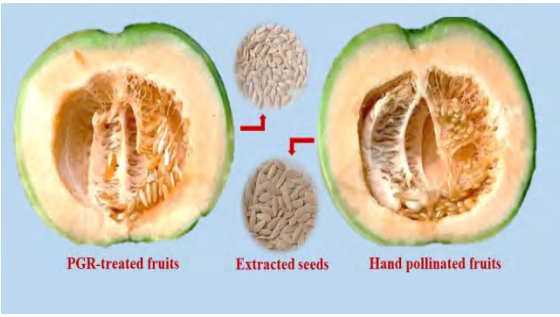


Fig. 3: PGR induced parthenocarpy in muskmelon

Bitter gourd

In our study, we applied a mixture of PGRs either through spray at 15 days interval during flowering season or by applying lanolin paste (containing PGRs) to the pedicels of fully open flowers once. Flowers from control plants were hand pollinated on the day of anthesis. Amongst the different treatments regarding induction of parthenocarpy fruit development in bitter gourd, the maximum numbers of fruits (74.47) was observed with the application of lanolin wax followed by treatment comprising spray of PGRs (70.21) in var. Kashi Pratishtha (Table 11). Likewise, the maximum fruit weight was noted in hand pollinated fruits (54.85 g), while the least was recorded in PGR-sprayed fruits (35.46 g), which was at par with PGR-Lanolin treated fruits (36.39 g). Despite smaller fruit size, PGR-Lanolin treated fruits registered numerically the highest yield (2.71 kg); however, it was at par with sprayed fruits and hand pollinated fruits. Smaller fruit in PGR-treated fruits might be attributed to higher female: male ratio and thus heavy fruit setting, which in turn caused competition amongst the developing fruits for photo-assimilates. However, the treated fruits were less seeded with rudimentary seeds (Table 12; Fig. 4). These traits are welcome, as consumers prefer the seedless fruits for cooking, processing and canning. In addition, PGR-spray treated fruits registered the highest TSS contents of fruits (4.23^0Brix) followed by PGR-lanolin (3.75^0Brix), while the least was noted in hand pollinated fruits (2.90^0Brix).

Table 11: Effect of hand pollination and PGR application on yield and associated characters

Treatment	Female to male flower ratio	No. of Fruits/ plant	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Yield/ plant (kg)
PGR Spray	0.59	70.21	35.46	2.31	1.97	2.49
PGR-Lanolin	0.86	74.47	36.39	2.54	1.99	2.71
Hand pollination	0.53	46.85	54.85	2.78	2.37	2.57
CD0.05	0.146	5.743	12.479	0.574	0.469	0.381

Table 12: Effects of pollination treatment on seed related characters of bitter gourd

Treatment	No. of seeds/ fruit	Fresh seed weight (g)/ fruit	Dry seed weight (g)/ fruit	Test weight (100 seeds)
PGR Spray	19.35	1.91	0.46	2.38
PGR-Lanolin	25.17	1.46	0.34	1.35
Hand pollination	27.09	5.17	4.18	15.43
$CD_{0.05}$	3.625	0.374	0.106	0.647

Fig. 4: Seed content of bitter gourd as affected by pollination and PGR application

Fig. 5: Shelf life of bitter gourd as influenced by pollination and PGR application

Further, PGR-lanolin treated fruits exhibited longer shelf life than PGR-Spray or hand pollinated fruits at the end of the 8-day shelf life study carried out at ambient temperature (Fig. 5).

In conclusion, in our experiments both the spray applications and the lanolin paste application set fruit reliably and yielded more fruit per plant than hand pollination. However, the fruits were smaller. Nevertheless, it also had lesser seed contents, which is desirable trait from the perspective of consumers' preference.

Off season cultivation of parthenocarpic cucumber under protected conditions: During this year also all the varieties/ line tested in previous year were evaluated for growth, yield and quality parameters under naturally ventilated polyhouse. The selected parthenocarpic varieties/ lines were Pusa Parthenocarpic Cucumber-6, DDPCW-1, DDPCG-1, Pant Parthenocarpic Cucumber-2, Pant Parthenocarpic Cucumber-3, Punjab Kheera-1, Fadia, King Star and Multi Star. The observations recorded in the given Table 13 reflects that the maximum plant height, fruit length, fruit diameter, average

Table 13: Features of parthenocarpic cucumber grown under off season

Parthenocarpic cucumber	Vine Length (cm)	Fruit length (cm)	Fruit Diameter (cm)	Average fruit wt. (g)	Yield Per Plant (kg)	Ascorbic acid (mg/ 100g FW)	TSS (0Brix)
Pusa Parthenocarpic- Cucumber-6	288.5	12.15	3.10	122.15	2.42	8.40	3.36
DDPCW-1	304.2	11.10	3.15	128.6	2.16	7.86	3.30
DDPCG-1	310.5	12.20	3.20	137.5	2.35	7.95	3.15
Pant Parthenocarpic Cucumber-2	313.7	11.35	3.17	143.3	2.20	8.00	3.10
Pant Parthenocarpic Cucumber-3	325.3	13.55	3.25	162.5	2.55	8.10	3.25
Punjab Kheera-1	310.5	11.75	3.05	112.7	2.20	8.35	3.20
Fadia	275.7	10.50	3.12	133.6	2.10	8.23	3.30
King Star	270.6	11.30	2.65	140.5	2.15	7.80	3.10
Multi Star	268.6	12.33	2.76	136.5	2.25	7.75	3.20
CD at 5%	6.25	2.25	0.25	5.16	0.24	1.12	NS

fruit weight and per plant yield was recorded in variety Pant Parthenocarpic cucumber-3. However, the maximum vitamin 'C' content 8.40 mg/100g and maximum TSS 3.36^{0}B was noted in variety Pusa Parthenocarpic Cucumber-6.

Evaluation of Muskmelon during off season: The experiment was laid under naturally ventilated polyhouse on Musk melon using 4 varieties. The seeds of muskmelon namely Hara Madhu, Kashi Madhu, Madhuras and Durgapur Madhu were collected and sown in the naturally ventilated poly house on 23.08. 2022. Data given in the table 14 clearly reflect that the maximum fruit length (12.46 cm), fruit diameter (14.75 cm), average fruit weight (585.6), per plant yield (2.27kg) and TSS (11.20^{0}Brix) was recorded in variety Kashi Madhu. Whereas the maximum plant height was recorded in variety Madhuras i.e. 236.7 cm under naturally ventilated polyhouse conditions.

Table 14: Characteristic features of muskmelon grown in off season

Musk Melon	Vine Length (cm)	Fruit length (cm)	Fruit Diameter (cm)	Average fruit wt. (g)	Yield / plant (Kg)	TSS (0Brix)
Hara Madhu	222.3	11.27	14.32	510.15	2.10	10.13
Kashi Madhu	227.6	12.46	14.75	585.60	2.27	11.20
Madhuras	205.5	10.25	13.60	436.75	1.82	8.67
Durgapur Madhu	198.7	10.15	11.65	522.10	2.05	7.56
CD at 5%	6.22	2.26	2.33	9.35	0.11	0.21

Table 15: Characteristic features of tomato grown in off season

Tomato	Plant Height (cm)	No of Flower/ Cluster	No. of Fruits/ Cluster	Fruit length (cm)	Fruit Diameter (cm)	Average fruit wt. (g)
VRNTH 19091	122.5	4.25	2.85	3.20	2.76	39.22
VRNTH 19089	127.3	3.88	2.63	3.27	2.32	35.43
VRNTH 19083	153.4	4.62	3.42	3.42	3.00	47.50
VRNTH 19088	122.1	4.26	3.15	3.41	3.21	44.15
VRNTH 18283	135.2	3.76	2.67	2.37	2.23	33.15
VRNTH 19095	111.3	4.33	3.32	3.36	3.30	36.56
CD at 5%	4.17	0.16	0.12	0.11	0.22	4.15

Table 16: Characteristic features of bitter gourd grown in off season

Varieties	Plant height (m)	Fruit length (cm)	Fruit width (cm)	Average Fruit Weight (g)	Per Plant Yield (kg)
Kashi Mayuri	2.86	13.60	4.21	36.7	2.85
Kashi Pratistha (VRBTG-10)	3.85	17.25	3.85	53.6	3.35
Priya	2.67	08.32	4.65	32.7	2.32
Kalyanpur Barahmashi	4.15	20.15	2.82	76.3	3.05
C.D. at 5%	0.32	2.14	0.12	4.25	0.22

Evaluation of Tomato lines for offseason cultivation: Experiment on off season cultivation of tomato under naturally ventilated protected condition were conducted with 6 different tomato lines of heat tolerant nature namely VRNTH 18283, VRNTH 19089, VRNTH 19083, VRNTH 19091, VRNTH 19088, and VRNTH 19095, transplanted on 9th March, 2022. Though the crop performed well in initial growth phase but later was affected due to high temperature. The observations on growth and yield parameter were recorded and given in the table 15 below. The analyzed data shows that the plant height, number of flower and number of fruits per cluster, fruit length, fruit diameter and average fruit weight was recorded in VRNTH 19083.

Evaluation of Bitter gourd during off season: The bitter gourd varieties namely Kashi Mayuri, VRBTG-10, Priya, and Kalyanpur Barahmashi were sown on 10th October 2022 to judge the performance during off season. The observations on morphological and quality characters were evaluated. The recorded data showed that the maximum plant height 4.15 m was recorded in Kalyanpur Barahmashi, followed by maximum fruit length 20.15 cm. The maximum fruit width was recorded 4.65 cm in Priya.

Project 3.10: Agronomic Bio-Fortification Studies in Vegetable Crops

Preparation and evaluation of crop group specific micronutrient formulations: Four crop-group specific micronutrient formulations each for legumes, cucurbits and root crops were prepared and evaluated for their efficacy on pea, French bean, carrot and beet root during *Rabi* (2021-22) and on bottle gourd and sponge gourd during *Zaid* (2022). A commercial formulation available in the market as well as the "Vegetable Special" from ICAR-IIHR, Bengaluru were also taken for comparison.

Rabi

Effect of micronutrient formulations on vegetable pea: During *Rabi* season pea var. Kashi Nandini was taken as a test crop. The results presented in Fig. 6 reveals that the green pod yield was significantly influenced by the foliar spray

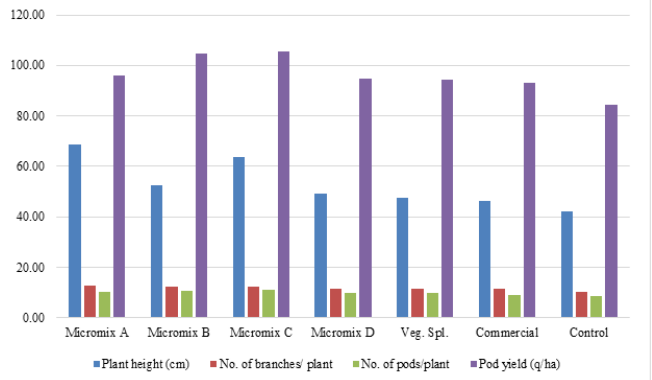


Fig. 6: Response of pea to foliar application of micronutrient formulations

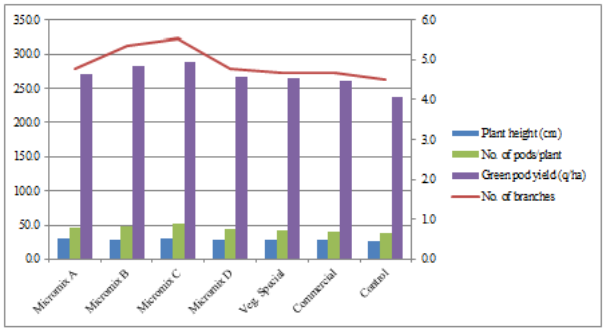


Fig. 7: Response of French bean to foliar application of micronutrient formulations

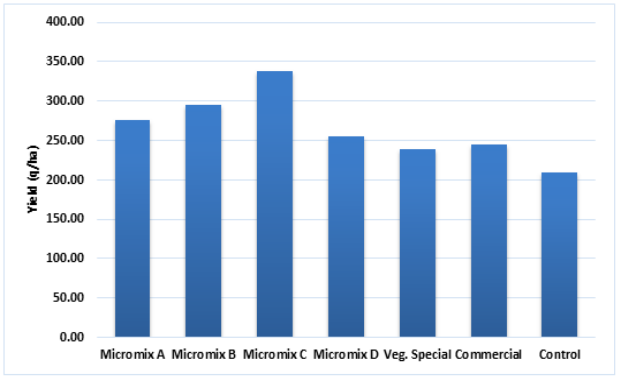


Fig. 8: Response of carrot to foliar application of micronutrient formulations

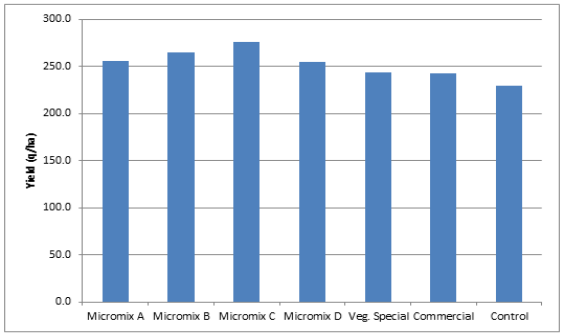


Fig. 9: Response of beetroot to micronutrient formulations

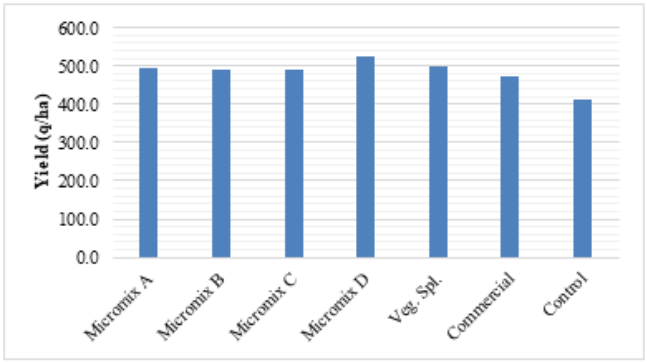


Fig. 10: Response of bottle gourd to micronutrient formulations

of micronutrient formulations over the control. Micromix C recorded the highest pod yield (105.5 q/ha) followed by Micromix B (104.7 q/ha). The lowest pod yield (84.5 q/ha) was obtained in control plot (Fig. 6).

Effect of micronutrient formulations on French bean: In another experiment, French bean var. Kashi Sampanna was taken as a test crop to evaluate the response of different micronutrient formulations. The data presented in Fig. 7 indicate that foliar application of different micronutrient formulations improved the pod yield by 10.26- 22.23% over control (236.37 q/ha).

Effect of micronutrient formulations on carrot: The foliar application of different micronutrient formulation significantly improved the root yield of carrot (cv. Nantes) over the control (Fig. 8). Among the four micronutrient formulations prepared for root crops, Micromix-C (338.35 q/ha) proved more effective than the others. The response to foliar feeding of micronutrients varied from 13.84 to 61.3 per cent over the control (209.76 q/ha).

Effect of micronutrient formulations on beetroot: The results of the effect of foliar application of different micronutrient formulations on beetroot have been presented in Fig. 9. It is evident from the data that root yield was significantly improved due to the application of micronutrient formulations and the response ranged from 5.4 to 20.3 over control (229.67 q/ha). Micromix C proved the best recording numerically maximum fruit yield (276.3 q/ha).

Zaid

During *Zaid* season, crop group specific micronutrient formulations for cucurbitaceous crops were prepared and their efficacy was evaluated on bottle gourd and sponge gourd.

Effect of micronutrient formulations on bottle gourd and sponge gourd: The data presented in Fig. 10 reveal that the fruit yield of bottle gourd was significantly improved due to foliar application of different micronutrient formulations as compared to the control. Micromix D registered the highest yield (525.27 q/ha).The yield improvement due to micronutrients application varied from 15.20 to 27.48% over the control (410.96 q/ha). Likewise, in sponge gourd (var. Kashi Divya) as well, Micromix D recorded the highest fruit yield.

Kharif

During *Kharif* season, crop group specific micronutrient formulations for leguminous crops were prepared and their efficacy was evaluated on cowpea.

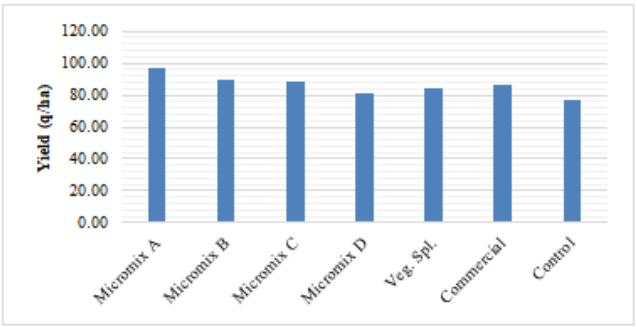


Fig. 11: Response of cowpea to micronutrient formulations

Effect of micronutrient formulations on cowpea: No significant difference was observed among different formulations (Fig. 11). The pod yield under different micronutrient formulations ranged between 81.51 q/ha to 97.27 q/ha whereas under control, it was found lowest (77.39 q/ha).

Project 3.11: Agro-techniques for Organic Farming in Vegetable Crops

Performance of rabi season crops: During rabi season 2021 cherry tomato, cauliflower, pea was grown which was harvested during January to March 2022. The results of the experiments are presented hereunder.

Cauliflower

The performance of cauliflower crop was assessed under non-mulch and two types of mulch at two rates of three different organic manures. The result revealed that under organic cultivation, the highest yield (271.88q/ha) and curd weight (1.23kg), was recorded with application of 200 Kg N/ha through vermicompost (Fig.12). This treatment was at par to inorganic treatment with 200 Kg N /ha which recorded yield of 284.69 q/ha with average curd weight of 1.012 kg/head. Application of 200 kg N /ha through different organic sources did not improve yield significantly over 150 Kg N/ha.

Irrespective of dose and source of organic manure, mulching increased the yield significantly. Weed mat mulch produced highest yield (264.05 q/ha) which was 6.02 and 14.04 percent higher over paddy straw mulch (applied @ 6t/ha) and no mulch treatment, respectively. Highest yield (297.74q/ha) of cauliflower was noted in the treatment having mulching with weed mat and application of 200kg N/ha through VC.

Fig. 12. Effect of mulching and source of organic manures on cauliflower yield

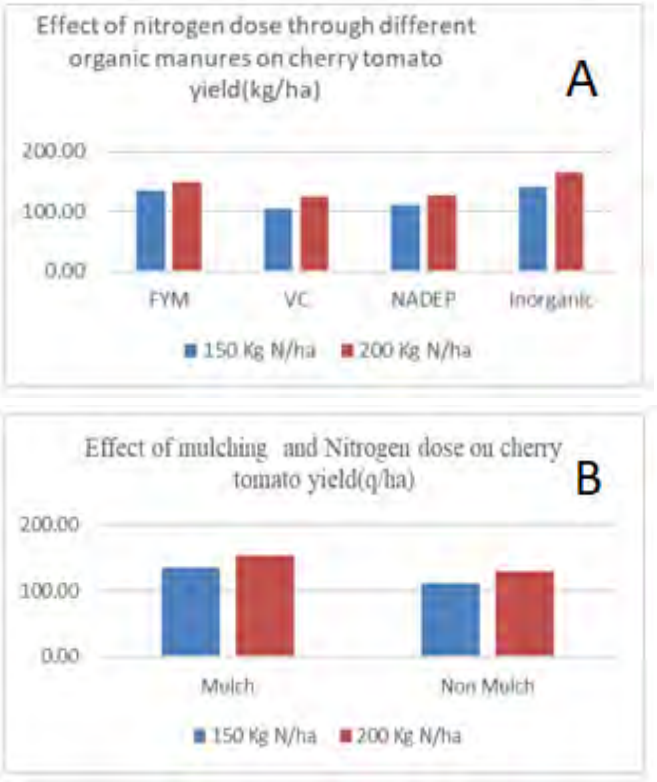


Fig. 13: A-Effect of nitrogen dose through different organic manures on cherry tomato yield (kg/ha) B- Effect of mulching and nitrogen dose on cherry tomato yield (q/ha)

Cherry Tomato

The performance of cherry tomato was assessed under mulching and without mulching condition at two rates of three organic manures (Fig. 13A & B). The result revealed that significantly higher yield (165.54q/ha), average fruit weight (8.97g) was recorded with application of 200 kg N/ha under inorganic cultivation. Under organic cultivation, highest yield (147.99q/ha), fruit weight (8.33g) was recorded with application of 200 kg N /ha through FYM. Increasing N dose from 150 kg/ha to 200 kg/ha increase the cherry tomato yield by 14.9 percent, however, under FYM application the increase was non-significant. Mulching recorded 19.98 percent higher yield of cherry tomato over no mulching irrespective of rates of organic manure application. Among the two hybrids tested, yellow fleshed hybrid Cherry tomato-1 produced significantly higher yield than red fleshed hybrid Cherry tomato-2. The yield recorded with 200 kg N/ha in non-mulch condition was at par to yield recorded with 150kg N/ha with mulch. There was no response of red skin variety to increase in nitrogen dose while in yellow skin variety yield increased with increase in N dose

Pea

The vegetable pea was grown under three variable rates of three organic manures application. The highest yield of vegetable pea (115.4q/ha) was recorded under application of NADEP compost @15t/ha which was significantly higher than inorganic treatment. The increase in yield was due to increase in number

of pods/plant and pod weight.

French Bean

Two varieties of French bean, Kashi Rajhans and Kashi Sampann was grown under organic farming at two rates of nitrogen supplied through three different sources of organic manures. There was no significant difference in yield of the two varieties tested. Under organic cultivation, highest yield of French bean pods was recorded with application of 200kg N/ha through Vermicompost +neem cake. Both the varieties were severely affected by rhizoctonia disease during January-February month.

Performance of summer season crops: During summer season, 2022, sponge gourd and pumpkin grown in the field after harvest of cauliflower, while, moong bean crop was taken in the field vacated by tomato under residual fertility.

Pumpkin

Application of 150 Kg N/ha through combined application of 100 Kg N/ha through FYM + 50kgN/ha through vermicompost produced highest yield of pumpkin (262.23q/ha) which was statistically at par to yield recorded with inorganic fertilizer application of 150 Kg N/ha with yield level of 246.43q/ha. The increase in dose of N from 100kg/ha to 150 kg /ha though increased the yield of pumpkin, but it was not to the level of significance.

Sponge gourd

Application of 150 Kg N/ha through inorganic fertilizer produced highest yield of sponge gourd (230.9q/ha) which was statistically at par to yield recorded with combined application of 100 Kg N/ha through FYM + 50kgN/ha through Vermicompost with yield level of 219.3q/ha. The increase in dose of N from 100kg/ha to 150 kg /ha increased the yield of sponge gourd significantly.

Moong

The grain yield of moong was in the range of 12.4 to 16.4 due to residual effect of organic manures after the harvest of cherry tomato. The grain yield was significantly lower under residual effect of inorganic treatment. The grain yield of moong was not influenced due to application of variable rates of organic manures applied to cherry tomato.

Performance of kharif season crops: During Kharif season, 2022, bottle gourd, okra, sponge gourd and cowpea were grown.

Bottle gourd

During kharif season bottle gourd was grown under flat bed and bower system for comparison to find best system for organic cultivation. The result revealed that among the two systems, significantly higher total yield was recorded under flatbed system (273.34q/ha) as compared to bower system (238.57 q/ha), however, marketable yield was at par. The average length and weight of marketable fruit was more in bower system. The application of nitrogen @ 150 Kg/ha through different sources though produced higher yield but was at par to 100 kg N/ha. Among the three sources FYM application produced significantly higher yield over vermicompost however it was at par to NADEP compost and inorganic nutrition.

Sponge gourd

During kharif season performance of sponge gourd variety Kashi Shreya was assessed with three rates of two organic manures i.e. NADEP compost and vermicompost under weed mat mulching. All the three rates of N (40, 80 and 120 kg/ha) through NADEP compost were at par. However, application of 120 Kg N/ha through vermicompost and inorganic fertilizer, produced significantly higher yield over 80 and 40 kg N/ha. The NADEP compost produced higher yield over vermicompost but was at par to inorganic treatment under weed mat mulching.

Cowpea

During kharif season, the performance of cowpea variety Kashi Nidhi sown on ridges in ridge and furrow system was assessed with three rates of nitrogen supplied through two different organic manures i.e. NADEP compost and vermicompost. The increasing rates of N (30,45 and 60 kg/ha) increased the yield significantly with highest yield recorded with 60 kg N applied through inorganic fertilizer, followed by FYM and vermicompost respectively.

Okra

During kharif season, the performance of okra sown on ridges in ridge and furrow system was assessed with three rates of nitrogen dose supplied through two different organic manures i.e. NADEP compost and vermicompost. The increasing rates of N (120,150 and 180 kg/ha) increased the okra fruit yield significantly with highest yield recorded with 180 kg N applied through inorganic fertilizer, followed by vermicompost and FYM respectively.

Effect on soil properties: Among organic manures treatments, highest organic carbon content of soil (0.544 %) and lowest bulk density (1.321) was noted with application of 200Kg N/ha through FYM. The organic carbon content of soil was 0.437% and BD (1.482) under inorganic treatment (Fig. 14).

Effect of organic treatment on soil microbial health: Organic manure in the form of farm yard manure, vermicompost and NADEP was used at different doses in the same plot for last 5 years. Soil samples were collected from the standing tomato crop and used for analysis. The soils were properly

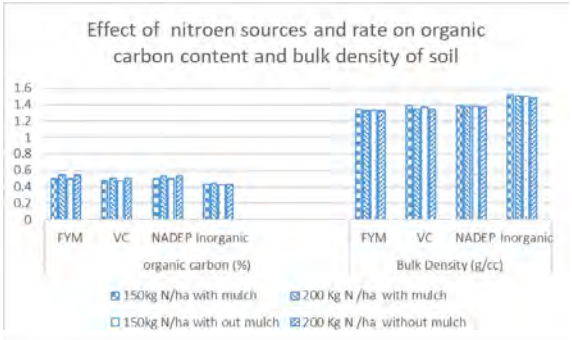


Fig. 14: Effect of nitrogen sources and rate on organic carbon content and bulk density of soil

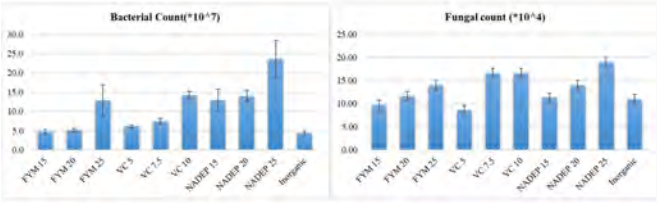


Fig. 15: Microbial count in plots treated with varied doses of organic manure viz. FYM, VC and NADEP as compared to those treated with inorganic fertilizer

dried and sieved before storing at 4°C. Bacterial count was significantly higher in soils treated with NADEP as compared to those treated with inorganic fertilizers. Similarly, fungal count in plots treated with 25% NADEP ($19.0x10^4$±3.61) was significantly higher than those treated with inorganic fertilizer alone ($11.0x10^4$±1.0) (Fig. 15).

Soil enzymatic activity in terms of dehydrogenases, fluorescein diacetate, acid and alkaline phosphatases were studied to determine the effect of organic treatment on soil enzymes. Plots with NADEP@ 25t/ha showed significantly higher dehydrogenases activity (189.38±14.24 µg TPF/day/gm of soil), fluorescein diacetate activity (3.46±0.33 µg fluorescein/gm/hr), acid phosphatases activity (171.49±6.93 µg p-nitrophenol/hr/gm) and alkaline phosphatases activity (518.92±3.87 µg p-nitrophenol/hr/gm) activity as compared to those treated with inorganic fertilizer.

Quality parameters of vegetables: The quality of vegetables in terms of vitamin C content was better under organic system as compared to inorganic system. The ascorbic acid and antioxidant content in organically produced bottle gourd were higher as compared to inorganic treatment. In cauliflower the ascorbic acid, and total phenol content was higher than the inorganic treatment (Table 17). The quality of cherry tomato was improved under organic farming as compared to inorganic

Table 17: Quality parameters of cauliflower curd as influenced by treatments

Treatments	MC (%)	DM(%)	Phenol (mg/100 gfw)	Antioxidant (%)	Ascorbic acid (mg/100gfw)
Dose of N Kg/ha)					
150	91.99	8.01	32.93	23.06	37.01
200	91.67	8.33	31.23	23.78	34.24
CD(P=0.05)	NS	NS	NS	NS	2.14
Mulching					
Weed mat	91.90	8.1	33.01	23.65	33.37
Paddy straw	92.00	8.00	33.18	22.67	37.50
No mulching	91.58	8.42	30.05	23.93	36.01
CD(P=0.05)	NS	NS	2.32	NS	2.98
Source					
FYM	91.78	8.22	34.28	24.12	35.72
VC	91.72	8.28	34.78	23.4	37.21
Inorganic	91.98	8.02	27.19	22.73	33.95
CD(P=0.05)	NS	NS	2.17	NS	2.11

Table 18: Quality parameters of cherry tomato as influenced by treatments.

Treatments	TSS (o B)	MC (%)	DM (%)	Antioxidant (%)	Ascorbic acid (mg/ 100g FW)	Lycopene (mg/100g FW)
Dose of N Kg/ha)						
150	6.36	94.18	5.82	94.76	84.5	6.54
200	6.36	94.01	5.96	94.2	84.51	6.66
CD(P=0.05)	NS	NS	NS	NS	NS	NS
Mulching						
Paddy straw	6.31	94.05	5.96	94.18	84.51	6.54
No mulching	6.41	94.14	5.82	94.78	84.5	6.66
CD(P=0.05)	NS	NS	NS	NS	NS	NS
Source						
FYM	6.82	93.92	6.08	94.81	82.07	6.59
NADEP	6.72	93.73	6.27	94.27	87.76	6.6
VC	6.7	93.6	6.4	94.64	84.54	6.62
Inorganic	5.18	95.21	4.79	94.2	83.66	6.59
CD(P=0.05)	NS	NS	NS	NS	NS	NS

treatment (Table 18).

Natural Farming in vegetables: A pilot project on natural farming in vegetable crops was started during rabi season 2021-22. Two crops viz., tomato and cauliflower was grown under natural farming in plots of $600m^2$ in ridge and furrow system. The crop was mulched with paddy straw @7.5t/ha and Jeevamrit was sprayed at 15 days interval and irrigation was given in alternate furrows. The 25 days old seedlings of cauliflower variety Pusa Snowball K-1 and tomato variety Kashi Aman were transplanted on 01.11.2021 and 11.11.2021, respectively

The result revealed that survival of seedlings was 83.8% and 85.4% in cauliflower and tomato, respectively. The yield of cauliflower was 124.62 q/ha with average curd weight of 434g in 89 days. In tomato the yield recorded was 144.97q/ha with average fruit weight of 32.35g having 6.83 fruits per plant.

After harvest of rabi crops, cowpea and moong bean crop succeeded cauliflower and tomato respectively. The grain yield recorded in moong bean was 7.89q/ha while the yield of green pods in cowpea was 41.16q/ha (Fig. 16). The foliage of moong bean and cowpea was turned down in the soil. Thereafter green manuring with dhaincha was done. The green manure crop of Dhaincha was sown with the seed rate of 30kg/ha. The Dhaincha crop of 45 days old was turned down in to the soil with mould board plough. The average dry matter added in the organic treatments ranged between 2.34 to 2.51 t/ha.

Kharif season: During kharif season, four scented rice

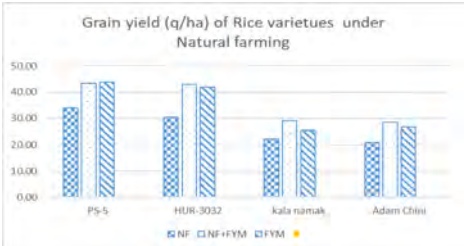


Fig. 16. Grain yield (q/ha) of rice varieties under natural farming

cultivars were tested under natural farming. The two land races were Adam Chini (V1) and Kala Namak (V2) and two high yielding varieties were HUR 3032 (V3) and Pusa Sugandha PS-5 (V4). The result revealed that highest yield of 46.54 q/ha was recorded in variety Pusa Basmati (V4) supplied with FYM @ 5t/ha while without FYM the yield was 39.86q/ha.

Rabi Season: During rabi season 2022 experiment on tomato, cauliflower, pea was conducted. The organic manure as per the treatment was added to the soil at least 15- 20 days prior to sowing/ transplanting. Crop stand of tomato, cauliflower and pea was unaffected due to organic sources or its dose.

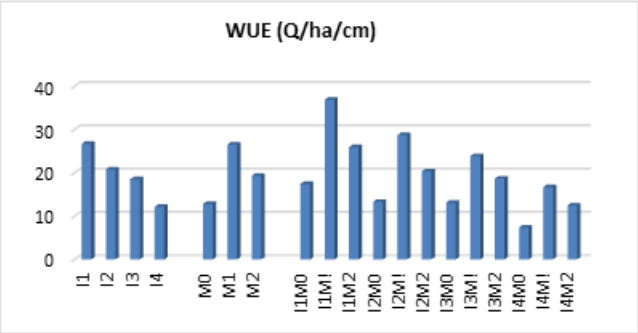


Fig. 17: Water use efficiency (q/ha/cm)

Project 3.12: Improving Water Productivity of Vegetable Crops Sequence Through Drip Irrigation System

Drip irrigation scheduling and mulching study in tomato and okra

Tomato

In this study, drip irrigation was scheduled at 50% (I_1), 75% (I_2) and 100% ET (I_3) at every 3rd day. For comparison, surface irrigation (I_4) at 7-15 days intervals was also carried out. Two types of mulches i.e. black-silver (M_1) and paddy straw (M_2) mulches were also used along with un-mulched control (M_0). Maximum fruit yield (3.22 kg/plant and 489.77 q/ha) was recorded with 100% ET, whereas maximum WUE i.e. 26.76 q/ha/cm was registered in I_1 (50% ET). Among mulch, black-silver much was found most effective with maximum fruit yields (3.44 kg/plant and 544.97q/ha) and WUE (26.55 q/ha/

Table 19: Effect of drip irrigation scheduling and mulching in tomato

Irrigation/ mulch	Plant height (cm)	Fruits/plant	Fruit weight (g)	Fruit yield (kg/ plant)	Fruit yield (q/ ha)
I_1	79.38	30.6	62.87	2.74	342.55
I_2	82.47	35.8	60.07	2.88	393.33
I_3	88.55	39.5	60.20	3.22	489.77
I_4	79.50	35.5	63.00	2.88	390.35
SeM±	2.15	1.83	0.81	0.10	25.09
CD0.05	6.25	4.80	2.23	0.32	78.05
M_0	69.22	28.1	56.25	2.43	264.37
M_1	91.20	42.7	67.28	3.44	544.97
M_2	87.01	35.2	61.08	2.93	402.67
SeM±	5.21	2.23	2.54	0.21	57.03
CD0.05	13.81	6.34	6.71	0.54	152.28
I_1M_0	65.10	24.2	58.4	2.31	223.36
I_1M_1	92.12	37.3	67.7	3.21	472.12
I_1M_2	80.92	30.2	62.5	2.69	332.16
I_2M_0	68.30	27.6	55.5	2.37	251.82
I_2M_1	87.32	42.2	64.3	3.40	543.50
I_2M_2	91.80	37.6	60.4	2.88	384.67
I_3M_0	76.76	32.4	56.7	2.68	345.81
I_3M_1	95.07	47.6	65.8	3.75	629.92
I_3M_2	93.81	38.4	58.1	3.22	493.58
I_4M_0	66.70	28.3	54.4	2.34	236.49
I_4M_1	90.30	43.6	71.3	3.39	534.32
I_4M_2	81.50	34.5	63.3	2.91	400.25
SeM±	3.19	2.05	1.50	0.14	38.28
CD0.05	9.15	5.88	4.31	0.39	109.85

I_1= drip irrigation at 50% ET, I_2= drip irrigation at 75% ET and I_3 drip irrigation at 100% ET

M_0= no mulch, M_1 = Black-silver and M_2 = dry grass mulch

Table 20: Effect of drip irrigation scheduling and mulching in okra

Treatment	CCI	Leaf area (m2)	Fruits/ plant	Yield (g/ plant)	Yield (q/ha)
Drip irrigation twice a day at 100% ET + Black-silver mulch (I1M1)	51.02	0.306	29.60	466.2	121.96
Drip irrigation twice a day at 100% ET + Pea straw mulch (I1M2)	48.28	0.256	25.60	304.2	85.96
Drip irrigation twice a day at 100% ET without mulch (I1M3)	48.12	0.228	22.40	250.8	61.14
Drip irrigation once a day at 100% ET + Black-silver mulch (I2M1)	50.88	0.198	27.80	362.8	108.81
Drip irrigation once a day at 100% ET + Pea straw mulch (I2M2)	49.51	0.217	25.80	354.8	66.98
Drip irrigation once a day at 100% ET without mulch (I2M3)	49.87	0.210	20.20	235.4	59.02
Drip irrigation alternate day at 100% ET + Black-silver mulch (I3M1)	46.07	0.187	22.40	340.2	87.56
Drip irrigation alternate day at 100% ET + Pea straw mulch (I3M2)	47.68	0.211	25.80	317.6	56.84
Drip irrigation alternate day at 100% ET without mulch (I3M3)	47.62	0.170	22.60	279.0	49.08
Furrow irrigation + Black-silver mulch (I4M1)	47.66	0.235	26.40	427.2	94.27
Furrow irrigation + Pea straw mulch (I4M2)	49.37	0.216	24.00	342.6	75.05
Furrow irrigation without mulch (I4M3)	46.90	0.166	21.80	301.4	59.13
SeM	0.45	0.011	0.80	19.4	4.17
CD	1.29	0.032	2.21	53.8	11.18

cm) (Table 19). Interaction of drip irrigation and mulch was also found highly significant, and maximum fruit yield of 3.75 kg/plant and 629.92 q/ha was observed with drip irrigation at 100% ET and black-silver mulch (I_3 M_1), whereas maximum WUE of 36.88 q/ha/cm was reported in I_1M_1 followed by 1_2M_1 (28.76q/ha/cm) (Fig. 17).

Okra

During spring-summer, drip irrigation in okra was carried out at 100% ET with twice daily (I_1), once daily (I_2) and alternate day (I_3). Black –silver (M_1) and pea-straw (I_2) mulches were also applied with un-mulched as control (M_0). Experimental findings reveal that drip irrigation scheduling and mulching significantly enhanced the CCI, leaf area, dry matter production, number of fruits/plant and fruit yield (Fig. 18) (Table 20). Maximum fruit yield of 466.2 g/plant and 121.96 q/ha was reported in I_1 M_1followed by I_1M_2 (108.81 q/ha). These two treatments noticed 106.25% and 84.01% higher fruit yield than control (I_4 M_0).

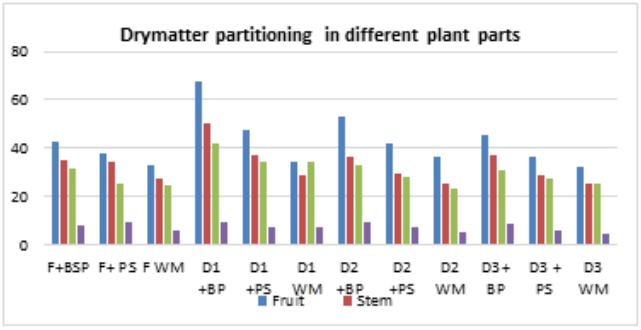


Fig. 18: Dry matter partitioning in different plant parts

Fig. 19: Field production of Pomato

Project 3.13: Enhancing Productivity, Quality and Tolerance to Biotic and Abiotic Stresses in Vegetables by Grafting Technology

Response of hybrid brinjal to different rootstocks: In this study, six brinjal rootstocks (wild and cultivated) e.g., IC111056, IC-354557, Surya, *Solanum laciniatum*, *S. gilo* and *S. torvum* were evaluated for fruit yield and disease tolerance in brinjal hybrid-Kashi Sandesh. Findings reveal that maximum number of fruits (43.6) and fruit yield (8.71 kg/plant) with low collar rot infestation (2.5%) Kashi Sandesh brinjal was grafted on Surya rootstock. Fruit yield with other rootstocks was *at par* to the ungrafted control, whereas brinjal yield with *S. torvum* was significantly lower (20.1%) than the control (Table 21). Brinjal grafted over all three wild species did not show symptom of little leaf, whereas no symptom of collar rot (*Sclerotium rolfsii*) was observed only when grafted over *S. torvum*.

Production of specialized grafted plants-Pomato and Brimato: For pomato production, grafts were prepared in month of October (Fig. 19). Kufri Bahar (white potato) was taken as rootstock, whereas for scions, two tomato cultivars-NS4266 (indeterminate) and Kashi Aman (determinate) were taken. Indeterminate tomato grafted on potato produced maximum fruits (87.67) and fruit yield (5.03 kg/plant), but lower potato yield (0.444 kg/plant). In contrast, Kashi Aman (det.) produced relatively lower fruits (67.0) and yield (2.64 kg/plant), but significantly higher potato

Table 21: Effect of different brinjal rootstocks on yield attributes and disease infestation in brinjal

Graft combination	Fruits/ plant	Fruit weight (g)	Fruit yield (kg/ plant)	Collar rot* (%)	Little leaf (%)
IC-111056 x K. Sandesh	33.4	253.65	7.555	5.50	7.5
IC-354557 x K. Sandesh	33.4	242.21	7.071	8.25	2.5
Surya x K. Sandesh	43.6	248.37	8.714	2.75	2.5
S. laciniatum x K. Sandesh	32.0	223.23	6.455	2.75	0.0
S. gilo x K. Sandesh	35.8	237.22	6.828	8.25	0.0
S. torvum x K. Sandesh	28.0	215.19	5.563	0.00	0.0
Kashi Sandesh un-grafted	37.4	232.66	6.962	11.00	12.5
Mean	34.8	236.08	7.021		
SeM±	1.85	5.16	0.367		
CD0.05	5.24	15.21	1.039		

Table 22: Effect of different brinjal and tomato scions on Brimato production

Graft combination	Brinjal		Tomato		Total fruit yield (kg/ plant)
	Fruits/ plant	Yield (kg/ plant)	Fruits/ plant	Yield (kg/ plant)	
IC 111056 x (K. Taru + K. Aman)	12.6	1.66	41.4	2.23	3.89
IC 111056 x (K. Sandesh + K. Aman)	7.6	2.56	44.6	2.68	5.24
KashiTaru	16.8	1.99	-	-	1.99
K. Sandesh	9.0	3.08	-	-	3.08
K. Aman	-	-	57.2	3.16	3.16
SeM±	2.06	0.31	4.83	0.27	
CD0.05	5.57	0.85	12.22	0.68	

yield (1.757 kg/plant). Graft combination- potato x Kashi Aman noticed 36.8% reduction in tomato yield, but around 200% higher potato yield than their sole production. It may conclude that use of dual grafting of determinate tomato on white potato is beneficial for pomato production.

Brimato production: In this study, two different scion cultivars of tomato and brinjal were used to graft over brinjal rootstock IC-111056. In brinjal scion, both round (Kashi Sandesh) and long (Kashi Taru) were used (fig. 20). Findings reveal that maximum yield of brinjal (2.56 kg) and tomato (2.68 kg) was recoded with Kashi Sandesh brinjal and Kashi Aman tomato (Table 22).

Fig. 20. Field production of brimato

Inter-specific grafting study in cucumber: In this study, cucumber variety Kashi Nutan was grafted over 5 different cucurbitaceous rootstocks (sponge gourd, ridge gourd, bottle gourd, ash gourd and Summer fit) to evaluate for yield and disease reaction in cucumber. It was observed that cucumber produced maximum no. of fruits (15.1/plant), fruit yield (2.835 kg/plant and 168.78 q/ha when grafted over Summerfit (hybrid of acid melon x snap melon) rootstock. A significant reduction in cucumber yield (62.6%) was reported over bottle gourd rootstock. As far as disease was concerned, maximum Fusarium wilt infestation (73.5%) was noticed over bottle gourd rootstock, whereas minimum incidence (4.9%) was recorded in ungrafted cucumber followed by grafting over Summerfit (7.84). Virus infestation in cucumber ranges between 14.7-24.5% with maximum infestation over sponge gourd and ridge gourd rootstocks (Table 23).

Salinity stress tolerance in cucurbits: A pot experiment was conducted to evaluate the salinity tolerance in various cucurbits (Fig. 21). Eight cucurbitaceous vegetables *viz.* Ridge gourd (Kashi Shivani), Bottle gourd (Kashi Ganga), Sponge gourd (K. Shreya), Pumpkin (VRPK-09-01), Ash gourd (K. Dhawal), Summerfit (interspecific hybrid), Satputia (Kashi Khushi) and *Cucumis hardwickii* were subjected to two levels of salinity stresses (3 and 6 dS m^{-1} of irrigation water). Experimental findings reveal that salt stress significantly decreased the membrane stability index (MSI) and chlorophyll content index (CCI) in all cucurbit species. There was least reduction in MSI and CCI in ash gourd (17.05 % and 27.69 %) and Pumpkin (18.53% and 34.59%) at 6 dS m^{-1}. Furthermore, there was also

Table 23: Effect of inter-specific grafting on fruit yield attributes and disease infestation in cucumber

Graft combination	Fruit weight (g)	Fruits/plant	Yield (kg/ plant)	Yield (q/ ha)	CCI	Fusarium wilt (%)	Virus (%)
Sponge gourd + Cucumber	180.85	7.8	1.742	96.11	79.89	11.76	24.50
Ridgegourd + Cucumber	231.98	9.8	1.811	104.27	65.98	18.62	24.50
Bottle gourd + Cucumber	230.23	4.1	0.683	35.87	67.84	73.50	14.70
Ash gourd + Cucumber	191.56	8.0	1.497	95.98	80.97	8.82	14.70
Summerfit + Cucumber	250.09	15.1	2.835	168.78	79.66	7.84	14.70
Un-grafted Cucumber	182.67	8.8	1.567	96.01	67.46	4.90	16.66
Mean	211.23	8.93	1.69	99.50	73.63	20.91	18.29
SeM	12.15	1.5	0.282	17.23	2.94	10.69	1.99
CD	34.13	4.1	0.794	48.41	8.27	30.03	5.58

least increase of proline content in ash gourd (2.22 mg g^{-1} FW) and pumpkin (2.26) at 6 dS m^{-1} salt stress. Activities of catalase (CAT) and peroxidase (POD) enzymes were significantly higher in pumpkin (33.50 µM H_2O_2 reduced g^{-1} FW min^{-1} and 12.52 µM tetra-guaiacol formed g^{-1} FW min,$^{-1}$ respectively) and ash gourd (30.53 and 11.61, respectively) as compared to other species at 6 dS m^{-1}. Ash gourd and ridge gourd showed least dry matter reductions (25.54% and 26.47%, respectively) at high salt stress. The results obtained in this study suggest that ash gourd and pumpkin have ability to tolerate salt stress condition better than the other cucurbit species tested.

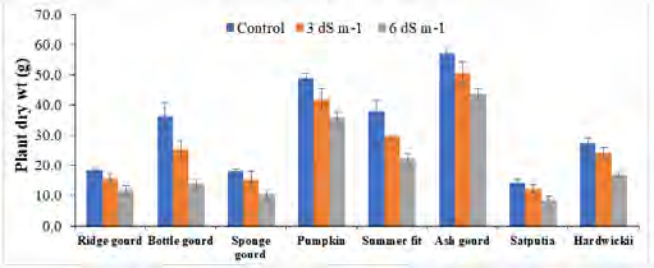


Fig. 21: Dry matter production in cucurbits plants at different salt treatments

Control **Salinity 4 dS m-1** **Salinity 8 dS m-1**

Fig. 22: IVBR-17+Kashi Chayan graft combination root architecture under control and salt stress conditions (4 dS m^{-1} and 8 dS m^{-1}). Images captured by Root Scanner Win-Rhizo- LA2400 (Regent Instruments Inc., Canada).

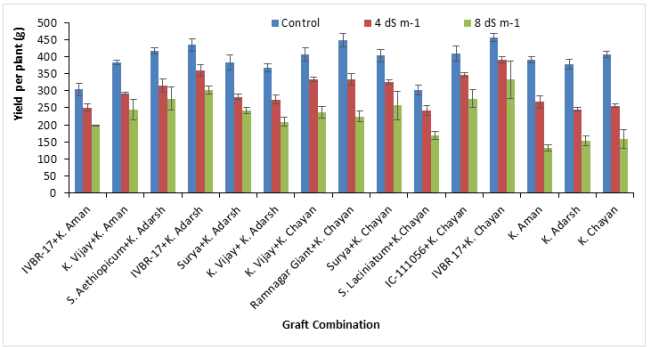


Fig. 23: Fruit yields (g/ plant) under different graft combinations and salinity stress condition

Yield stability of grafted tomato plants under salinity stress: Pot experiment was also conducted in tomatoes (Kashi Aman, Kashi Adarsh and Kashi Chayan) grafted on brinjal rootstocks (IC-111056, IVBR-17, Kashi Vijay, Surya, Ramnagar Giant, *Solanum aethiopicum* and *Solanum laciniatum*) for their yield stability under salinity stress (4 and 8 dS m^{-1} irrigation water). There was higher reduction in MSI in non-grafted plants than grafted plants. Both the salinity levels caused a decline in total chlorophyll content, but there was higher reduction in non-grafted plants (e.g. 68.58%, 65.28% and 65.15% in KashiAdarsh, Kashi Chayan and Kashi Aman, respectively) at 8 dS m^{-1} salinity stress. Proline content in non-grafted plants was higher as compared to grafted plants under both the salinity stress conditions. IVBR-17 + Kashi Chayan, IVBR-17 + Kashi Adarsh and IC-111056 + Kashi Chayan graft combinations registered least proline accumulation under salinity stress. Activities of catalase and peroxidase enzymes were found to be significantly higher in grafted tomatoes as compared to non-grafted plants. Graft combinations IVBR-17 + Kashi Chayan, IVBR-17 + Kashi Adarsh and IC-111056 + Kashi Chayan showed highest catalase activity of 38.89, 37.14 and 36.30 µM H_2O_2 reduced g^{-1} FW min^{-1}, respectively as well as peroxidase activity of 28.30, 23.66 and 25.14 µM tetra-guaiacol formed g^{-1} FW min^{-1}, respectively under high salinity stress. The grafted tomato plants showed higher yield per plant as compared to non-grafted plants under salt stress conditions for all the three tomato varieties (Fig. 23). The graft combination IVBR-17 + Kashi Chayan was identified as the best combination with least yield reduction (25.39%) under high salinity stress (8 dS m^{-1}), which was followed by IVBR-17 + Kashi Adarsh (28.57%) and IC-111056 + Kashi Chayan (29.96 %). Furthermore, IVBR-17 + K. Chayan and IVBR 17 + K. Adarsh graft combinations showed highest root area and root volume at 8 dS m^{-1}stress. Thus, IVBR-17 + K. Chayan and IVBR 17 + K. Adarsh graft combinations have best salt tolerance ability (Fig. 22).

Screening of brinjal germplasm for salinity tolerance: A pot experiment was conducted in brinjal genotypes to evaluate the tolerance towards the salinity stress (8 dS m^{-1}). A total of 12 brinjal genotypes *viz.*, *Solanum gilo*, *Solanum torvum*, *Solanum incanum*, *Solanum laciniatum*, CNUS, Surya, Zippy, IC-111056, IC-354557, Kashi Sandesh, Kashi Taru and Kashi Vijay were taken for evaluation. Results showed that salinity stress causes decline in total chlorophyll content, MSI and RWC in all brinjal genotypes. The least reduction in RWC was observed in Zippy (10.74%), IC-111056 (11.16%) and IC-354557 (13.27%). Likewise, there was also least reduction of MSI in Zippy (7.23%), IC-111056 (8.03%) and IC-354557 (8.47%) genotypes, whereas least reduction of total chlorophyll content was observed in Zippy(10.22%), IC-111056 (11.08%) and *Solanum torvum* (11.49%). Minimum accumulation in proline content was observed in leaves of *S. torvum* (70.43%), IC-111056 (73.63%) and Zippy (77.83%) genotypes under salinity stress. Among brinjal germplasm, *Solanum torvum* has the highest root surface area (1060.03 cm^2) and root volume (19.31 cm^3) under salinity stress. Thus, it was concluded that *S. torvum*, IC-111056 and Zippy genotypes have better tolerance towards salinity stress (Fig. 24).

Control **Salinity stress (8 dS m-1)**

Fig. 24. Solanum torvum root architecture under control and salt stress (8 dS m-1). Images captured by Root Scanner Win-Rhizo- LA2400 (Regent Instruments Inc., Canada).

Screening of cucurbits as rootstocks for gummy stem blight tolerance: Cucurbits gummy stem blight causing pathogen, *Stagonosporopsis cucurbitacearum* (syn. *Phoma cucurbitacearum*; teliomorph- *Didymella bryoniae*) isolates (BGSB-1, AGSB-2, CGSB-3) were established from bottle gourd (var. Kashi Ganga), ash gourd (var. Kashi Dhawal) and cucumber (Fig. 25). Established isolated were used for further artificial screening of GSB resistant cultigens of cucurbits. Eleven cultigens viz. bottle gourd (Kashi Ganga, Legacy, VBRTG-61), bitter gourd (IC-2125004), ash gourd (Kashi Dhawal), cucumber (*Cucumis sativus var. hardwickii*), interspecific hybrid of acid melon and snap melon (Summer fit), sponge gourd (Kashi Shreya, VRRG-68-2011, VRRG-75-2016) and ridge gourd (Kashi Sivani) were screened for GSB resistance under pot. The spore suspension of mass inoculum of *S. cucurbitacearum* isolate (GSB-1) was standardized to a concentration of 2.3 × 10^6 spore per ml. A 14 days old plants having 2-true leaf of bottle gourd (*cv* Kashi Ganga) were inoculated by spraying of *S. cucurbita cearum* spore suspension (2.3 × 106 cfu/ml) of pathogen isolate to test pathogenicity under green garden shed net. Based on the PDI (1-10%) on tested cultigens namely summer fit, C, *hardwickii* and bitter gourd IC-2125004 have identified as potential rootstocks for cucurbits against GSB.

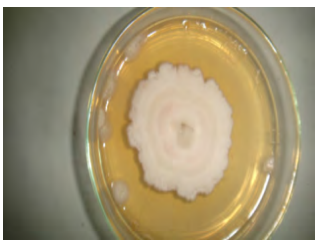
***In vitro* screening of fungicides and botanical against *Stagnospora* gummy stem blight:** *In vitro* screening of fungicides (teboconazole 50%+ trifloxystrobin 25%, tebuconazole 25.9% SC, azoxystrobin 23% SC, azoxystrobin 18.2% + difenconazole 11.4% SC, fluopyram 17.7+tebuconazole 17.7 SC), tebuconazole 6.7% + captan 26.9% SC, copper oxy-chloride 50% WP and botanicals (kurax-herbal, sonata-botanical and spotless-phytotonic) against *Stagnospora*

Gummy stem blight on leaves of bottle gourd

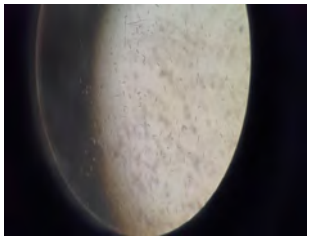
Typical symptom of gummy stem blight in bottle gourd

Typical symptom of gummy stem blight in ash gourd

Pathogenicity test of *S. cucurbitacearum* isolate on bottle gourd (*cv.* Kashi Ganga)



PDA culture plate of *GSB* pathogen *(S. cucurbitacearum)*



Conidia of *S. cucurbitacearum* (GSB pathogen)

Fig. 25: Symptoms of gummy stem blight on bottle gourd and ash gourd and B- pathogenicity test, PDA culture and conidia

cucurbitacearum gummy stem blight of bottle gourd and cucumber were done followed by poisoned food technique. Among tested fungicides, tebuconazole 25.9 % SC, azoxystrobin 3% SC and botanical (spotless) @ 500 ppm were found most effective against tested pathogen.

Project 3.17: Bioregulator Induced Drought Stress Tolerance in Okra (*Abelmoschus Esculentus*)

Activity 1: Screening of okra genotypes for drought stress tolerance at germination stage

An experiment was conducted to identify drought stress (moisture stress) tolerance in okra genotypes. Seeds of twenty okra genotypes were taken and disinfected by 1% sodium hypochlorite for 5 minutes. Twenty number of seed were randomly selected for each genotype and kept in petri plates embedded with whatman no. 1 filter paper. Thereafter, petri plates with seeds were kept in seed germinator (temp, 25 ± 2°C). To induce drought stress, 18% polyethylene glycol (PEG 6000) was used which creates -0.41 MPa of osmotic stress. Furthermore, the distilled water was used as control. After 3 days (72 hrs) of sowing, percent germination, radical and plumule length, and vigor index of okra seedlings were measured. The above experiment was performed with 3 replications.

Nine genotypes namely VRO 114, VRO 102, Kashi Lalima, VRO 156, Kashi Chaman, P.P, Pusa sawani, VROB 124 and Phule Utkarsha showed less than 50% of germination whereas eleven genotypes namely VRO 110, VRO 113, VRO 103, VRO 6, VRO 106, VRO 160, VRO 4, 416-10-1, VRO 124, Punjab 8 and Pusa Makhmali showed more than 50% of germination under 18% PEG treatment. It was found that VRO 110, VRO 106 and Pusa Makhmali genotypes didn't show significant reduction in germination percentage under PEG treatment as compared to control condition. Okra seedlings fresh biomass, shoot and root length reduced under PEG 18% treatment as compared to control condition. Moreover, it was also observed that VRO 110, VRO 106 and Pusa Makhmali genotypes have better seedling vigor index under PEG treatment (Fig. 26) and can be used in further breeding programmes for drought stress tolerance in okra.

Activity 2: Screening of okra genotypes for drought stress tolerance under field condition

A field experiment was conducted in the summer season at ICAR-IIVR, Varanasi during 2022. Twenty-four genotypes of okra were evaluated for their drought tolerance (moisture stress) ability. Drought stress was applied by withholding the irrigation at 55 days of sowing for 20 days. The experiment was carried out in randomized block design with three replications in control and drought conditions.

Soil moisture measurements: Soil samples from each experimental unit, at the depth of 15 cm were collected and kept in aluminium boxes with secure lids. The samples were weighed immediately and then oven dried at 105°C for 72 h for determining soil moisture content. Mean plant available water content in the root zone at 65 DAS was 15.31% and 9.67%, whereas at 75 DAS, it was 20.63% and 7.37% for irrigated and

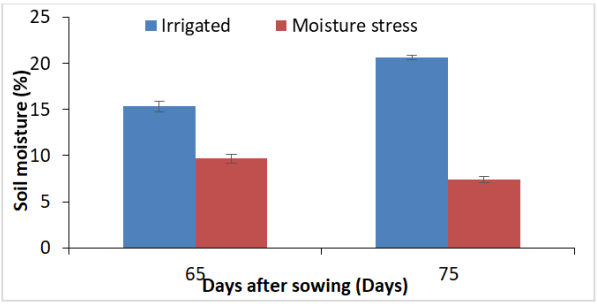


Fig. 27: Soil moisture (%) content under irrigated and drought stress condition

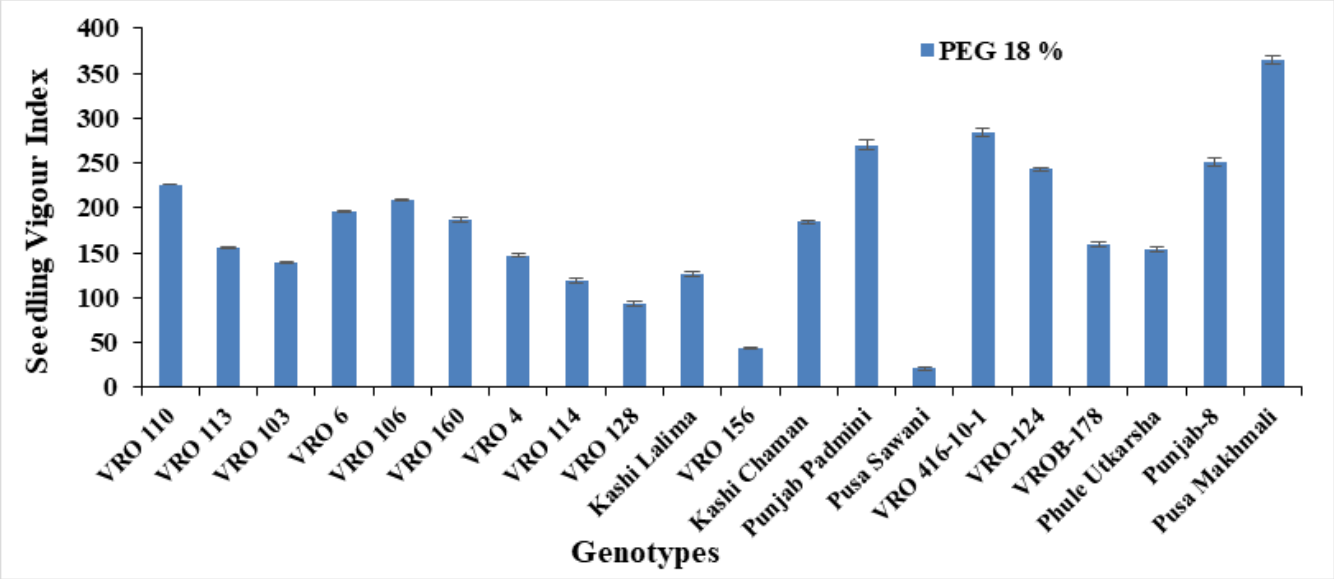


Fig. 26: Seedling Vigor Index of okra genotypes under 18% PEG 6000 mediated osmotic stress (-0.41 MPa)

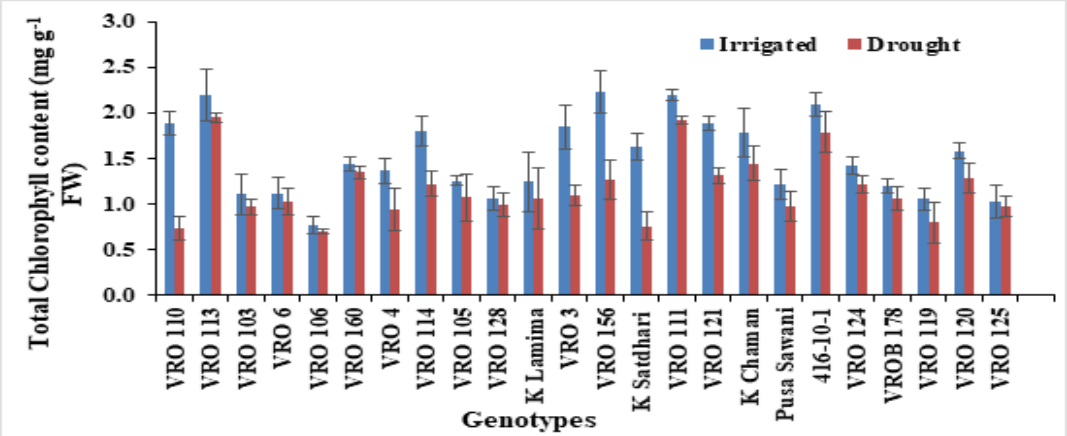


Fig. 28: Total chlorophyll content in the leaf of okra genotypes under irrigated and drought stress conditions

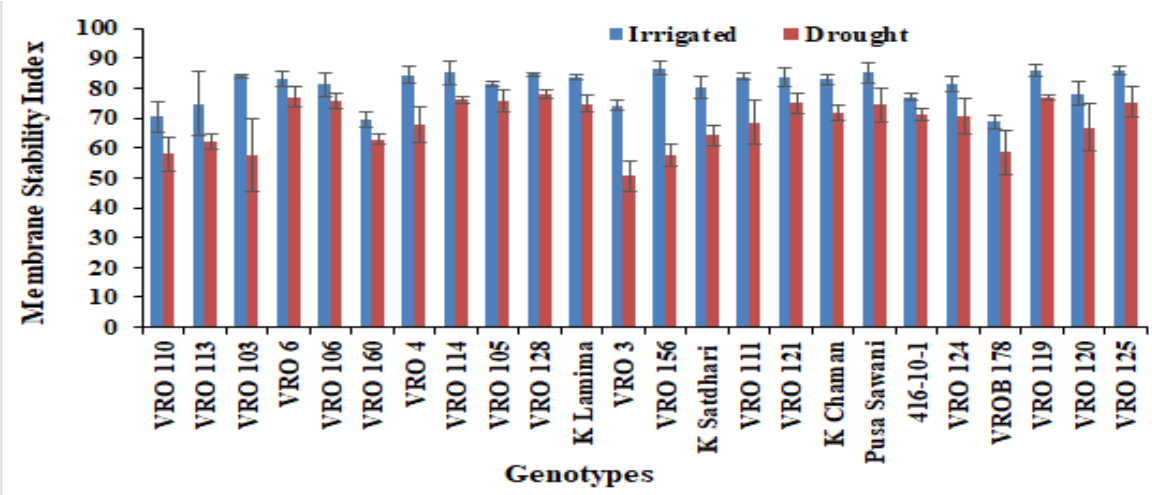


Fig. 29: Effect of irrigated and drought stress conditions on the membrane stability index (MSI) of okra genotypes.

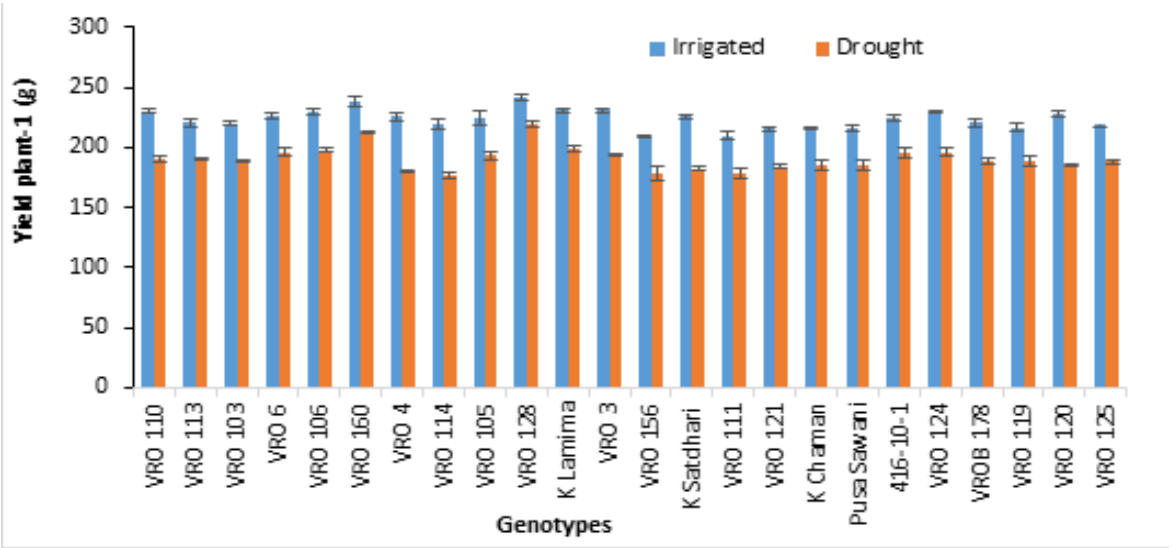


Fig. 30: Pod yield of okra genotypes under irrigated and drought stress conditions

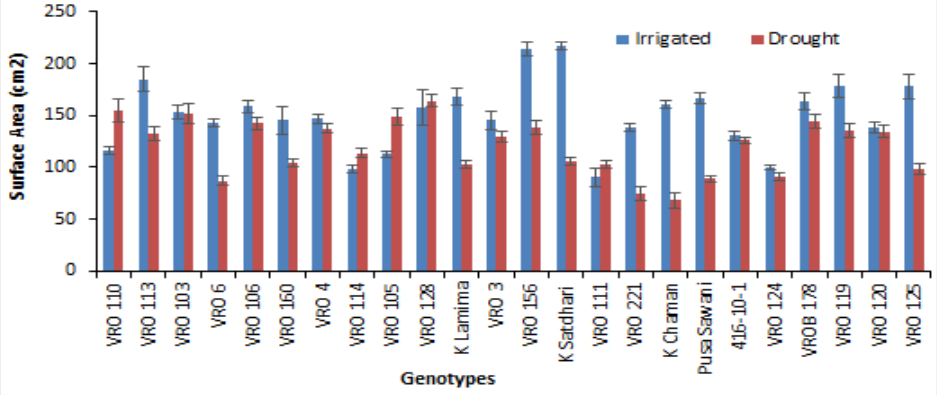


Fig. 31: Root surface area (cm^2) of okra genotypes under irrigated and drought stress conditions.

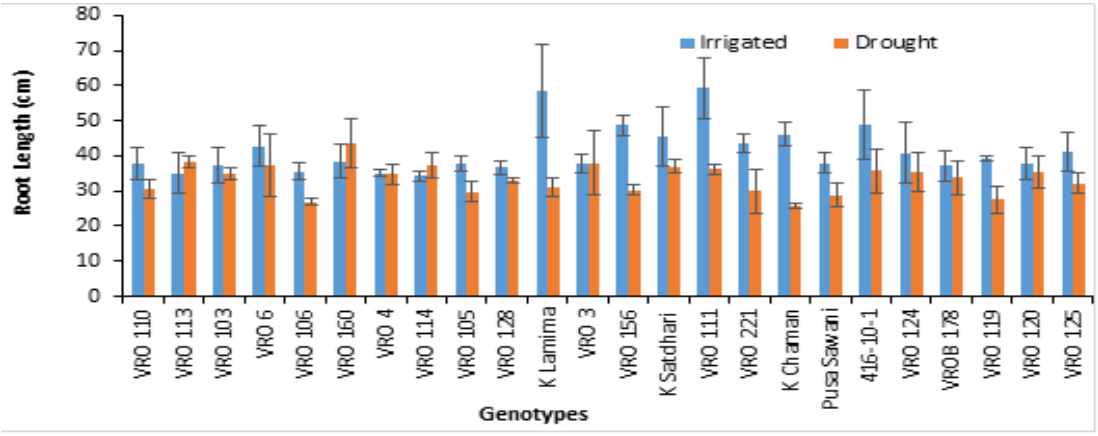
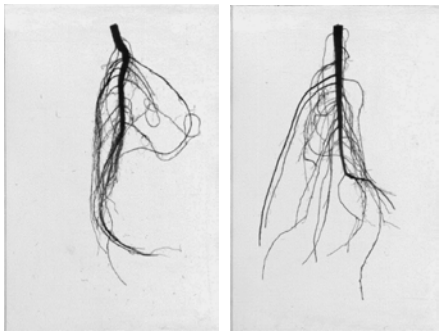


Fig. 32: Root length (cm) of okra genotypes under irrigated and drought stress conditions

drought stress conditions, respectively (Fig. 27).

Plant physiological parameters: Plant stress indicator traits like relative water content (RWC) and membrane stability index (MSI) and total chlorophyll content (mg g^{-1} DW) were measured in the matured leaf, after 75 DAS. Results showed that under drought stress condition there was decrease in total chlorophylls (mg g^{-1} DW) content in the leaf. The least percent decrease in total chlorophyll content was observed in VRO 125 (4.84%), VRO 160 (6.53%) and VRO 128 (6.78%), respectively (Fig. 28). Moreover, RWC and MSI were also found to be considerably reduced under drought stress as compared to irrigated condition. VRO 128 (4.58%), VRO 106 (7.17%) and 416-10-1 (8.48%) genotypes showed least reduction in RWC whereas VRO 106 (6.58%), VRO 105 (6.61%) and VRO 6 (7.38%) genotypes showed least reduction in MSI (Fig. 29) under drought stress.

Furthermore, the least increase of proline content (mg g^{-1} FW) was observed in VRO 128 and VRO 160 under drought stress condition compared to control. The highest percent increase of catalase enzyme activity (µM H_2O_2 reduced g^{-1} FW min^{-1}) under drought stress was observed in Pusa Sawani (267.51%), VRO 6 (250.55%) and VRO 128 (244.85%) genotypes whereas highest percent increase of peroxidase enzyme activity (µM tetra-guaiacol formed g^{-1} FW min^{-1}) was observed in VRO 128 (417.27%), VRO 160 (365.60%) and VRO 6 (315.12%) genotypes.



(a) Irrigated **(b) Drought stress**

Fig. 33: Root architecture of VRO 128 genotype under irrigated (a) and drought stress (b) conditions.

Pod yield and root characteristics: There was a significant decrease of pod yield in okra under drought stress as compared to irrigated condition. Drought stress leads to 9.40 to 20.37% yield reduction as compared to irrigated condition. The least yield reduction was observed in VRO 128 (9.40%) and VRO 160 (10.6%) genotypes under drought stress (Fig. 30). Moreover, the examination of okra root characteristics (root surface area,

root volume and root length) via EPSON Expression 11000XL instrument deciphered that VRO 128 has highest root surface area (cm^2) and root volume (cm^3) (Fig. 31, 32) whereas VRO 160 has highest root length (cm) (Fig. 33) under drought stress among the okra genotypes. Thus, the study revealed that VRO 128 and VRO 160 have the better drought tolerance ability.

MEGA PROGRAMME- 4: POST HARVEST MANAGEMENT AND VALUE ADDITION

Project 4.4: Influence of Polyamines on Postharvest Senescence and Quality of High Value Vegetables

Polyamines (spermidine and spermine) are naturally and ubiquitously present in all living organisms co-ordinating various cellular processes. Chitosan is a bio-compatible, non-toxic, anti-microbial and bio-degradable polysaccharide prepared by deacetylation of chitin. The effect of polyamines (spermidine and spermine @ 1.5 mM) and bilayer coating of carboxymethyl cellulose and chitosan on the fruit quality dynamics of cherry tomato during storage was studied. The fruit were held at 10°C. The treated cherry tomatoes showed no weight loss till 4 days followed by slow increase in weight loss with the advancement in storage. Weight loss in control fruit increased at a faster rate in comparison to both treatments. On the final day of storage, 2.8% WL was noted in T3 while it was 4.3% in control cherry tomatoes (Fig. 34C). It is evident from the figure 34 that cherry tomatoes register a slow increase in weight loss rates in comparison to other vegetables. However, the diminished surface glossiness and development of slight wrinkling on the surface results in the loss of postharvest marketability. Higher moisture retention and consequent lower physiological loss in weight might be directly attributed to the anti-senescent properties of spermidine, spermine and the barrier and anti-transpirant properties of chitosan and carboxy methyl cellulose surface coating. It was observed that lycopene content during most of the storage period was higher in spermine treated fruit with a bilayer coating than other treatment. Maximum 13.6 mg/100 g fw lycopene content was observed in T3 fruit on the last day of storage, which was about 15% higher over control. The initial ascorbic acid content in cherry tomato was recorded to be 19.9 mg/100 g FW. Lowest ascorbic acid content (about 15.0 mg/100 g FW) was observed on the last day

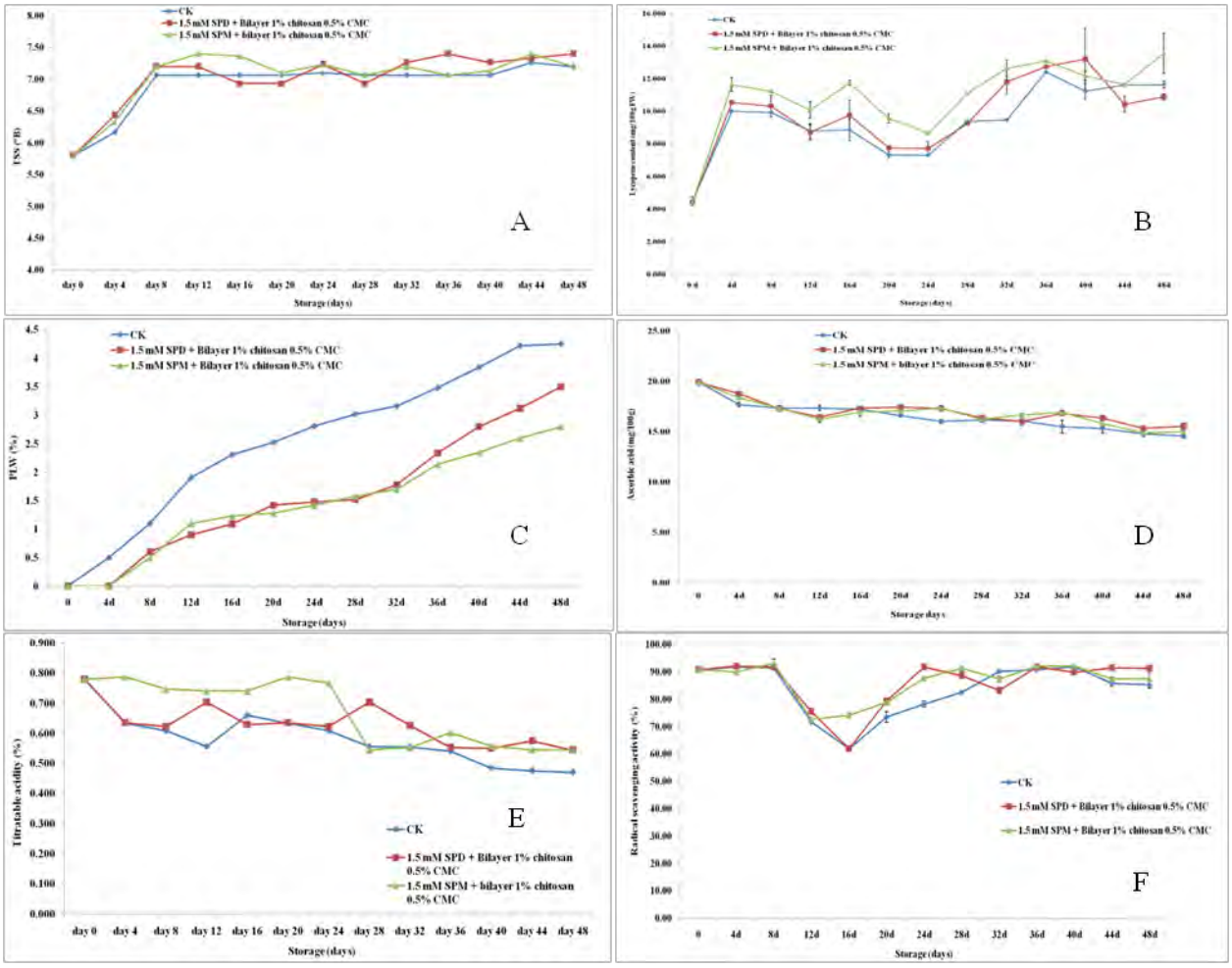


Fig. 34: Effect of polyamines treatment followed by bilayer coating of chitosan and carboxy methyl cellulose on quality and storability of cherry tomatoes during storage (A-Total Soluble Solids, B-Lycopene content, C-Physiological loss in weight, D- Ascorbic acid, E- Titratable acidity, F-Radical Scavenging Activity).

of storage. The ascorbic acid content in all three treatments was found to be non-significant at several intervals during storage. Minimum phenolics were observed in control fruit from 12th day onwards. On the final day of storage, T1 fruit showed lower radical scavenging activity (85.3%), followed by T3 (87.55%) and T2 (91.3%). High antioxidant capacity in cherry tomatoes is attributed to lycopene, ascorbic acid and total phenolics content. Maximum 29.54 mg GAE/100 g and minimum 12.42 mg GAE/100 g was observed in spermidine treated fruit of T2 on 32nd day and control fruit on the last day of storage, respectively. However, no general trend was observed. About 2.2 and 1.7-fold higher phenolic content retention was noted in T2 and T3 fruit, respectively over control at the end of storage period. The total soluble solids showed increase for first 8 days while the lowest titratable acidity was observed in control fruit on the last storage day. Among treatments 1.5 mM spermine followed by bilayer chitosan and CMC coating showed lowest weight loss and preserved overall fruit quality during storage.

Sensory evaluation of carrot genotypes: Nine carrot genotypes VRCAR-206, VRCAR-85, Kashi Arun, VRCAR-134, VRCAR-107-2, VRCAR-127, VRCAR-165, Kashi Krishna, VRCAR-44 (G1 to G9) ranging in outer colour from red, orange, purple, yellow and white were selected. These were scored on the basis of appearance, colour (outer and inner), texture, taste, aroma and overall acceptability by a semi-trained panel. Findings reinforced that red and orange colours are most acceptable (VRCAR-206, VRCAR-44 and VRCAR-134). Purple VRCAR-107-2 and Kashi Krishna had intermediate overall acceptability scores (6.63±0.19 and 6.81±0.18, respectively) (Table 24). Notably, it was found that white VRCAR-165 and yellow VRCAR-127 scored as low as (5.07±0.26, 6.06±0.26, respectively) projecting their poor probable marketability. All three red types VRCAR 206, VRCAR-85 and Kashi Arun, were more apart in comparison to orange coloured VRCAR-134 and VRCAR-44 which were relatively nearer on bi-plot. G7 (VRCAR 165), white was found to be on the farthest end suggesting maximum deviation in its sensory attributes over other carrot genotypes (Fig. 35).

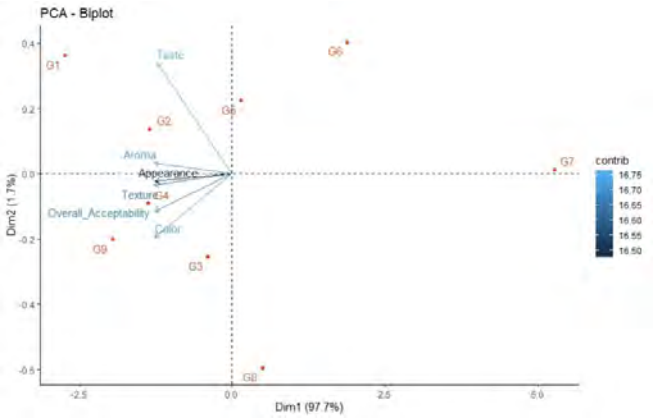


Fig. 35: Relationship among nine carrot genotypes on the basis of six sensory attributes separated by principal component analysis represented as bi-plot

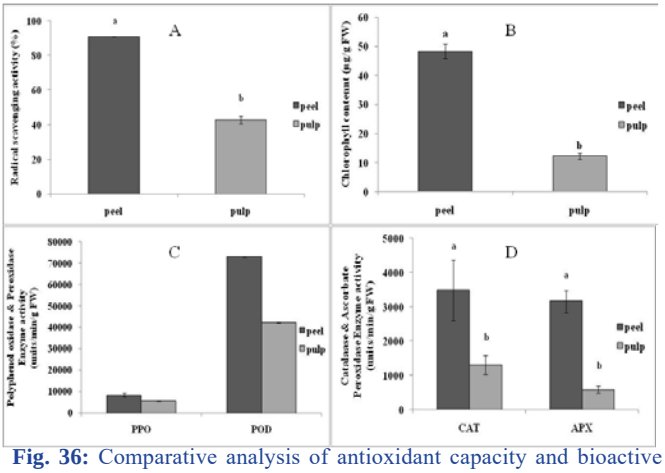


Fig. 36: Comparative analysis of antioxidant capacity and bioactive compounds in the peel and pulp of bottle gourd fruit (A- Radical scavenging activity, B- Chlorophyll content, C- Polyphenol oxidase and Peroxidase activity, D- Catalase and Ascorbate Peroxidase activity)

Surprisingly, we observed almost nil correlations among carrot genotypes as well. The correlation coefficient values of G1 (red) with G6 (yellow) and G7 (white) were as low as 0.004 and 0.019, respectively. Correlation coefficients showed that

Table 24: Mean value of sensory characteristics of nine carrot genotypes differing in colour ranging from white, yellow, orange, red, dark purple and rainbow.

Sensory attributes	Carrot genotypes								
	G1	G2	G3	G4	G5	G6	G7	G8	G9
Appearance	7.72±0.15a	7.41±0.12ab	7.06±0.16bc	7.36±0.19ab	6.72±0.21cd	6.42±0.26d	5.22±0.27e	6.72±0.21cd	7.76±0.15a
Colour	7.77±0.13a	7.36±0.16abc	7.22±0.17abc	7.50±0.19ab	6.86±0.22c	6.00±0.26d	4.83±0.27e	7.00±0.23bc	7.69±0.18a
Texture	7.58±0.13a	7.13±0.17abc	6.83±0.16bc	7.28±0.19abc	6.83±0.18bc	6.13±0.25d	5.13±0.27e	6.64±0.20c	7.33±0.18ab
Taste	7.90±0.14a	7.25±0.18b	6.68±0.19bcd	7.11±0.18b	6.86±0.22bc	6.38±0.27cd	4.97±0.29e	6.17±0.22d	7.22±0.19b
Aroma	7.27±0.19a	6.91±0.23ab	6.66±0.21ab	6.88±0.19ab	6.47±0.21bc	5.97±0.27c	5.06±0.3d	6.31±0.21bc	6.97±0.19ab
Overall acceptability	7.76±0.16a	7.20±0.14abc	6.98±0.13bcd	7.22±0.16abc	6.63±0.19d	6.06±0.26e	5.07±0.26f	6.81±0.18cd	7.52±0.16ab

Values are mean ± standard error of 36 determinations (n = 36). Mean values followed by same letters in a row are not significantly different ($p<0.05$).

VRCAR-206, red was at most extreme point with VRCAR-127, yellow followed by VRCAR-165, white coloured carrots.

Bottle gourd (*Lagenaria siceraria*), is consumed widely as a summer season cucurbitaceous vegetable crop. Besides its utilization as food, this vegetable is an abundant source of bioactive compounds and well known for its nutraceutical properties. Notably, the fruit peel is also consumed as a vegetable in some states of our country. Also, different parts of bottle gourd fruit are used in different medicine systems for their potential health benefits. This study was therefore, taken up to study the bioactive potential of the pulp and peel of bottle gourd cultivar "Kashi Ganga". It was observed that bottle gourd peel showed about 2-fold stronger antioxidant capacity in comparison to the pulp (42%). Importantly, chlorophyll content in bottle gourd peel (48 µg/g FW) was noted to be about 4-fold higher than the pulp portion of the fruit. Similar trend was observed for antioxidant enzyme activity which was higher in bottle gourd peel over the pulp (catlase-3495 units/min/g FW and 1306 units/min/g FW, respectively). However, polyphenol oxidase activity was found to be at similar levels in both bottle gourd pulp as well as peel (Fig. 36). This study maybe useful for extraction of bioactive compounds from the peel of bottle gourd fruit, which otherwise is generally discarded as waste in most of the households. Also, it re-affirms the importance of documentation and studies on the indigenous traditional knowledge and food habits of the diverse population of our country.

MEGA PROGRAMME 5: PRIORTIZATION OF R&D NEEDS AND IMPACT ANALYSIS OF TECHNOLOGIES DEVELOPED BY IIVR

Project 5.4: Empowering Rural Youth for Vegetable Based Entrepreneurship

The group dynamics of the rural youths were measured in three different time frames: at the start of the project period, in the middle of the process, and at the end of the project period (Fig. 37). To measure the group dynamics, the following ten factors were assessed: Group Purpose, Structure, Function, Cohesiveness, Atmosphere, Pressure, Effectiveness, Coaching, Goal, and Group Leadership. This study aimed to assess the changes in group dynamics over time and to identify any areas for improvement. A positive trend in group dynamics pattern was observed due to intervention under the project. The major aim of the project was to empower rural youths and women through vegetable based entrepreneurship. Positive changes in all aspects of empowerment i.e. economic empowerment, administrative empowerment, social empowerment, political empowerment, leadership and motivational empowerment, technological empowerment, health and security empowerment, environmental empowerment was observed after need based interventions. Vegetable varieties like Brinjal (Kashi Sandesh), Pumpkin (Kashi Harit), Cowpea (Kashi Nidhi), has enhanced the income of the farmers more than earlier. The potential of good variety has been harnessed through sound technology delivery system (fig. 38)

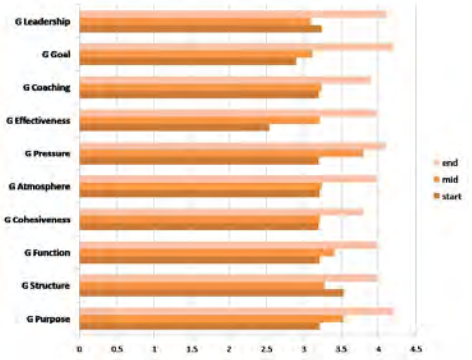


Fig 37: Changes in group dynamics of the rural youths

Fig 38: Changes in empowerment of rural youths

Project 5.5: Economic Impact Assessment of IIVR Developed Technologies

Economic impact assessment of Kashi Aman variety of tomato has been done using Economic surplus model and partial budgeting techniques. Area coverage under the cultivation of Kashi Aman variety of tomato has been estimated. The approximate spread of area under Kashi Aman variety was estimated at 247876.13ha during 2014-15 to 2021-22 covering a total of 146 districts in 25 states (calculated from the sale of both TL and breeder seeds data). The average tomato area in

Table 25: Economic impact assessment of Kashi Aman using Economic surplus model

Sl. No.	Cost Benefit Analysis (Rs. crores)	
1	Net Present Value (NPV)	48.83
2	Net Present Benefit (NPB)	49.62
3	Net Present Cost (NPC)	0.79
4	Internal Rate of Return (IRR)	85 %
5	Benefit Cost Ratio (BCR)	62.91
	Distribution of Economic Surplus (Rs. crores)	
6	Producer surplus	19.18
7	Consumer surplus	30.44
8	Total Economic surplus	49.62

the country was 8,15,000 ha. during TE 2020-21. The annual average area under Kashi Aman variety of tomato in the country was 30,985 ha. and it was around 3.80 per cent of total tomato area in the country. The estimated results of economic surplus model (ESM) showed that there was producer surplus of Rs. 19.18 crores, consumer surplus of Rs. 30.44 crores and total economic surplus of Rs. 49.62 crores generated from the variety. The Internal Rate of Return (IRR) was 85 per cent and Benefit Cost Ratio (BCR) 62.91 in the present technology.The share of producer and consumer surplus in total surplus was 39: 61 (Table 25).

The total cost of cultivation of Kashi Aman variety of tomato was Rs. 194101 per hectare compared to Rs. 211303 per hectare of private variety. The share of fixed and variable cost in Kashi Aman variety of tomato was 18:82 in total cost of cultivation. The total variable cost in Kashi Aman variety of tomato was Rs. 159026 per hectare compared to Rs. 175928 per hectare of private variety. The net return in Kashi Aman variety of tomato was Rs. 294149 per hectare while it was Rs. 218697 per hectare in private variety of tomato. The BC ratio was 2.52 and 2.04 for Kashi Aman variety and private variety of tomato grown by the farmers. Cost of cultivation according to various cost concepts reveals that all the costs were higher in cultivation of private variety of tomato over Kashi Aman variety of tomato. The cost A_1 was higher by around 13.60 per cent in cultivation of private variety of tomato over Kashi Aman variety of tomato. Similarly, the cost C_2 was higher by around 8.86 per cent in cultivation of private variety of tomato over Kashi Aman variety of tomato. The costs reduction and additional returns incurred in the Kashi Aman variety of tomato production over private variety reveals that the increment in profit realization in Kashi Aman variety of tomato production was Rs. 75452/ ha. The cost on seed, manures & fertilizers, plant protection chemicals, staking and fencing etc. mainly contributed to the reduction in cost of Kashi Aman variety of tomato production. The added return in Kashi Aman variety of tomato production was attributed mainly through the increased productivity and higher price realization over private variety. It can be concluded from the partial budgeting analysis that the adoption of Kashi Aman variety of tomato production technology would provide an additional profit to the farmers.

Project 5.6: Development & Promotion of Nutri-Garden Module for Rural Households

One of the easiest ways of ensuring access to adequate macro and micronutrients is to produce and consume different kinds

of vegetables from the garden. Nutri gardening is the easiest way of growing desired vegetables on our own piece of land. It can be grown in the empty space available in the backyard of the house or a group of women can come together, identify a commonplace or land and grow the desired vegetables, fruits, etc. This can benefit the women and community as a whole. Home-grown vegetables are organic, low cost and could be totally free from chemicals and pesticides. During 2022 apart from sensitizing rural people particularly women through training and demonstrations, trials of 02 nutri-garden modules for small family size were conducted in different cropping season at ICAR-IIVR research farm in an area of 100 m^2 and 150 m^2 with three replications to study its impact on vegetable consumption. The yields of all three replications were pooled to get an average production of different vegetable crops during rabi, zaid & kharif season and hence per day availability of leafy vegetables and other green vegetables were calculated. The findings of conducted trials showed that home production of vegetables for small family size (5-8 member) resulted in significant improvement in the vegetables availability and consumption for the whole family in general and women & children in particular.

Trials conducted in 100 m^2 area fetched a total of 210.54 kg leafy vegetables and 359.44 kg other green vegetables with daily availability of 0.58 kg leafy vegetables while 0.98 kg other green vegetables which is sufficient for a family size of 5-6 members (recommended per capita per day consumption of leafy vegetables is 100 gm. and other green vegetables 150 gm.) (Table 26). Similarly, in 150 m^2 area total vegetables fetched were 271.61 kg leafy vegetables and 498.89 kg other green vegetables with daily availability of 0.74 kg leafy vegetables while 1.37 kg other green vegetables which is sufficient for a family size of 7-8 members. These gardens have an established tradition and great potential for improving household food security and alleviating micronutrient deficiencies. Most importantly, it gives direct access to diverse nutritionally rich vegetables along with increase in the purchasing power through savings on food bills.

Table 26: Vegetable Production in Nutri Garden for Small Family Size

S.No.	Crop (Variety)	Rabi 2022 (Yield in kg)		Zaid 2022 (Yield in kg)		Kharif 2022 (Yield in kg)		Total Vegetables (Yield in kg)	
		100 m^2	150 m^2	100 m^2	150 m^2	100 m^2	150 m^2	100 m^2	150 m^2
Leafy Vegetables									
1.	Kasuri Fenugreek	33.44	30	-	-	-	-	33.44	30.0
2.	Coriander (Ganga)	25.74	26.24	6.16	6.05	-	-	31.90	32.05
3.	Spinach (K. Baramashi)	42.58	50.84	-	-	-	-	42.58	50.84
4.	Soya	11.05	7.87	-	-	-	-	11.05	7.87
5.	Kateli Spinach	14.6	29.34	-	-	-	-	14.6	29.34
6.	Chinese Mustard	11.1	19.34	-	-	-	-	11.1	19.34
7.	Red Amaranthus	-	-	14.33	24.94	18.12	13	32.45	37.94
8.	Green Amaranthus	-	-	15.37	26.16	-	-	15.37	26.16
9.	Water Spinach	-	-	-	-	18.05	38.07	18.05	38.07
TOTAL		138.51	163.63	35.86	57.15	36.17	51.07	210.54	271.61
Other Green Vegetables									
1.	Radish (K. Sweta)	21	20.2	-	-	-	-	21	20.02
2.	Carrot (K. Arun, K.Naintus)	22.35	21.86	-	-	-	-	22.35	21.86
3.	Pea (K. Udai)	13.48	13.03	-	-	-	-	13.48	13.03
4.	Chilli (K. Tej)	9.63	10.56	-	-	-	-	9.63	10.56
5.	Brinjal (K. Sandesh, K. Komal)	64.31	87.69	-	-	-	-	64.31	87.69
6.	Okra (K. Lalima K. Chaman)	-	-	26.11	45	33.33	36.02	59.44	81.02
7.	Cow pea (Kashi Nidhi)	-	-	22.34	9	15.15	24.7	37.49	33.7
8.	Bottle gourd (Kashi Ganga)	-	-	14.56	30.04	17.33	16.57	31.89	46.31
9.	Pumpkin (Kashi Harit)	-	-	12.23	21.89	27	18.23	39.23	40.11
10.	Sponge gourd (K. Jyoti, K. Shreya)	-	-	20.54	23.62	8.23	12.44	28.77	36.06
11.	Bitter gourd (IVBTG-10)	-	-	-	-	3.15	7.37	3.15	7.37
12.	Cauliflower	-	22.14	-	-	-	-		22.14
13.	Broccoli	-	20.52	-	-	-	-		20.52
14.	Cabbage	-	22	-	-	-	-		22
15.	Gram (Green)	-	7.88	-	-	-	-		7.88
16.	Banana	-	-	-	-	23.8	28.62	23.8	28.62
17.	Moringa	-	-	-	-	4.9	-	4.9	
TOTAL		130.77	225.88	95.78	129.55	132.89	143.95	359.44	498.89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DIVISION OF VEGETABLE PROTECTION

MEGA PROGRAMME 6: INTEGRATED PLANT HEALTH MANAGEMENT

Project 6.1: Bio-Intensive Management of Major Insect Pests of Vegetables in the Current Scenario of Weather Change

Evaluation of different pest management modules in tomato: Different pest management modules were evaluated against the major insect pests of tomato (cv. Kashi Aman). Among the three tested modules (M1= Biointensive pest management module, M2= Chemical pest management module, M3= Integrated pest management module), minimum fruit damage (4.33%), whitefly/leaf (0.33), Jassids/leaf (0.14), aphids/leaf (0.014) were recorded with Chemical pest management module (M2) *i.e.*, spraying of Imidacloprid 17.8 SL @ 0.35 ml/l at 30 DAT, spiromesifen 22.9 SC @ 1.25 ml/l at 50 DAT and Indoxacarb 14.5 SC @ 1ml/l at 70 DAT against 9.5% fruit damage, 9.66 whitfly/leaf, 2.20 Jassids/leaf, and 2.40 aphids/leaf in control. Further, M1 (BIPM) and M3 (IPM) modules were also significantly effective over control for all pests. Additionally, BIPM module secured higher spider (1.05/ plant) and predatory mirid bug population (1.04/ plant) followed by IPM module (Table 1).

Project 6.2: Toxicological Investigations on the Novel Insecticide Molecules and Plant Origin Insecticides Against Major Insect Pests of Vegetables

Efficacy of newer molecules against Pod borer, *Maruca vitrata* in Cowpea: A field experiment was conducted to find out the viable and environmentally friendly control measure against *M. vitrata*. The effect of insecticides on mean populations of *M. vitrata* showed that plots treated with Chloratraniliprole 18.5% SC had lower pod borer populations and high yield than the untreated control plots. Lower pod infestation was recorded in newer insecticide molecules treated plots *viz*., Spinosad 45 SC, Fipronil 5% SC, Flubendiamide 39.35% SC and Cypermethrin 25% EC. Least cowpea pod and flower damage were recorded in plots treated with Chlorantraniliprole in comparison to untreated control plots. Highest green pod yield was noted in Chlorantraniliprole treated plots (Table 2). Natural enemies like coccinellids and spider population were least affected in Chlorantraniliprole treated plots (Table 3). Thus, Chlorantraniliprole can be recommended as an environment friendly option to manage *Maruca vitrata*.

Effectiveness and benefit-cost ratio of botanicals in managing the major insect pests of cabbage: Mustard aphid

Table 1: Effect of different pest management modules against insect pests in tomato

Treatments	Fruit damage (%)			Whitefly/leaf			Jassids/leaf			Aphids/leaf			Spider/leaf			Mirid bug/twig		
	BS	AS	PROC	BS	AS	PROC	BS	AS	PROC	BS	AS	PROC	BS	AS	PROC	BS	AS	PROC
M1	8.34	5.79	38.98	11.34	7.04	27.07	1.38	0.92	57.91	1.46	0.58	75.58	1.98	1.05	67.72	1.67	1.04	36.23
M2	9.87	4.33	54.4	11.27	0.33	96.58	1.28	0.14	93.81	2.54	0.014	99.41	1.89	0.268	91.72	1.89	0.26	83.66
M3	10.43	6.58	30.6	12.46	5.00	48.16	1.56	0.168	92.36	1.32	0.28	88.00	1.67	0.288	91.11	1.54	0.28	82.44
Control	9.38	9.50		10.57	9.66		178	2.20		1.98	2.40		2.67	3.24		1.34	1.64	
SEm (%)		0.54			0.45			0.27			0.23			0.40			0.14	
CD 5%		1.59			1.34			0.80			0.67			1.18			0.41	

BS- Before spray; AS – After spray; PROC – Percent reduction over control

Table 2: Field evaluation of novel insecticides for management of pod borer, Maruca vitrata in cowpea

Treatment	Dose (g a.i./ha)	*Maruca vitrata* in Flowers		*Maruca vitrata* in Pods		Flower damage	Pod damage	Green Pod Yield
		PTC	Mean*	PTC	Mean*	(%)	(%)	(Q/ha)
Spinosad 45% SC	84	9.10^{a}	3.60^{abc} (2.02)	13.80^{a}	5.80^{abc} (2.51)	11.30^{b}	12.60^{b}	138.97^{d}
Fipronil 5% SC	50	8.93^{a}	4.10^{abc} (2.14)	14.07^{a}	6.60^{bc} (2.66)	14.70^{c}	17.53^{c}	121.81^{a}
Flubendiamide 39.35% SC	48	9.20^{a}	4.70^{bc} (2.28)	14.33^{a}	7.73^{cd} (2.87)	17.30^{cd}	18.30^{c}	118.43^{a}
Cypermethrin 25 % EC	50	9.10^{a}	5.40^{d} (2.43)	15.00^{a}	9.60^{d} (3.18)	19.37^{d}	20.60^{c}	104.13^{b}
Chloratraniliprole 18.5% SC	30	9.30^{a}	2.10^{ab} (1.61)	13.73^{a}	3.80^{a} (2.07)	6.70^{a}	7.27^{a}	154.20^{f}
Chloratraniliprole 18.5% SC	15	8.87^{a}	2.60^{ab} (1.76)	14.27^{a}	4.60^{ab} (2.26)	7.30^{a}	8.80^{ab}	147.40^{e}
Chloratraniliprole 18.5% SC	60	9.13^{a}	1.80^{a} (1.52)	14.20^{a}	3.20^{a} (1.92)	5.80^{a}	6.20^{a}	160.90^{g}
Control		10.00^{a}	18.20^{e} (4.32)	14.60^{a}	16.80^{e} (4.16)	35.07^{e}	38.03^{d}	52.40^{a}
LSD at 5%	-	NS	1.86	NS	1.91	1.60	2.70	2.32
df	-	7,16	7,16	7,16	7,16	7,16	7,16	7,16
F value	-	1.96	42.86	2.43	28.12	75.07	49.32	378.49
P value	-	0.126	<0.001	0.067	<0.001	<0.001	<0.001	<0.001

PTC-Pre-treatment Count, NS-Non-Significant, *Mean immature and adult population per five plants, *Pooled mean population of *M. vitrata* larvae after three sprays. Data are means of three replications. Figures in parentheses are $\sqrt{x+0.5}$ transformed values. Means in the same column followed by different letters differ significantly ($P < 0.05$) on the basis Duncan's Multiple Range Test.

Table 3: Effect of insecticides on coccinellids and spiders in cowpea

Treatment	Dose (g a.i./ha)	Coccinellids		Spiders	
		PTC	Mean	PTC	Mean
Spinosad 45% SC	84	3.30^{a}	3.00^{b} (1.87)	2.02^{a}	1.90^{ab} (1.55)
Fipronil 5% SC	50	2.30^{a}	1.53^{a} (1.43)	1.73^{a}	1.34^{a} (1.36)
Flubendiamide 39.35% SC	48	3.20^{a}	2.20^{ab} (1.64)	2.33^{a}	1.27^{a} (1.33)
Cypermethrin 25 % EC	50	2.63^{a}	1.60^{a} (1.45)	2.24^{a}	1.40^{a} (1.38)
Chloratraniliprole 18.5% SC	30	3.10^{a}	2.80^{b} (1.82)	2.74^{a}	2.13^{ab} (1.62)
Chloratraniliprole 18.5% SC	15	2.90^{a}	2.70^{ab} (1.79)	3.37^{a}	2.90^{b} (1.84)
Chloratraniliprole 18.5% SC	60	2.83^{a}	2.63^{ab} (1.77)	2.54^{a}	2.40^{ab} (1.70)
Control		2.60^{a}	3.10^{b} (1.90)	2.33^{a}	2.93^{b} (1.85)
LSD at 5%	-	NS	0.92	NS	0.772
df	-	7,16	7,16	7,16	7,16
F value	-	0.603	2.872	0.875	2.971
P value	-	0.745	0.038	0.546	0.034

PTC-Pre-treatment Count, NS-Non-Significant, *Mean immature and adult population per five plants, *Pooled mean population of *Maruca vitrata* larvae after three sprays. Data are means of three replications. Figures in parentheses are $\sqrt{x+0.5}$ transformed values. Means in the same column followed by different letters differ significantly ($P < 0.05$) on the basis Duncan's Multiple Range Test.

(MA), diamond back moth (DBM) and cabbage butterfly (CB) were observed as major yield-restricting factors in cabbage. Considering the adverse impacts of synthetic agrochemicals, an investigation was carried out in search of eco-friendly and sustainable management options for these pests. Several botanicals were evaluated against MA, DBM and CB. The effectiveness of botanicals was assessed by comparing treated vs untreated control plots for the nymphal/larval densities of each species of insect, immature and adult natural enemies, crop damage ratings and marketable yield. To assess the economics of botanical application, the benefit-cost ratio (BCR) was computed. The application of Azadirachtin @ 2 ml/L and garlic oil @ 2 ml/L showed a gradual increase in the reduction of MA, DBM and CB populations. Azadirachtin caused the higher percent reduction 70.19, 70.87 and 69.36 in the population of MA, DBM and CB. Garlic oil was responsible

Table 4: Compatibility and synergism of neonicotinoids with EPF against aphids, *Aphis craccivora*

Insecticides	Heterogenity		Regression Equation (Y=)	LT_{50} (hr)	Fiducial Limit	Co-toxicity coefficient w.r.t.	
	df	χ^2				EPF	Neonicotinoid
Beauveria bassiana	3	0.153	5.798X – 4.629	45.77	50.31 – 41.64	--	--
Metarhizium anisopliae	3	1.598	5.676X – 4.462	46.45	51.14 – 42.19	--	--
Lecanicillium lecanii	3	2.714	5.204X – 3.567	44.29	49.13 – 39.92	--	--
Imidacloprid 17.8 SL	3	0.105	3.971X – 0.711	27.43	33.22 – 22.64	--	--
Thiamethoxam 25 WG	3	0.276	4.023X – 0.747	26.82	32.61 – 22.06	--	--
Acetamiprid 20 SP	3	1.004	5.012X – 2.125	26.39	30.09 – 22.41	--	--
B. bassiana + Imidacloprid	4	2.837	1.908X + 2.335	24.92	32.40 – 19.16	1.84	1.10
M. anisopliae + Imidacloprid	4	1.085	1.991X + 2.191	25.76	33.06 – 20.07	1.80	1.07
L. lecanii + Imidacloprid	4	1.039	2.449X + 1.595	24.54	29.97 – 20.10	1.81	1.12
B. bassiana + Thiamethoxam	4	5.057	1.871X + 2.462	22.59	29.35 – 17.38	2.03	1.19
M. anisopliae + Thiamethoxam	4	5.379	1.697X + 2.600	25.94	34.99 – 19.23	1.79	1.03
L. lecanii + Thiamethoxam	4	2.986	2.401X + 1.741	22.55	27.74 – 18.32	1.96	1.19
B. bassiana + Acetamiprid	4	3.312	1.907X + 2.409	22.82	32.04 – 16.26	2.01	1.16
M. anisopliae + Acetamiprid	4	6.209	1.999X + 2.265	23.32	32.34 – 16.82	1.99	1.13
L. lecanii + Acetamiprid	4	6.456	2.486X +1.669	21.85	28.14 – 16.97	2.03	1.21

for 67.40, 68.67 and 67.17 percent reduction in the population of MA, DBM and CB. Mahogany oil and pongamia oil were found least effective against all the major insect pests of cabbage in both seasons. The highest cost: benefit ratio of 2.43 was noticed for the insecticide treatment Tolfenpyrad. Among the botanicals, a comparable cost: benefit ratio was recorded in Azadirachtin (2.19) and garlic oil (2.03). Least cost: benefit ratio was recorded for Pongamia oil (1.16) and mahogany oil (1.12) due to their lesser efficacy in controlling the MA, DBM and CB which ultimately resulted in higher crop loss. Botanical insecticides varied significantly in their efficacy at controlling insect pests and cost-benefit ratios. In terms of efficacy and cost-benefit ratio, botanicals such as Azadirachtin and garlic oil were comparable to Tolfenpyrad insecticide. The adverse effects of the botanicals on predatory insect populations were negligible in comparison to the chemical insecticides. Therefore, botanicals like Azadirachtin and garlic oil are recommended as alternative options to manage the insect pests of cabbage in an eco-friendly and cost-effective manner.

Monitoring baseline susceptibility and resistance of DBM, *Plutella xylostella* against newer insecticides: Diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae), is a damaging global pest that harms cruciferous crops, and insecticides are the primary management option. The objective of this study was to assess the level of pesticide resistance in *P. xylostella*, which was collected from different locations from Eastern Uttar Pradesh, India, against a wide range of insecticides. The results revealed that, in comparison to a susceptible laboratory population, Spinetoram was very harmful to *P. xylostella*, with a resistance ratio ranging from 2.62 to 14.68-fold. Spinosad, Emamectin benzoate, and Indoxacarb all showed low to moderate levels of resistance in all field populations, however high levels of resistance were found for Flubendiamide, Chlorantraniliprole, Cypermethrin and Fipronil. Therefore, an array of insecticides with various modes of action should be used in rotation to prevent resistance in *P. xylostella*.

Project 6.3: Biological Control of Major Insect Pests of Vegetable Crops

Compatibility and synergism of major neonicotinoids with different entomopathogenic fungi (EPF) against *Aphis craccivora* Koch.: To control the black bean aphid, *Aphis craccivora* feeding on leguminous vegetables *viz.*, Cow pea, Indian bean, French bean, pea etc. commonly used neonictinoids (Imidacloprid, Thiamethoxam and Acetamiprid) and biopesticides *viz., Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii* were tested at half of their recommended doses and found compatible. Combination of Acetamiprid and *L. lecanii* took the lowest median lethal time (21.85 hour) with Co-toxicity coefficient (CTC) value (1.21). A similar observation was also noted in case of Thiamethoxam where *L. lecanii* when mixed with Thiamethoxam at half of recommended doses took the lowest median lethal time (22.55 hour) and with highest CTC value (1.19) (Table 4). Similar observation was also noted combination of Imidacloprid and three EPF. Co-application of these EPF with sub-lethal concentration of neonicotinoids could not only be a green eco-friendly option against this sucking pest but also able to minimize the chemical insecticides load in the environment.

$$\text{Co-toxicity co-efficient w.r.t. neonicotinoids} = \frac{LT_{50} \text{ value of Neonicotinoid insecticide alone}}{LT_{50} \text{ value of insecticide and EPF mixture}}$$

Table 5: Forward stepwise regression models of variable selection with partial R2 and model R2

Number of fruit fly/trap	Variable entered	Partial R^2	Model R^2
$Y = -156.2 + 0.95x_1$	Max Temp (x_1)	0.252	0.252
$Y = -205.23 + 0.95x_1 - 2.36x_2$	Min Temp (x_2)	0.201	0.453
$Y = -108.53 + 1.80x_1 - 5.32x_2 + 0.31x_3$	Morning RH (x_3)	0.131	0.584
$Y = -128.53 + 0.92x_1 - 0.03x_2 + 0.32x_3 - 0.35x_4$	Evening RH (x_4)	0.050	0.634
$Y = -161.83 + 0.66x_1 - 0.01x_2 + 0.20x_3 - 0.74x_4 - 0.87x_5$	Sunshine hour (x_5)	0.051	0.685
$Y = -114.08 + 0.37x_1 - 0.01x_2 + 0.18x_3 - 0.74x_4 - 2.07x_5 + 1.79x_6$	Evaporation (x_6)	0.043	0.728
$Y = -114 + 0.40x_1 + 1.18x_3 - 0.72x_4 - 2.12x_5 + 1.97x_6 + 0.70x_7$	Rainfall (x_7)	0.030	0.758
$Y = -216.70 + 9.95x_1 - 4.85x_2 + 2.60x_3 - 2.11x_4 - 12.66x_5 + 0.69x_6 + 0.56x_7 + 0.14x_8$	Wind velocity (x_8)	0.020	0.778
	Overall R^2	0.778	

Distribution and abundance of cucurbit fruit fly *Zeugodacus Bactrocera cucurbitae* in relation to abiotic parameters: The cucurbit fruit fly, *Zeugodacus* (=*Bactrocera*) *cucurbitae* (Coquillett) (Diptera: Tephritidae) is a polyphagous and a major pest of cucurbitaceous vegetables. The tune of crop losses varies from 20 to 100%, depending on the cucurbit species and the prevailing weather conditions. Field experiments were carried out to study the population fluctuation of cucurbit fruit fly in different cucurbitaceous vegetables and its relationship with different weather variables in Varanasi region. Weekly data on adult fruit fly caught in cuelure traps installed in different cucurbits were taken whereas different abiotic parameters were obtained from the meteorological observatory of the institute. Six year mean data revealed that there were two major peaks of fruit fly incidence in the region i.e., the first occurred during 13 (last week of March) and the second during 46 (third week of November) standard meteorological week (SMW) and the corresponding adult fruit fly caught per trap were 90.33 and 96, respectively. The maximum temperature (r =+0.447**), sunshine hour (r= +0.448**) and evaporation rate (r= +0.439**) showed highly significant positive correlations with this fruit fly abundance in the region whereas morning and evening relative humidity (r= -0.570** and r= -0.724**), rainfall (r= -0.266*) and wind velocity (r= -0.08) adversely affect the population build up. Based on stepwise forward regression, maximum temperature played significant role explaining 25.2% fruit fly abundance followed by minimum temperature sharing 20.1% abundance. Morning relative humidity accorded 13.1% share of this polyphagous pest followed by evening relative humidity and sunshine hours (5% each). All the eight meteorological parameters combinedly contributed about 77.8% abundance of fruit fly under Varanasi conditions (Table 5). A weather-based prediction model has also been developed with different weather indices. The model thus derived for fruit fly incidence (Y) is as follows

$$Y = -216.70 + 9.95x_1 - 4.85x_2 + 2.60x_3 - 2.11x_4 - 12.66x_5 + 0.69x_6 + 0.56x_7 + 0.14x_8$$

Project 6.4: Development of Effective Integrated Management Package for Important Fungal Diseases of Vegetable Crops

Evaluation of integrated packages for eco-friendly management of fungal diseases of brinjal: A field experiment was conducted with eight integrated packages for eco-friendly management of fungal diseases of brinjal variety Kashi Uttam using truthfully labelled seeds of institute. Soil solarization on nursery beds, nylon net 40 mesh covering of nursery beds and green manuring in main field are common for all the treatments. The details of eight modules are given below:

Chemical Module-I (T_1): Seed treatment by captan 70% WP + hexaconazole 5% @ 0.25% during sowing; Seedling root dipping in captan + hexaconazole @ 0.25% during transplanting; Spray mancozeb 75% WP @ 0.25% at 55 DAT; Spray of carbendazim @ 0.1% at fruit initiation stage 70 after first spray; Spray of carbendazim @ 0.1% 100 DAT; Spray of mancozeb @ 0.25% at fruit maturity

Chemical module-II (T_2): Seed treatment by carbendazim @ 0.25% during sowing; Seedling root dipping in carbendazim @0.1% for 30 minutes during transplanting; Spray carbendazim @0.1% 55 DAT; Drench CoC @0.3% 70 DAT; Drench carbendazim @ 0.1% at 90 DAT; Spray of tebuconazole @ 0.1% at fruiting stage; Last spray of mancozeb @ 0.25% at fruit maturity

Integrated Disease Management (IDM)- I (T_3): Seed treatment by *T. asperellum* @1%; Seedling root dipping @ 1% by *T. asperellum* 10 minutes during transplanting; Drenching of *T. asperellum* @1% 4 times at 20 days interval; Spray of carbendazim @0.1% thrice at 15 days interval started 70 DAT

IDM-II (T_4): Seed treatment by TCV-1 @1%; Seedling root dipping TCV-1 @1% for 10 minutes during transplanting; Drenching of TCV-1 @ 1% 4 times at 20 days interval; Spray of mancozeb @0.25% thrice at 15 days interval sarted 70 DAT

IDM-III (T_5): Nursery soil application by TVBG @100g/ m^2 area; Slurry root treatment by TVBG with compost during transplanting; Drenching of 10g TVBG 4 times at 20 days interval; Foliar spray of tebuconazole @0.1% thrice at 15 days interval started 70 DAT

IDM-VI (T_6): Seed treatment by *T. asperellum* @ 0.5% + CRB-7@ 0.5%; Seedling root dipping *T. asperellum* @ 0.5% + CRB-7@ 0.5%; Drenching of *T. asperellum* @ 0.5% + CRB-7 @ 0.5% @ 1% 4 times at 20 days interval; Spray of tebuconazole @0.1% alternated by mancozeb @0.2% at 15 days interval started 70 DAT twice.

Good Agricultural Practices (GAP) (T_7): Use of *Phomopsis* free selected seeds for sowing; Removal /Rouging of coller rot, Rhizoctonia infected plants; Periodical removal of dicot weeds; Cutting of *Phomopsis* and *Sclerotinia* infected twigs along with healthy in morning; Spray of micronutrients @0.3% four times started after at 55 DAT at 15 days interval

Untreated Control (T_8)

The seed treatment components were applied and tested in Petri plates under blotter method for its germination, seed mycoflora, and seedling vigour. The *in vitro* seed germination percentage was maximum 95.33% in T4 (95.33%) followed by T2 (93.33%) and T6 (92.33%) in comparison to untreated control 86.66% after ten days of seed plating (Table 6). The total of shoot and root length was highest 9.35 cm was in T7 followed by T4 (8.86 cm). Maximum shoot length was 4.49 cm and root length 4.94 cm were also found in T7. Statistically T7, T4, T6 and T3 were at par. Chemical seed treatment by coordinated compound of captan 70% + hexaconazole 5% @ 0.25% was lethal and drastically reduced the shoot length (1.23 cm) and root length (1.85 cm) in comparison to remaining all the treatments including untreated control after 12 days of seed plating (Table 6). It clearly indicates that seed treatment of brinjal by these fungicides was harmful to seedling vigour.

In another set of experiment the same treated seeds were sown in earthen pots which resulted maximum seed germination of 79.6% in T6 closely followed by T3 (79.0%) and T2 (78.8%) in comparison to untreated control 55% after 22 days of sowing under net house conditions (Table 7; Fig. 1). In this experiment shoot length and root length of seedling were significantly increased in all the modules except T1 i.e. chemical module-1 (Table 7). The maximum shoot & root length was 21.58 cm inT3 followed by T4 (20.62 cm) in comparison to only 12.48 cm in T1 at 34 days of sowing. Inhibitory effects of the fungicides on seedling vigour were also very clear under pot conditions (Table 7).

Finally, at third stage of experimentation the same lot of treated seeds were sown in nursery beds wherein maximum seed germination was 91.40% in T6 after 16 days of sowing (DOS) and 91.6% after 29 DOS (Table 8) in comparison to control (64%). It was followed by T5 with 88.9% seedling stand at 29 (DOS). In nursery beds also, the chemical module-1 (T1) reduced the seed germination and seedling vigour at 16 DOS and 29 DOS. It is concluded that the seed treatment of brinjal by coordinated compound of captan 70% + hexaconazole 5% @0.25% should not be recommended for nursery of brinjal.

Fig. 1: Brinjal nursery view

Table 6: Effect of different management modules on *in-vitro* germination and shoot, root length of brinjal seeds in Petri plates

Treatment modules	Germination (%)	Germination (%)	Shoot length (cm)	Root length (cm)	Total seedling length (cm)
T1-CM-1	50.60	92.33	1.23	1.85	3.08
T2-CM-2	83.33	93.33	4.08	2.78	6.86
T3-IDM-I	78.0	88.0	3.39	5.09	8.48
T4-IDM-II	79.33	95.33	4.29	4.57	8.86
T5-IDM-III	74.0	87.33	3.97	4.77	8.76
T6-IDM-IV	82.33	92.33	4.41	4.25	8.66
T7-GAP	66.67	91.67	4.49	4.94	9.35
T8-Control	77.67	86.66	3.97	4.15	8.32
CD	N/A	N/A	0.417	0.397	-
CV	18.16	23.08	6.408	5.607	-

Table 7: Effect of different management modules on seedling stand, shoot and root length of brinjal plants in earthen pots

Treatment modules	Germination (%)	Germination (%)	Shoot length (cm)	Root length (cm)	Total seedling length (cm)
T1-CM-1	72.0	73.4	7.8	4.68	12.48
T2-CM-2	78.8	77.8	12.68	7.5	20.18
T3-IDM-I	79.0	78.2	13.88	7.7	21.58
T4-IDM-II	77.0	75.8	13.52	7.1	20.62
T5-IDM-III	74.6	73.6	10.6	7.14	17.74
T6-IDM-IV	79.6	77.8	10.72	6.74	17.46
T7-GAP	74.6	86.2	11.88	6.58	18.46
T8-Control	55.0	64.0	8.98	5.7	15.56
CD	0.27	N/A	0.86	0.984	-
CV	5.164	17.488	15.76	11.447	-

Table 8: Effect of different management modules on seedling stand, shoot and root length of brinjal plants in nursery beds

Treatment modules	Germination (%)	Germination (%)	Shoot length (cm)	Root length (cm)	Total seedling length (cm)
T1-CM-1	67.5	68.67	11.02	5.74	16.76
T2-CM-2	84.83	88.64	12.18	6.62	18.8
T3-IDM-I	75.23	83.32	14.08	7.26	21.34
T4-IDM-II	76.53	86.51	12.6	7.36	19.96
T5-IDM-III	80.37	88.90	11.94	6.22	18.16
T6-IDM-IV	91.4	91.57	11.7	6.26	17.96
T7-GAP	68.57	68.08	11.4	8.48	19.88
T8-Control	64.67	63.93	8.8	7.4	16.2
CD	3.305	3.679	1.306	1.03	-
CV	2.487	2.602	8.56	11.138	-

Although the fungal disease pressure during the year of experimentation was negligible in the entire region except Alternaria leaf blight. The experiment resulted significant reduction of *Alternaria* leaf blight severity in all the treatment in comparison to control. The minimum *Alternaria* leaf blight was recorded 24.1% (Table 9) in T2 i.e. chemical module-2 followed by T6 (37.44%). Statistically T6, T5, T4, T3 were at par. The maximum marketable yield 192.24q/ha was recorded in T1 followed by T6 (156.04 q/ha), T5 and T7 in comparison (Table 9). The unmarketable yield comprised of mostly fruit borer damage.

Field screening of sponge gourd against Downy mildew diseases: Among 116 genetic materials of sponge gourd screened under natural field condition only VRSG-136 showed resistant against the downy mildew disease with 4.9% PDI based of 0-5 point rating scale in *Kharif* season. Six moderately resistant lines namely VRSG-18-10 (18.1%), VRSG-17-10 (20%), VRSG-19-6 (21.22%), VRSG-21-6 (22.7%), VRSG-18-4 (23.33%) and VRSG-21-8 (23.33%) were recorded in *Kharif* season.

Effect of brinjal and chilli seeds germination using soil borne fungal pathogens Brinjal (Kashi Taru) and Chilli (Kashi Anmol) seeds treated with talc based bioformulation of *Actinomyces* sp. strain N1.2 and its seeds germination evaluation was done against soil-borne fungal inoculants (*Sclerotinia* sp., *Macrophomina* sp., and *Sclerotium* sp.) using sterile and normal soil cup pot experiments. Significant increase in seed germination percentage was reported in bio-agent treated seeds against all 3 soil-borne fungal pathogens in both sterile and normal soil when compared with the control cup pot experiments. Seed germination percentage was higher in sterile soil when compared with the normal soil (Table 10).

Evaluation of *Actinomyces* sp. strain N1.2 in pot experiments using bioformulation coated brinjal and chilli seeds: Brinjal (Kashi Taru) and chilli (Kashi Anmol) seeds were treated with N1.2 talc bioformulation @ 10 g/kg seeds with (T1) and without (T2) drenching of 10 g/lit of bio-agent thrice at weekly interval. Treated seeds along with control were sown in the soil filled pots in seven replicates, and were kept in net house. Talc-based bio-agent N1.2 (10 g/kg seed) + Drenching (10 gram/litre) thrice at 7 days interval gave the best results in term of % seed germination, post emergence damping off, root/stem length and fresh/dry weight with significant increase over the control in both brinjal and chilli pot experiments. In both chilli and brinjal, average percent seed germination was

Table 9: Effect of different management modules on Alternaria leaf blight and yield of brinjal

Treatment modules	PDI	Marketable yield (q/ha)	Unmarketable yield (q/ha)	Total yield (q/ha)
T1-CM-1	64.21	192.24	225.22	417.46
T2-CM-2	24.068	136.50	148.06	284.56
T3-IDM-I	47.50	133.59	156.96	290.55
T4-IDM-II	42.74	146.15	198.93	345.08
T5-IDM-III	35.69	153.79	163.89	317.68
T6-IDM-IV	37.44	156.04	171.39	327.43
T7-GAP	49.17	152.18	156.39	308.43
T8-Control	75.75	127.69	164.31	292.0
CD	16.07	20.8	N/A	-
CV	22.95	22.89	26.49	-

Table 10: Effect of brinjal and chilli seeds germination using soil borne fungal pathogens

Treatments	No. of seeds sown/pot	No. of seeds germinated (Avg. of six pots)					
		Brinjal			Chilli		
		Sclerotinia sp.	*Macrophomina* sp.	*Sclerotium* sp.	*Sclerotinia* sp.	*Macrophomina* sp.	*Sclerotium* sp.
Sterilized Soil + Inoculums + N1.2 treated seeds	10	5	5	5	7	7	8
Sterilized Soil + Inoculums + Normal seeds	10	0	1	1	1	2	2
Normal Soil + Inoculums + N1.2 treated seeds	10	4	5	4	5	5	6
Normal Soil + Inoculums + Normal seeds	10	3	3	3	4	3	5
Normal Soil + Normal seeds	10	4	4	5	5	4	5
Normal Soil +N1.2 treated seeds	10	6	5	6	7	6	7

higher in treated seeds compared with the control and percent of post emergence damping off were decreased in treatment than that of control (Table 11).

Evaluation of *Actinomyces* sp. strain N1.2 in nursery experiments using bioformulation coated brinjal and chilli seeds: In both brinjal and chilli nursery experiments seeds treatment with N 1.2 talc bioformulation (10 g/kg) and drenching with 10 g/lit thrice at a week interval gave the best overall performance when compared with the control (Table 12).

Evaluation of *Actinomyces* sp. strain N1.2 in field experiments using bioformulation coated brinjal and chilli seeds: brinjal and chilli field experiments were conducted with following eight treatments in triplicate in RBD. Treatment (T4**)** gave the highest (6.88 q/ha) brinjal fruit yield with compared to the control (5.23 q/ha) (Table 13). The chilli field experiment was not up to the standard for the data compilation and authentication, and was therefore dropped.

***In-vitro* screening of newer fungicides, bio-agents and botanical against plant pathogens:** *In vitro* screening of fungicides (teboconazole 50%+ trifloxystrobin 25%, tebuconazole 25.9 % SC, azoxystrobin 23% SC, azoxystrobin 18.2% + difenconazole 11.4% SC, fluopyram 17.7+tebuconazole 17.7 SC), tebuconazole 6.7% + capton 26.9% SC, copper oxychloride 50% WP and botanicals (kurax-herbal, sonata-botanical and spotless-phytotonic) @ 500 ppm against pathogens *viz*. *Stagnospora* gummy stem blight of bottle gourd and cucumber, *Colletotrichum* anthracnose of bean and *Rhizcotonia* root rot of fenugreek were tested by poisoned food and dual culture technique. Among tested molecules, tebuconazole 25.9 % SC, azoxystrobin 23% SC and botanical (spotless) @ 500 ppm were found most effective against all tested pathogens under confrontation test after 7 days of incubation at 20 ± 1°C.

Collection of gummy stem blight pathogen: Gummy stem blight, *Stagonosporopsis cucurbitacearum* (syn. *Phoma cucurbitacearum*; teliomorph- *Didymella bryoniae*) isolates (BGSB-1, AGSB-2, CGSB-3) were established from bottle gourd (var. Kashi Ganga), ash gourd (var. Kashi Dhawal) and cucumber for artificial screening of GSB resistant cultigen of cucurbits (Fig 2).

Table 11: Pot experimental data of chilli (Kashi Anmol) and brinjal (Kashi Taru) seeds treated with *Actinomyces* sp. N1.2 talc formulation

Treatment	Seed germination (%)	Post emergence damping off (%)	Avg. Root length (cm)	Avg. Stem length (cm)	Fresh weight /5 plants (g)	Dry weight /5 plants (g)
Chilli						
N1.2 (10 g/kg seed) Drenching (10 g/litre) thrice	74.13	3.33	4.13	20.13	9.7	0.60
N1.2 talc formulation (10 g/kg seed)	56.5	9.23	3.33	13.30	4.3	0.33
Control	36.25	13.33	2.32	9.98	2.7	0.19
Brinjal						
N1.2 (10 g/kg seed) Drenching (10 g/litre) thrice	65.18	1.6	2.94	13.20	6.30	0.53
N1.2 talc formulation (10 g/kg seed)	54.33	2.3	2.44	11.03	2.93	0.33
Control	39.13	3.93	2.30	7.09	1.33	0.19

Table 12: Nursery experimental data of chilli (Kashi Anmol) and brinjal (Kashi Taru) seeds treated with *Actinomyces* sp. N1.2 talc formulation

Treatment	Avg. % seed germination	Avg. % of Post emergence damping off	Avg. Root length (cm)	Avg. Stem length (cm)	Fresh Weight/5 plants (g)	Dry Weight/5 plants (g)
Chilli						
N1.2 (10 g/kg seed) drenching (10 g/l) thrice	70.33	7.34	5.9	24.4	17.9	3.6
Control	46.53	15.33	3.3	15.0	6.9	1.3
Brinjal						
N1.2 (10 g/kg seed) drenching (10 g/l) thrice	65.33	3.93	4.98	16.33	9.30	1.1
Control	45.13	6.73	3.70	8.68	5.20	0.59

Table 13: Field evaluation of *Actinomyces* sp. strain N1.2 with other bioagents on Brinjal (Kashi Taru)

Treatment	Treatment Details	Yield (q/ha)
T1	Root dipping – 10g/lit N1.2 formulation – 15 min & drenching – 10g/lit N1.2 formulation 15 DAT thrice at 20 days interval.	6.23
T2	Root dipping – 10g/lit CRB-7 – 15 min & drenching – 10g/lit CRB-7 formulation 15 DAT thrice at 20 days interval.	5.95
T3	Root dipping – 10g/lit *T. asperellum*– 15 min & drenching – 10g/lit *T. asperellum* formulation 15 DAT thrice at 20 days interval at collar region.	5.75
T4	T1 & T2	6.88
T5	T1 & T3	6.12
T6	T2 & T3	6.30
T7	T1, T2 & T3	5.52
T8	Control	5.23
SD		0.60
%CV		10.12
CV		0.10

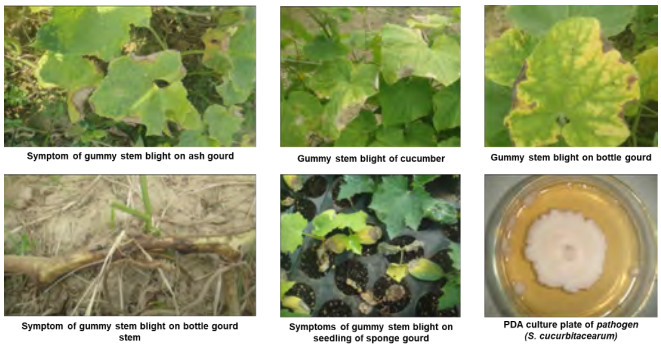


Fig. 2: Collection of gummy stem blight pathogen

***In planta* mass screening of gummy stem blight (GSB) resistant cultigens of cucurbits**: Eleven cultigen *viz.* bottle gourd (Kashi Ganga, Legacy, VBRTG-61, Maxima), bitter gourd (IC-2125004), ash gourd (Kashi Dhawal), Cucumber (Summer fit, Hardwiki), sponge gourd (Kashi Shreya, VRRG-68-2011, VRRG-75-2016) and ridge gourd (Kashi Shivani) were screened under pot and leaf detached method. The spore suspension of mass inoculum of *S. cucurbitacearum* isolate (GSB-1) was standardized to a concentration of 2.3×10^6 spore per ml by haemocytometer. A 14 days old plant having 2- true leaf of bottle gourd (cv. Kashi Ganga) was inoculated by spraying of *S. cucurbitacearum* spore suspension (2.3×10^6 cfu/ml) of pathogen isolate to test pathogenicity under green garden shed net. Visual rating of disease development and disease severity on leaves and stem were assessed using a 1-5 visual rating scale after 28 days of inoculation (Fig 3). Based on the disease reaction on tested cultigen and PDI calculated, cultigens were categorized in two groups viz. resistant (1-10%) - summer fit, hardwiki and bitter gourd IC-2125004; and susceptible (26-50%) - Kashi Ganga, Legacy, VBRTG-61, Maxima, Kashi Dhawal, Kashi Shreya, VRRG-68-2011, VRRG-75-2016 and Kashi Sivani.

Fig. 3: Mass culturing and pathogenicity test of *S. cucurbitacearum* GSB isolate

Project 6.5 Bioprospecting of Microorganisms Associated with Vegetables Against Plant Pathogens

Ten (10) isolates of *Trichoderma* species from the rhizospheric soil and their surfaces of the plants/host and an isolate of *Cordyceps javanica*, a potential entomopathogenic fungi was isolated from the white flies/infesting brinjal leaves in 2021-22. Among the isolated *Trichoderma* species, seven (07) isolates were identified as strong antagonistic and an isolate showing antagonistic and antibiosis efficacy against different types of soilborne phytopathogens which inhibited *Fusarium oxysporum* (80%), *Sclerotinia sclerotiorum* (72%), *Rhizoctonia solani* (66%) and *Sclerotium rolfsii* (58%) and mycelial growth within 5-days of inoculation in dual culture plate techniques (Fig. 4a) while *Cordyceps javanica* was tested for their parasitism and pathogenicity against white flies which showed strong pathogenicity within 4-5days of spraying (Fig. 4b). Rhizosphere competence of the potential isolates of *Trichoderma* species, isolate VRTC-03 showed strong competitive saprophytic ability which established root association within 18-20 days after transplanting in cabbage and tomatoes while in pea 20-22 days and 26 days requred after sowing in bottle gourd.

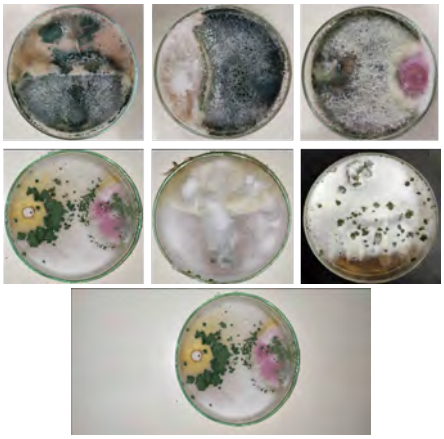


Fig. 4a: Antagonistic efficacy of *Trichoderma* against soil borne phytopathogens

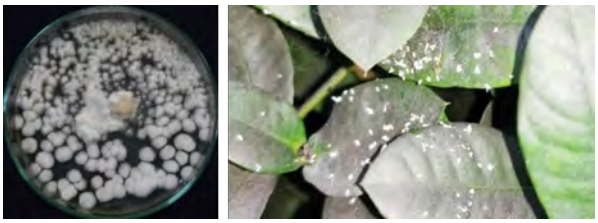


Fig. 4b: An entomopathogenic fungus *C. javanica* isolated from brinjal white flies and tested their pathogenicity against white flies

Field evaluation of five potential bioagents namely *Trichoderma asperellum*, *Trichoderma* species isolate TCV-2, *Trichoderma* species isolate TTV-2 @ 10g/kg seed, *Bacillus subtilis* (CRB-7) @5g/kg seed, Consortia of *T. asperellum* + *B. subtilis* (CRB-7) along with a chemical fungicide captan @2.5g/kg seed were evaluated for their plant growth promotion and biocontrol potential of soilborne diseases namely white rot (*S. sclerotiorum*), *F. oxysporum* f.sp. *pisi* (root rot), *R. solani* (damping off) and *S. rolfsii* (collar rot) in pea and cabbage in 2021-22. In pea, minimum root rot/wilt incidence was recorded in seed treated with Consortia formulation-*T. asperellum* + *B. subtilis* (4.62%), *T. asperellum* (4.79%), captan (5.31%) showed minimum disease incidence compared to control (14.29%). While incidence of *Sclerotinia* fruit rot (32%) was recorded maximum in surface irrigation plots of pea when applied after the fruit set in the plants (Fig. 5).

Fig. 5: Wilt and root rot in infected pea plants, *Sclerotinia* fruit rot of pea

Vigour index and plant growth promotion were recorded maximum in seed treated with consortia of *T. asperellum* + *B. subtilis* CRB-7 (2070) followed by CRB-7 (1922), *T. asperellum* (1899) and *Trichoderma* species isolate TTV-2 (1814) as compared to control (1578).

By application of fungal bioagents as root dip of cabbage seedlings showed highly responsive in plant growth promotion in term of average canopy (cm) and average weight of the heads. Highest canopy and weight of head was recorded in *T. asperellum* treated seedlings (76 cm, 1.33kg) followed by *Trichoderma* species isolate TCV-2 (68 cm, 1.26 kg), Consortia formulation of *T. asperellum* + *B. subtillis*-CRB-7 (66 cm, 1.24 kg) as compared to control (64 cm, 1.10kg) and Captan (60 cm, 1.04 kg). Moreover, highest yield was also recorded in seedlings of cabbage treated with *Trichoderma asperellum* (167.78 q/ha) followed by *Trichoderma* species-TTV-2 (163.44 q/ha), Consortia formulation of *T. asperellum* -TCV-2 (162.85 q/ha) as compared to control (143.59 q/ha). No soil borne diseases incidence were recorded during the entire cropping season in cabbage.

PGPR traits of biocontrol agent *Bacillus subtilis* CRB7: Plant growth promoting trait of bacterial BCA *Bacillus subtilis* CRB7 isolated under this project was studied. The isolate could solubilize phosphorus with P- solubilization index of 1.21 ± 0.02 (Fig 6). However, the isolate was found to be negative for K and Zn solubilisation ability. The isolate could also produce plant growth promoting hormone IAA of 64.58 ± 2.25 µg/ml and 31.46 ± 3.55 µg/ml when culture medium was supplemented with and without tryptophan, respectively. CAS (Chrome Azurol S) agar plate test showed that the isolate could produce siderophore with Siderophore Production Index of 1.61 ± 0.08. The isolate could not produce HCN. However, it could produce ammonia and might be the reason for its anti-microbial property.

Fig. 6: P- solubilization and siderophore production ability of Bacillus subtilis CRB7

Biological, botanical and chemical seed treatment: Commercially available bio-agents and botanicals were applied as seed treating agents in bottle gourd (Kashi Ganga) @ 500 ppm/kg seed in which tested chemicals were found effective for seed germination in comparison to control. However, botanical was found poor than control specially phytotonic spotless (contact botanical), nimbicidine, Stanes Microfood was phytotoxic and causes seed necrosis (Table 14). Talc based formulation of bioagents were applied as seed treatment @ 4g/kg and pot application with vermicompost bio- fortified (1:150) @ 600g/pot of tomato (var. Kashi Chayan and VRT-50) (Table 15).

Table 14: Botanical, biological and chemical seed treatment in bottle gourd

No.	Seed treatment (500 ppm)	Germination (%)
1	Kurax (Herbal Stenes)	91.66
2	Sonata (Phytotonic/bio stimulant HPM chemical)	21.66
3	Stenohume (Humic liquid con.)	8.33
4	Spotless (contact botanical)	0.00
5	Nimbicidine (0.03% EC)	0.00
6	Stanes microfood (Liqud micronutrient fertilizer)	0.00
7	*T. Viride* 1.5% (1×10^8 cfu/ml)	38.33
8	*Pseudomonas fluorescens* 1.5% (1×10^8 cfu/ml)	41.66
9	Tebuconazole 6.7% + Captan 26.95 % SC	31.66
10	Azoxystrobin 23.5% SC	95.00
11	C-UTC	70.0
	SEm (±)	13.42
	CV	70.80
	CD	40.18

Development of talc based bioformulation of *Actinomyces* sp. strain N1.2: Talc based bioformulation of *Actinomyces* sp. strain N1.2 was prepared in our laboratory using the standard protocol. Autoclaved talcum powder (2 kg) was mixed with 48 hours old nutrient broth culture (1 litre) of *Actinomyces* sp. strain N1.2 along with carboxymethyl cellulose (5 g). The components were mixed well, and left for drying at room temperature for 2 days, finally packed and kept in the cold room. Colony forming unit (cfu/gram of sample) of talc based bioformulation of *Actinomyces* sp. strain N1.2 was reported to be 2.30×10^9. Talc based bioformulation of *Actinomyces* sp. strain N1.2 was distributed to different AICRP(VC) centres for the bio-intensive management of soil-borne diseases of French bean and cucumber.

Table 15: Invivo evaluation of bio-agents in tomato

Treatments	Kashi Chayan				VRT-50		
	Shoot length (cm)	Root length (cm)	Vigour index	Damping off	Shoot length (cm)	Root length (cm)	Vigour index
T1 - UTC (control)	2.2	6.1	354.0	10.0	4.6	7.6	518.5
T2 - Captan	4.3	7.3	495.5	5.0	4.8	12.6	742.0
T3 - CRB-7 (*Bacillus subtilis* IIVR-strain) 2.5×10^{11} cfu/g	8.0	8.1	686.8	2.0	4.1	9.6	587.3
T4 - *Trichoderma asperellum* (IIVR strain) 2×10^{7} cfu/g	5.8	11.8	750.5	2.0	5.0	15.0	850.0
T5 - Carbendazim 50% WP	4.8	9.2	597.5	4.0	5.0	7.3	524.0
CD	3.5	11.8	-	-	NS	2.0	-
CV	36.4	16.2	-	-	23.58	10.0	-
SE (m)	1.0	0.8	-	-	0.91	0.8	-

Table 16: Incidence of bacterial wilt caused *R. solanacearum* on solanaceous vegetables crops

Location	Crop	Variety	Bacterial Wilt (%)
Araziline, Varanasi	Tomato	Namdhari 585	75
Magaraha, Mirzapur	Brinjal	Nav Kiran	35
		Naveen	10
Bangalipur, Varanasi	Brinjal	Kashi Sandesh	100
Kusi Dour, Sonabhadra	Chilli	VNR 305	40
		Bioseed 615	10
		Sanaya 3131	30
		Namdhari 1101	10

Fig. 7: Incidence of bacterial wilt on Solanaceous crops in eastern Uttar Pradesh

Project 6.6: Management of Important Bacterial Diseases of Vegetables Crops

Survey and incidence of emerging bacterial wilt caused by Race 1 of *Ralstonia solanacearum* on solanaceous vegetable crops: Recently bacterial wilt occurrence on solanaceous vegetables is being noted in farmers' field around research farm, ICAR-IIVR, Varanasi, Sonebhadra and Mirzapur district of Eastern Uttar Pradesh (Fig 7). The bacterial wilt incidence was recorded on brinjal, tomato and chilli were provided in Table 16. However, incidence of bacterial soft rot was recorded on summer squash cv. Kashi Shubhangi (3.3%), VRSS-65 (1.6%), VRSS-6566 (5%) and Seven Star (20%) including cauliflower cv. Pusa Snoball (19.25%) at IIVR Research Farm, Varanasi.

Establishment of pure cultures and identification of bacterial pathogens: Pure cultures of tomato bacterial blight pathogen, *Xanthomonas campestris* pv. *vesicatoria* (*Xav 1, xav2, xav1/3, xav1/4, xav5, xav1/6, xav7, xav8,xav1/9, xav1/10,xav11,xav12, av13, xav14, xav15, xav16, xav17, xav18, xav1/20, xav21, xav22, xav23, xav24, xav 25, xav1/26, xav 1/27, xav 1/28, xav 1/29, xav 1/30, xav 1/31, xav1/32, xav1/35, xav 1/17, xav1/16, xav 1/2, xav 28, xav1/2, xav1/5, xav1/8);* cabbage bacterial black rot pathogen from cabbage *X. campestris* pv. *campestris (XCC-1, XCC-2); Erwinia* spp. from cauliflower and summar squash *(Erc-1, Erw-2, Erc-3)* and bacterial wilt pathogen from brinjal and chilli, *R. Solanacearum (Rsb-1, Rsb-2 & Rsc-2*) were established. Pure cultures of bacterial wilt pathogen, *R. solanacearum* were established from infected samples of brinjal and chilli on Kelman's triphenyl tetrazolium chloride (TZC) medium. All the isolates could oxidize the sugars (lactose, maltose and cellobiose) and sugar alcohols (mannitol, sorbitol and dulcitol) as compared to un-inoculated control. Based on the cultural, morphological characteristics, sugar oxidation test and cross pathogenicity test we confirmed that race 1/ biovar III of *R. pseudosolanacearum* caused the wilt on solanaceous vegetables.

Standardized inoculation method for mass screening of bacterial wilt resistant cultigens of solanaceous vegetable crops: Cross pathogenicity of *R. solanacearum* isolates were tested on twenty-five days old seedlings of brinjal (*Solanum lanciatum, S. incanum, S. torvum*, IC-35457, IC111056, Ram Nagar Giant, EC-790570, Surya, IVBHR-16, 17, 20, 22,

IVBHL-20, 21, 22, Mau Local-1-BUAT-1 and Kashi Taru). Individual seedling was inoculated with 5 ml of bacterial inoculum (10^8cfu/ml) in the leaf axil of third expanded leaf from top and pricking with the help of a sterilized syringe needle. Typical wilt symptoms were not observed in inoculated seedlings due to latent infection within 30 days (Fig. 8).

Fig. 8: Cross pathogenicity test of R. solanacearum isolates on cultigens of brinjal

Evaluation of different management modules against major bacterial disease of tomato: Among different modules, chemical and biological module (T4) applied at 20 days after transplanting of tomato (cv. VRT-50) four subsequent sprays done at 20 days interval which recorded highest yield (46.60 t/ha) as compare to control (26.10 t/ ha) and lowest early blight disease PDI (33%) however all treatment were found free from bacterial blight (Table 17).

Table 17: Evaluation of different management modules against disease of tomato and yield

Treatment	PDI (Early Blight)	Yield (H)-t/ha	Yield (D)-kg/plot
T1–Biological module	66.06	27.1	1.15
T2-Botanical module	54.90	41.6	1.24
T3- Chemical module	54.90	36.2	0.87
T4-Chemical & Biological	33.00	46.6	0.90
T5-Chemical & Botanical	47.05	45.6	0.97
T6- IDM module	58.88	36.4	1.04
T7-Untreated Control	66.66	26.1	0.90
C.D.	-	NS	NS
SE(m)	-	66.66	0.327
C.V.	-	54.90	55.95

Effectiveness of bacterial bio-agents, fungicides and bactericides against bacterial diseases on cauliflower and yield: The highest cauliflower (cv. Pusa Snowball) yield (28.98 t/ha) recorded with chemical and botanical module (T5) applied at 20 DAT and 4 subsequent spray done after 20 days of interval from first spray when compared to control (5.49 t/ ha) with lowest black rot PDI (2%) (Table 18).

Evaluation of bio-agents against bacterial soft rot on cauliflower: In organic block of cauliflower (var. Pusa Snowball) among treatments T1- NADEP @ 15 t/ha was found free from bacterial soft rot. Its incidence was lowest (15.3%) on without weed mat plots in which liquid formulation of *T. asperellum* and CRB-7 were applied as seed treatment @ 4g/kg and soil application with bio-agents fortified compost (1:150).

Table 18: Evaluation of different management modules against disease of cauliflower and yield

Treatment	Yield (kg/ plot)	Yield (t/ha)	*Xanthomonas* blight/black rot (PDI)
T1– Biological module	22.33	18.6	15
T2- Botanical module	18.93	15.74	11
T3- Chemical module	26.60	22.15	12
T4-Chemical & Biological module	13.80	10.82	11
T5-Chemical & Botanical module	34.80	28.98	2
T6- IDM module	31.86	26.53	8
T7- Untreated Control (UTC)	6.60	5.49	21
C.D.	4.16	-	-
SE(m)	1.33	-	-
CV	10.47	-	-

Evaluation of seed health and detection of seed borne pathogens in seeds of vegetable crops: Vegetable crop seeds of brinjal and Indian bean were sterilized with sodium hypochlorite (1.0%) for one minute and rinsed with sterilized water. Surface sterilized seeds were plated @ 10 seeds per Petri plates and incubated at 24 ± 2 °C for 7 days. Seed borne bacterial pathogens *viz Xanthomonas axonopodis* pv. *vesictoria* (90%) and *Phomopsis vexans* (80%) on brinjal and *Colletotrichum lindemuthianum* (60%) on Indian bean were recorded. Maximum germination percentage varied in the range of 50-80% in Indian bean (Table 19-20 & Fig 9-10).

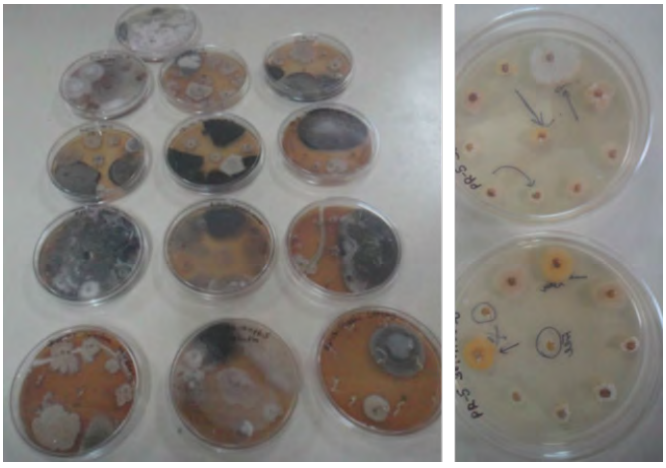


Fig. 9: Infection count of *P. vexans* and *Xanthomonas* spp. on brinjal seeds

Table 19: Infection counts of *Xanthomonas axonopodis* pv *vesictoria* and *Phomopsis vexans* in seeds of brinjal

No.	Seed samples	*P. vexans* (%)	*Xanthomonas* spp. (%)	No.	Seed samples	*P. vexans* (%)	*Xanthomonas* spp. (%)
1	Uttara	6.6	-	22	Arka Abhiman	10.00	-
2	Kashi Himani	15.55	-	23	Ram Nagar Giant	20.00	70.00
3	Pant Rituraj	66.66	90.00	24	JB-8	10.00	
4	SBJH	24.44	-	25	Kashi Sandesh	40.00	80.00
5	MH9-39	26.66	-	26	Kashi Prakash	10.00	30.00
6	Green Long	77.77	-	27	Kashi Taru	10.00	-
7	IVBL-22	48.88	-	28	Kashi Himani	10.00	90.00
8	IVBL-23	57.77	-	29	Co-11	10.00	60.00
9	Punjab Sadabahar	37.77	-	30	SBJ-631	10.00	20.00
10	Punjab Barsati	24.44	-	31	Sabha	10.00	50.00
11	Co-11	6.66	-	32	Anna Malai	10.00	75.00
12	ADM-19	57.77	-	33	Durga	10.00	50.00
13	VR-11	11.11	-	34	ADM-190	10.00	90.00
14	Arka Abhiman	8.88	-	35	Arka Keshav	10.00	10.00
15	Navina	66.66	-	36	MHB-39	10.00	60.00
16	JBL-03-04	11.11	-	37	Utkal Keshari	10.00	90.00
17	Anna Malai	57.77	-	38	JBL-03	10.00	25.00
18	IVBL-20	68.88	-	39	Pusa Bindu	10.00	40.00
19	IPL-Nepal	80.00	-	40	DMV-1	10.00	60.00
20	Punjab Nagina	50.00	-	41	PR-5	10.00	40.00
21	NB-2	50.00	-	42	NBJ-19	10.00	70.00

Table 20: Infection counts of anthracnose (*Colletotrichum lindemuthianum*) in seeds of Indian bean

Seed sample	Germination (%)	Infection (%)
Kashi Haritima	70	10
Kashi Sheetal	60	20
Kashi Khushal	50	20
Kashi Bauni Sem - 3	60	10
VRSEM -738	70	10
Kashi Bauni Sem - 9	70	60
VRSEM-1	60	40
VRSEM-101	50	30
VRSEM -737	80	30
VRSEM-776	50	50
VRSEM-207	80	20
Kashi Bauni Sem -18	60	20

Fig. 10: *Colletotrichum lindemuthianum* infected seedlings of Indian bean and PDA culture plate

Project 6.7: Characterization of Viruses Infecting Vegetable Crops and Their Management

Characterization of viruses causing yellowing disease in cucurbits: Totally 102 cucurbit samples showing yellowing disease were collected from 11 different locations of Varanasi and Mirzapur districts. Average disease incidence in Varanasi district was around 35.17% whereas 44.36% in Mirzapur district. Molecular results of the survey samples indicated occurrence of crinivirus and polerovirus among the tested samples. Out of 102 samples, 16 were detected with crinivirus in RT-PCR assay with universal primer pairs Crini Pol-F/ R (with ~500bp amplicon among 14 samples) (Fig 11A) and

CriniRdRp 251F/995R (~750bp amplicon among 2 bitter gourd samples). Likewise, polerovirus infection was detected among 23 samples by two universal primer pairs Pol-Gen-Up2 / Pol-Gen-Down2 and Pol-G-F/Pol-G-R. Amplicon of ~1100bp produced only among two samples of ivy gourd with primer pair Pol-G-F/Pol-G-R, whereas Pol-Gen-Up2 / Pol-Gen-Down2 primer pair produced amplicon of ~600bp among 21 samples (Fig 11B).

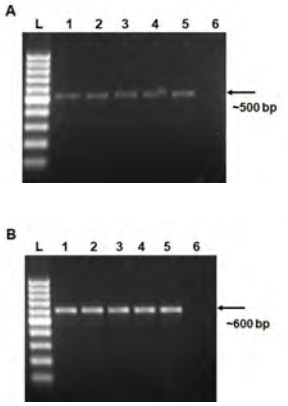
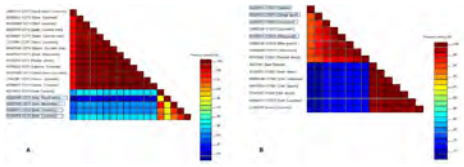


Fig. 11: RT-PCR assay for the detection of Crinivirus using Crini Pol-F/ R: (A); and Polerovirus using Pol-Gen-Up2 / Pol-Gen-Down2 (B) among tested cucurbits samples

Based on the sequence analysis of amplified product, two criniviruses (cucurbit chlorotic yellows virus - CCYV and cucurbit yellow stunting disorder virus - CYSDV) and two poleroviruses (cucurbit aphid-borne yellows virus - CABYV and luffa aphid-borne yellows virus - LABYV) were characterized. Infection of CCYV on cucumber, round melon and muskmelon; CYSDV on satputia and sponge gourd; CABYV on ivy gourd; and LABYV on ridge gourd, satputia and muskmelon were documented for the first time in India. Further mixed infection of polerovirus and crinivirus were also detected among bitter gourd (LABYV+CYSDV), satputia (LABYV+CYSDV), muskmelon (LABYV+CCYV) and sponge gourd (LABYV+CYSDV).

Sequence analysis: Sequences analysis of CCYV isolates (OQ285908-11) showed study isolates shared 94-98% nucleotide homology among themselves. In BLAST analysis all the 4 CCYV isolates of this study showed highest nucleotide identity (>95%) with the previously reported Pumpkin isolate from India (MZ318673) whereas isolates from USA (MW685455 and OM489400), Japan (NC018173), China (MZ392420) and Greece (LT81297) had <91% identity. CYSDV also showed similar pattern to CCYV, as Indian isolates (OQ285912-15) revealed highest level of nucleotide similarity (95-99.33%) among themselves and also shared highest identity with the previously reported Indian isolates (cucumber, watermelon and bitter gourd) and Thailand isolate (MT813029) (Fig 12). In case of polerovirues, CABYV isolate from ivy gourd (OQ285916) of this study showed maximum identity of 88.69% with the pumpkin isolate from China (EF063704) whereas it shared 82.19% nucleotide identity with the previously reported watermelon isolate (MN688220) from India. In case of the LABYV isolates (OQ285917-21) characterized in this study shared nucleotide identity of 94.31-97.67% identity among each other (Fig 13).



Fig, 12: Heat map showing identity matrix of criniviuruses CCYV (A) and CYSDV (B) isolates of India with other previously reported isolates

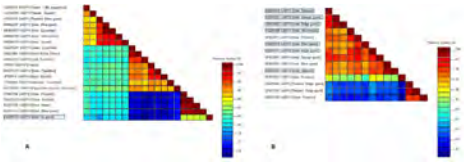


Fig. 13: Heat map showing identity matrix of poleroviruses CABYV (A) and LABYV (B) isolates of India with other previously reported isolates

Phylogenetic analysis: Phylogenetic analysis was performed using the Indian isolates and homologous sequences of corresponding genomic region available for CCYV, CYSDV, CABYV and LABYV (Fig. 14). The phylogenetic trees of CCYV showed less genetic distances among the different isolates of India and are grouped under single cluster (Fig. 14a). Similarly, all the Study Indian isolates and previously reported isolates of CYSDV from India were grouped under single cluster along with the Thailand isolate (MT813029) whereas the other CYSDV isolates from USA, Spain and Greece were clustered separately (Fig. 14b). All the Indian isolates of CABYV clustered in the same group (group I) with the isolates from China, Thailand and Taiwan (Fig. 14c). LABYV isolates from India formed one group while China and Thailand isolates formed separate group (Fig. 14d).

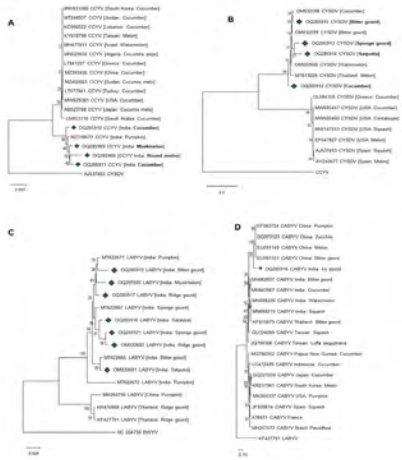


Fig. 14: Phylogenetic analysis of crinivirus and poleroviruses species associated with yellowing disease of cucurbits in Uttar Pradesh CCYV (A) CYSDV (B) LABYV (C) and CABYV (D) with the previously reported isolates

Characterization of virus associated with new necrosis disease in tomato: A new necrosis was observed on tomato crop cultivated in protected structures at ICAR-IIVR, Varanasi. Symptoms of infected plants are observed with the similar to tomato spotted wilt virus (TSWV) infection in tomato. On lower side of leaves circular necrotic lesions with green centre and necrosis of veins, veinlets, midrib and petiole were appears to occur. Symptoms advanced to stem and necrosis seen on growing buds. Later infected plant began to wilt and dry. Infected plant remain stunted in growth compared to uninfected plants (Fig 15a). Plants were tested positive for the infection of tospovirus with the universal primer pair in RT-PCR assay. In order to check the tospovirus species causing the necrosis disease, species specific primer pair of groundnut bud necrosis virus, capsicum chlorosis virus, TSWV and watermelon bud necrosis virus (WBNV) were used. All the symptomatic samples were showed positive amplification with the WBNV specific primer pair with the expected amplicon size of ~930 bp (Fig 15b). Further sequencing of the amplified product further confirms the WBNV infection. Upon mechanical inoculation on the cowpea (C152), inoculated cotyledonary leaves produced the circular chlorotic local lesions after 8 days of inoculation. This study confirms the association of WBNV with the necrosis disease infected samples of tomato.

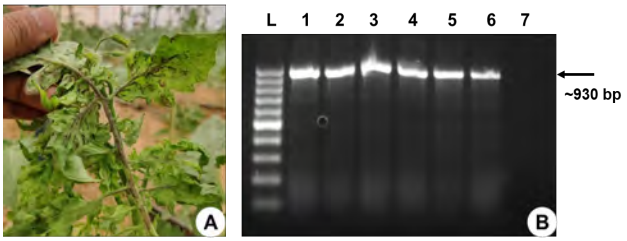


Fig. 15: Symptoms of necrosis disease on tomato (A) and RT-PCR based detection of WBNV in necrosis infected tomato samples (B)

Project 6.9: Management of Plant Parasitic Nematodes Infecting Vegetable Crops

Identification and maintaining pure culture of root knot nematode inoculum for experimental assays: Infected tomato roots from IIVR nursery were collected and stained with the NaOCl-acid fuchsin-glycerin technique. The perineal pattern of root-knot nematode (RKN) female (n = 25) was cut with a stainless-steel blade and placed into a drop of 45% lactic acid on the slide for easy clearing of body tissues and then mounted on glycerol medium. The oval-shaped perineal pattern of RKN female showed a typical high dorsal arch and closely spaced wavy striae and also lateral lines were absent. Based on microscopic observation, the identity of RKN species was confirmed as *Meloidogyne incognita*. Pure culture of *M. incognita* was maintained on the susceptible host *i.e.,* Brinjal (cv. Kashi Taru) under screen house conditions by following standard protocol.

Evaluation of *Trichoderma* isolates against *Meloidogyne incognita* for nematode antagonistic activity: Culture filtrate of six *Trichoderma* isolates (IIVR) were evaluated for juvenile mortality at different concentrations (0%, 25%, 50% and 100%) after 12 and 24 h exposure under laboratory conditions. At 0% (sterilized distilled water) concentration didn't cause mortality of the second-stage juvenile. However, second-stage juvenile mortality ranged between 0 and 22.8% in sterilized potato dextrose broth at different culture filtrate concentration after 12 h and 24 h of exposure (Table 21). Among, *Trichoderma* isolates TTV1, TTV2 and Tasp were found most effective by causing highest juvenile mortality (100%) at 50% culture filtrate concentrations after 24 h of exposure. Similarly, TCV1 and TVBG isolates were found next effective among bio-agents in different concentration and exposure period under *in-vitro* conditions. Among all, TCV2 isolate was found least effective against *M. incognita* at different culture filtrate concentrations.

Table 21: Effect of *Trichoderma* isolates on *Meloidogyne incognita* juvenile's mortality (%)

Trichoderma isolates	12 Hour			24 Hour		
	Culture filtrate concentrations			Culture filtrate concentrations		
	25%	50%	100%	25%	50%	100%
SM	0.0 ± 0.0^{e}	2.8 ± 0.3^{f}	6.4 ± 0.9^{f}	3.2 ± 0.5^{e}	8.0 ± 0.9^{d}	22.8 ± 1.1^{b}
TCV1	4.0 ± 0.5^{cd}	28.2 ± 1.1^{c}	58.0 ± 1.6^{c}	16.6 ± 0.4^{c}	46.4 ± 0.6^{b}	100.0 ± 0.0^{a}
TCV2	2.2 ± 0.5^{d}	17.2 ± 0.7^{e}	24.2 ± 0.9^{e}	9.4 ± 0.6^{d}	39.2 ± 1.0^{c}	100.0 ± 0.0^{a}
TTV1	10.4 ± 0.8^{a}	48.4 ± 1.4^{a}	71.8 ± 0.8^{a}	24.4 ± 0.9^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}
TTV2	5.0 ± 0.6^{c}	30.4 ± 0.7^{c}	62.0 ± 1.0^{b}	22.2 ± 0.6^{a}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}
Tasp	7.7 ± 0.3^{b}	34.2 ± 0.9^{b}	69.0 ± 1.^{0a}	19.4 ± 0.9^{b}	100.0 ± 0.0^{a}	100.0 ± 0.0^{a}
TVBG	4.0 ± 0.3^{c}	21.6 ± 0.7^{d}	31.2 ± 0.8^{d}	18.8 ± 1.0^{bc}	40.6 ± 0.9^{c}	100.0 ± 0.0^{a}
df	6, 28	6, 28	6, 28	6, 28	6, 28	6, 28
F value	61.41	268.72	369.98	104.02	3376.30	2316.26
P<0.05	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Data represented in (Mean ± SE). Different letters on each column indicate statistically significant difference between *Trichoderma* isolates at ($P < 0.05$) using Tukey's HSD test. SE: Standard error, SM: Sterilized Potato Dextrose broth media.

Project 6.10: Pest and Disease Dynamics, and Behavior Modifying Strategies for Major Insect Pests of Important Vegetable Crops in Relation to Changing Weather Scenario

Fall Armyworm characterization, incidence and management in baby corn: Fall armyworm, *Spodoptera frugiperda* incidence was recorded on baby corn in ICAR-IIVR, field conditions. The pest identity was confirmed with the morphological and molecular tools. Newer insecticide molecules like Spinetoram, Chlorantraniliprole, Spinosad, Lambda Cyhalothrin etc. were evaluated in-vitro and in-vivo conditions. Spinetoram 11.7 SC and chlorantraniliprole 18.5 SC were found the most effective insecticides for managing *S. frugiperda*. The dynamics of fall armyworm (FAW), *Spodoptera frugiperda* in baby corn was recorded by taking observations on number of larvae per plant using sequential sampling at weekly intervals (Fig. 16). Incidence of BSFB was recorded throughout the year during 2022 at IIVR farm, Varanasi. Large fluctuation in the incidence of FAW population in baby corn was observed with several peaks. The first peak of moth catches (3.30 larvae/plant) was recorded during 13th SMW (Last week of March, 2022). The highest larvae per plant was recorded during 40th SMW (4.23 larvae/plant, first week of October, 2022) and no larval population was observed from 1st to 8th SMW, 20th to 30th SMW and 47th to 52nd SMW (Fig. 16).

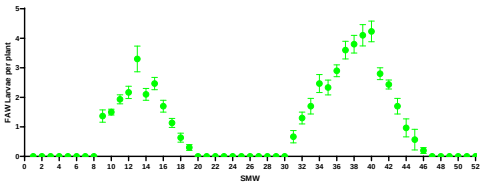


Fig. 16: Seasonal incidence of FAW in baby corn

Seasonal incidence of *Leucinodes orbonalis* during the year 2022: The dynamics of brinjal shoot and fruit borer (BSFB), *L. orbonalis* in brinjal was recorded by installing sex pheromone traps (Fig. 17). Incidence of BSFB was recorded throughout the year during 2022 at IIVR farm, Varanasi, Uttar Pradesh, India. Large fluctuation in the incidence of *L. orbonalis* population in brinjal was observed with several peaks. The first peak of moth catches (9.40 moths/trap) was recorded during 12th SMW (3st week of March, 2022). The highest moth catches in the pheromone traps were recorded during 45th SMW (16.20 moths/trap, 2nd week of November, 2022) and no moth activity was observed from 20st to 22nd SMW (Fig. 18).

Fig. 17: Adult moths of *Leucinodes orbonalis* (A) and *Spodoptera litura* (B)

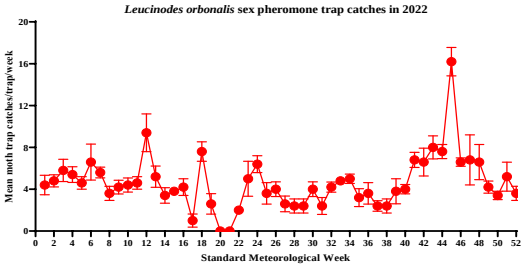


Fig. 18: Dynamics of *Leucinodes orbonalis* moth population during 2022

Seasonal incidence of *Spodoptera litura* during the year 2022: Population dynamics of *S. litura* majorly infesting different vegetables was studied by installing the sex pheromone traps (Fig. 17). The incidence of *S. litura* was recorded throughout the year from January 2022 to December 2022 at IIVR farm, Varanasi, Uttar Pradesh, India. A considerable fluctuation in the adult moth catches in the pheromone trap was observed during the study period. Several peaks were observed from 40th to 48th SMW. The first peak of moth catches (13.77 moths/trap) was recorded during 24th SMW (2nd week of June). The highest trap catches were recorded during 45th SMW (203.25 moths/trap, 2nd week of November, 2022). No activity of *S. litura* moths were noted from 26th to 36th SMW (Fig. 19).

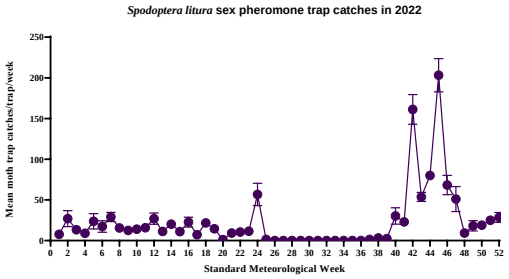


Fig. 19: Dynamics of *Spodoptera litura* moth population during 2022

Project 6.12: Bio-Management of Postharvest Diseases in Major Vegetable Crops

Plant- growth promoting attributes of potential Biocontrol agents: Microorganisms exert a beneficial effect on plants due to various PGP (plant growth promoting) traits. Microorganisms transform organic matter into plant nutrients that are assimilated by plants. Nine potential biocontrol agents isolated from a soil sample collected from the ICAR-IIVR farm were tested for various PGPR traits.

Nutrient Solubilization: Phosphorus Solubilizing bacteria and fungi play an important role in converting insoluble phosphatic compounds such as rock phosphate, bone meal etc. particularly the chemically fixed soil phosphorus into available form. Phosphorus-solubilizing rhizobacteria are able to convert insoluble phosphorus into soluble forms as they have the ability to produce organic acid, cause chelation, and ion-exchange reactions and make them available to plants. Nutrient solubilisation index was computed based on the formula given below:

$$Nutrient\ Solubilization\ Index = \frac{Total\ Diameter\ (Colony\ +\ Halo\ Zone\ Diameter)}{Colony\ Diameter}$$

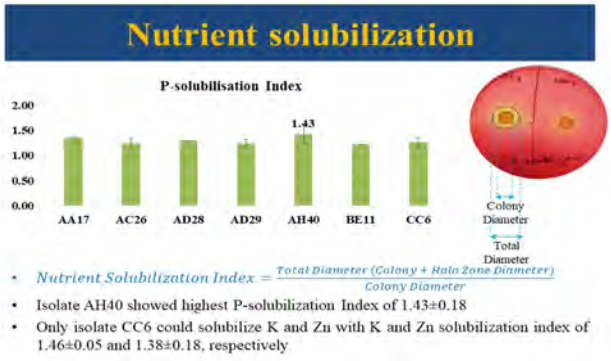


Fig. 20: P- solubilisation index of bacterial biocontrol agents

P- solubilization Index ranged from 1.22 to 1.43 where isolate AH40 showed highest P-solubilization Index of 1.43 ± 0.18 (Fig 20). Out of the nine tested biocontrol agents, seven isolates could solubilize phosphorus. Only isolate CC6 could solubilize K and Zn with K and Zn solubilization index of 1.46 ± 0.05 and 1.38 ± 0.18, respectively.

IAA production: Soil and plant-associated bacteria are known to produce various phytohormones and have the potential for the growth promotion of plants. A large number of indole-3-acetic-acid (IAA) producing bacteria have been isolated from the roots, leaves and stems of various crops. IAA production of 17.25 ± 1.56µg/ml in the absence of tryptophan by AD28 was significantly higher as compared to other biocontrol agents. The isolate AD28 and AH40 could produce 45.00 ± 0.46µg/ml and 43.63 ± 0.17µg/ml, respectively when tryptophan amino acid was supplemented in the culture medium (Fig 21).

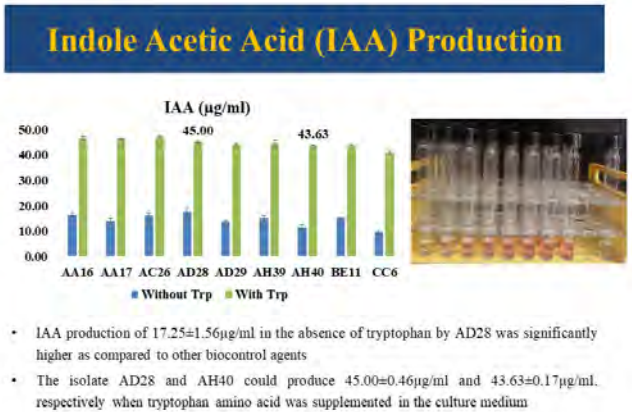


Fig. 21: Bacterial BCA producing Indole Acetic Acid (IAA)

Siderophore production: Siderophore is a low molecular weight (<10KD) iron-chelating compound synthesized by many bacteria. They form a complex with free iron and transport it into the cell by membrane receptor molecules. They deprive the pathogenic bacteria of iron and act as an anti-microbial agent. Six isolates tested positive for siderophore production. Isolate AD28 is the most efficient siderophore producer with a siderophore production index of 2.01 ± 0.17 (Fig 22).

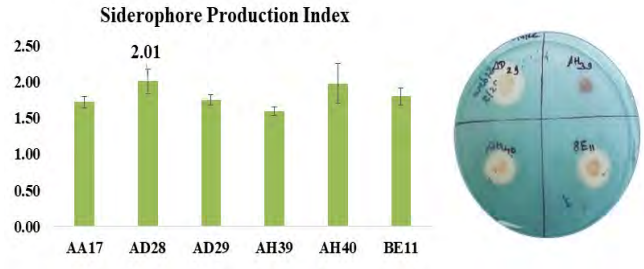


Fig. 22: Microbial isolates producing Siderophore

HCN and Ammonia production: None of the isolates could produce HCN (Figure 4). Seven isolates were positive for ammonia production viz., AC26, AD28, AD29, AH39, AH40 and CC6 (Fig 23).

Fig. 23: Microbial isolates being tested for HCN and ammonia production

Submission of potential bacterial biocontrol agents at NCBI: The potential BCA obtained in this project were identified through sequencing of the 16S rRNA region. The bacterial isolates were identified based on NCBI BLAST. The sequences have now been submitted to NCBI and the accession numbers have been received (Table 22).

Effect of biocontrol agents on the biochemical parameters of the tomato plant: A pot tray trial was conducted in the year 2021-22 where the efficacy of selected BCA in suppressing damping-off pathogens was evaluated. The leaves samples were harvested twice at 20 and 35 DAS and checked for plant anti-oxidant enzymes. The antioxidant defense enzyme catalase, peroxidase and polyphenol oxidase act as first line of defense against the plant pathogens. It was found that the application of AD 28, AH 40 and Tasp strains significantly enhance the enzymatic activity of CAT, POX and PPO in the leaves of tomato as compare to chemical control and no management conditions under presence of pathogen. The elevated activities of antioxidant enzymes are an adaptation by plants to ameliorate the stress-induced oxidative stress.

Table 22: Summary of isolates submitted to NCBI

S. No.	Isolate No	Query Length	Query cover	Percent identity	NCBI Accession Number
1	*Bacillus subtilis* AA16	446	100%	99.33%	ON834751
2	*Bacillus velezensis* AA17	248	97	98.46	ON834752
3	*Bacillus* sp AC26	662	100	98.79	ON834753
4	*Stenotrophomonas maltophilia* AD28	663	100	98.79	ON834754
5	*Bacillus amyloliquefaciens* AD29	771	100	99.74	ON834755
6	*Bacillus subtilis* AH39	665	98	96.65	ON834756
7	*Bacillus velezensis* AH40	523	100	97.23	ON834757
8	*Bacillus subtilis* BE11	697	100	99.43	ON834758
9	*Paenibacillus* sp. CC6	704	100	99.29	ON834759

Furthermore, it was also observed that the enzymatic activity of CAT, POX and PPO were significantly higher at 35 DAS as compared to 20 DAS under presence of pathogen.

Antifungal activity in Moringa leaf extracts against major plant pathogens: Moringa popularly known as a miracle plant has a number of medicinal uses due to its antimicrobial, antihelmintic, antinflammatory, antiarthritic, antipyretic, antihepatotoxic and antidiabetic properties. This research was carried out to study the effect of different solvents used in preparation of plant extracts on extraction of bioactive antimicrobial compounds. For this purpose, we used three organic solvents viz. water, hexane, acetone and ethyl acetate for extraction of bioactive antimicrobial compounds from dried Moringa leaves. Plant extracts obtained from Moringa leaves were tested against three major soil pathogens viz. *Sclerotium rolfsii, Fusarium* sp. and *Rhizoctonia solani*. Antifungal activity was evaluated. The mycelial growth in the fungi (mm) both in treated (T) and control (C) was measured diametrically in three different directions and growth inhibition (I) was calculated using the formula:

I (%) = (C-T)/C x 100;

ED_{50} (Effective Dose required for 50% inhibition of fungus growth)

ED_{50} (mgL^{-1}) values (Effective Dose for 50% inhibition) were calculated using SPSS Package (Probit Analysis)

The Moringa leaf extract possesses antifungal activity as it could significantly inhibit the mycelial growth of *Sclerotium rolfsii*. The antifungal activity varied with the change in the solvent used for the extraction of active compounds. The inhibition percentage in the water extract of Moringa leaf was significantly higher when compared to other solvents used for extraction. A gradient increase in the concentration of leaf extract in the PDA medium led to a gradual increase in antifungal activity as 30.74, 39.26, 64.44 and 88.89% mycelial inhibition was observed at 250, 500, 750 and 1000 mg kg^{-1} of leaf extract in water. Significantly higher inhibition was observed when water was used for extraction followed by acetone, ethyl acetate and hexane. Antifungal activity in the hexane extract of the Moringa leaf was very poor as supplementation of 1000 mg kg^{-1} of the extract could only inhibit mycelial growth by 12.22%. Significantly higher mycelial inhibition in water extract led to a lower ED_{50} value of 546.51 mg L^{-1}. ED_{50} value of 546.51, 624.35 and 680.75 mg L^{-1} was observed when water, acetone and ethyl acetate, respectively were used for the extraction of active compound from Moringa leaf (Table 23). The Moringa leaf extracts were even effective against the *Rhizoctonia solani* pathogen and could significantly retard its growth. The percent mycelial inhibition was significantly higher when leaf extracts were prepared in water followed by acetone, ethyl acetate and hexane. At 1000 mg L^{-1} concentration an inhibition of 78.15, 62.96, 61.48 and 7.04% in mycelial growth was observed when water, acetone, ethyl acetate and hexane were used for the extraction of active compound, respectively. A significantly lower ED_{50} value of 620.61 was observed when water was used as a solvent followed by acetone (670.57) and ethyl acetate (885.70) (Table 23). The Moringa leaf extract did show a negative effect on the growth of *Fusarium* sp. The percent mycelial inhibition ranged from 21.85% to 82.59% at different concentrations of the leaf extract when water was used as a solvent. Significantly higher inhibition was observed in the water extract followed by acetone and ethyl acetate. The ED50 value was computed to be 583.10, 629.91, and 864.77 when water, acetone and ethyl acetate, respectively were used for the extraction of bioactive compounds. A higher percent inhibition of *Fusarium* sp. led to relatively lower ED_{50} values suggesting that the anti-microbial compounds are polar in nature (Table 23). The Moringa leaf extract with water showed better fungicidal activity against all the tested fungi followed by acetone > ethyl acetate > hexane. Hexane extract showed the least fungicidal activity against all the tested fungi. The results explain that active compound (s) in Moringa leaf might be polar in nature as water extract gives the highest activity and hexane gives the least activity.

Table 23: Fungicidal activity of the different solvent extracts against *Sclerotium rolfsii, Rhizoctonia solani* and *Fusarium* sp

Conc. (mg kg^{-1})	*Sclerotium rolfsii*		*Rhizoctonia solani*		*Fusarium sp*	
	% Inhibition	ED_{50} in mg L^{-1}	% Inhibition	ED_{50} in mg L^{-1}	% Inhibition	ED_{50} in mg L^{-1}
Water extract						
250	30.74 ± 2.80	546.51	21.85 ± 1.70	620.61	21.85 ± 1.70	583.104
500	39.26 ± 1.70		28.15 ± 1.70		31.48 ± 1.70	
750	64.44 ± 2.22		55.56 ± 1.11		57.04 ± 1.70	
1000	88.89 ± 1.11		78.15 ± 1.70		82.59 ± 2.31	
Acetone extract						
250	21.85 ± 1.70	624.35	12.59 ± 2.31	670.57	15.19 ± 1.70	629.91
500	31.85 ± 1.70		26.30 ± 1.70		28.52 ± 2.31	
750	55.19 ± 1.70		51.85 ± 1.70		53.33 ± 1.11	
1000	74.81 ± 2.80		62.96 ± 1.70		64.81 ± 1.70	
Ethyl acetate extract						
250	18.52 ± 1.70	680.75	11.11 ± 1.11	885.70	12.59 ± 1.70	864.77
500	34.81 ± 3.57		20.37 ± 2.31		21.85 ± 2.31	
750	50.00 ± 3.33		38.89 ± 1.11		40.37 ± 1.70	
1000	69.26 ± 2.80		61.48 ± 1.70		62.22 ± 1.11	
Hexane extract						
250	1.11 ± 1.11	3.81E+03	1.11 ± 1.11	1.27E+04	1.11 ± 1.11	9.23E+03
500	2.22 ± 1.11		2.22 ± 1.11		2.22 ± 1.11	
750	5.93 ± 1.70		3.33 ± 1.11		4.07 ± 0.64	
1000	12.22 ± 1.11		7.04 ± 3.57		7.78 ± 2.94	

ED_{50} is the dose of the drug at which 50% of the maximum potential effect is produced. 50% inhibition is obtained at which dose.

Project 6.13: Residue Dynamics, Safety Evaluation and Decontamination of Chlorantraniliprole, Deltamethrin, Azoxystrobin and Kresoxim-Methyl in Tomato, Brinjal and Chilli

A gas chromatographic method for estimation of chlorantraniliprole residue in cowpea and safety evaluation of chlorantraninliprole in cowpea pod and leaf: Cowpea is diploid annual herbaceous legume crop known for its high protein content (18% –25%) and also chiefly raised for green fodder purpose. Being an important fodder crop and source of rich nutrition, it becomes necessary to manage the pests and diseases. The infesting pests, cowpea pod borer and aphids are the most destructive ones, to control these chlorantraniliprole emerges as a promising pesticide. But likewise other pesticide it also leaves residues in soil and crop which may lead to serious health and environment hazards. To assess its persistence in nature a trial was conducted at IIVR, Varanasi. The field trials were carried out on cowpea crop var. Kashi Kanchan at the experimental farm of ICAR- Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India for two consecutive kharif seasons. The crop was imposed in the field with randomized block design with three treatments and three replications. The cowpea crop was grown in raised beds of size 4 m x 5 m following the recommended agronomic practices. The crop was sprayed with chlorantraniliprole 18.5% SC@ 30 g ai ha^{-1} as single dosage (SD) and double dosage (DD), respectively. Insecticide applications were carried out using a high-volume knapsack sprayer fitted with a hollow cone nozzle. The spray volume of 500 L water was used per hectare during sunny and warm conditions with no or little wind. The first spraying was done during flowering stage, and the following two sprays were applied at an interval of ten days.

Standardization of residue extraction method: Crushing the cowpea pods with addition of water produced a homogenous material which provided extraction and thereby unsatisfactory recovery of the residues. The ethyl acetate extract of cowpea pod and leaf produced higher matrix induced signal enhancement when the analysis was done without or no cleanup or with only 50 mg, 75 mg and 100 mg of PSA. d-SPE cleanup of 1.5 ml ethyl acetate extract of cowpea pod and leaf matrix were optimized with 75 mg PSA along with 225 mg $MgSO_4$ and 15 mg GCB only.

Method validation: The analytical method was validated according to SANTE guideline for estimation of chlorantraniliprole residues in cowpea pods and leaf. The percentage recovery was estimated at five levels for the entire cowpea pod and leaf samples. The percentage recoveries at 0.01, 0.02, 0.04, 0.08 and 0.1 mg kg^{-1} were found in the

range between 80.00-84%. Chlorantraniliprole was detected at the time of 16.655 min i.e. retention (RT) in standard chromatographic condition. The calibration curve with the coefficient of determination (R^2) were 0.9989 for solvent standard, 0.9983 for matrix matched standard (cowpea pods) and 0.999 for matrix matched standard (leaf) within the calibration range of 0.01-0.5 mg kg^{-1} showed good linearity of the method. The LOD and LOQ were established 0.005 mg kg^{-1} and 0.01 mg kg^{-1} respectively. The average matrix effect (ME) percentage were less than 13.05 % for pods and 12.07 % leaf.

Residues dissipation kinetics in cowpea pod and leaf: The dissipation behavior in pod was primarily faster and then became slower over lapse of time. This exhibited an exponential pattern of degradation and which implies that the residue dissipation behavior follows simple first-order kinetics with R^2 value of 0.993 and 0.9507 for SD and DD, respectively for the year-I, whereas the R^2 values for year- II were 0.9841 and 0.933 for SD and DD, respectively. The half-lives of particular residue in cowpea pods were 2.79 and 2.33 days for SD and DD respectively for the year-I where as in the year-II, half-lives were 2.51 days and 2.32 days for the same (Table 24). In cowpea pods, after the last spray (2 h after application) the initial deposition of chlorantraniliprole residues turned to 0.71 and 0.98 mg kg^{-1} for SD and DD respectively for the year-I while for the year-II, 0.67 and 0.96 mg kg^{-1} were found as initial deposition of residue for same doses as stated above. The dissipation pattern was almost similar in both the consecutive years. The degradation was rapid till 5 days after application (DAA) in almost all doses and on 15 DAA residues were below detectable limit (BDL) (Table 25). The dissipation behavior of chlorantraniliprole residues in leaves follows good linearity of exponential simple first order dissipation kinetics with R^2 values 0.951 and 0.976 in case of SD while 0.922 and 0.9346 for DD in both of the consecutive years. Initial residue deposition in leaf was determined to be 0.83 mg kg^{-1} for SD and 1.10 mg kg^{-1} for DD for the year-I. For the year-II, initial residue deposition was found to be 0.85 mg kg^{-1} and 0.99 mg kg^{-1} for the same doses described above. Chlorantraniliprole degraded more quickly up to 5 DAA, then at a steady rate over the following time period at all dosages (Table 26). The half-lives of chlorantraniliprole residue in leaf samples are 1.33 and 1.56 for the SD and DD respectively in the first year whereas it is 2.43 and 2.29 for the same dosage in second year.

Consumer risk assessment: For all doses, the residues began to degrade until they were below the MRL of 0.03 mg kg^{-1} of chlorantraniliprole. The acceptable daily intake (ADI) of the pesticide (chlorantraniliprole) is 1.56 mg kg^{-1} of body weight. The multiplier is the ADI divided by the average child's body weight (16 kg), and the estimated MPI of chlorantraniliprole was 24.96 mg per person per day. According to NSS report, 2012 average per capita consumption of cowpea is 0.005 kg day^{-1} which is less than the MPI of 24.96 mg $person^{-1}$ day^{-1} on all sampling days, represents the dietary exposures to the residues (Table 27). Thus, it has been demonstrated that when sprayed for pest management in cowpea at a specific dose in accordance with acceptable agricultural procedures, chlorantraniliprole possess low risk.

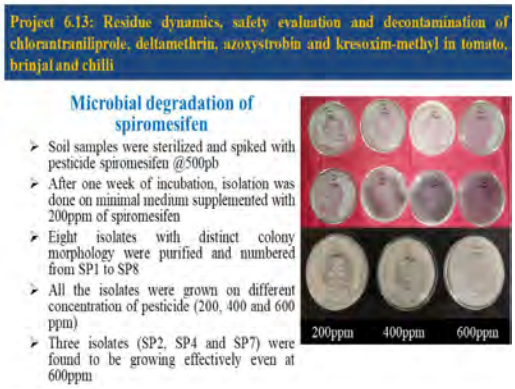


Fig. 24: Plates showing bacterial isolate capable of utilizing Spiromesifen

Table 24: Coefficient of determination and half-life of chlorantraniliprole in different matrix of the cowpea

Doses	Year- I			Year-II		
	Regression equation	Coefficient of determination (R^2)	Half-lives ($t_{1/2}$)	Regression equation	Coefficient of determination (R^2)	Half-lives ($t_{1/2}$)
Pod						
SD	$Y = 0.07703e^{-0.248x}$	0.993	2.79	$Y = 0.79e^{-0.276x}$	0.9845	2.51
DD	$Y = 1.1687e^{-0.297x}$	0.9507	2.33	$Y = 0.13341e^{-0.299x}$	0.933	2.32
Leaf						
SD	$Y = 1.118e^{-0.281x}$	0.9508	1.33	$Y = 0.9558e^{-0.285x}$	0.9757	2.43
DD	$Y = 1.5657e^{-0.305x}$	0.922	1.56	$Y = 0.14155e^{-0.303x}$	0.9346	2.29
Soil						
SD	$Y = 0.7572e^{-0.376x}$	0.9206	1.84	$Y = 0.8424e^{-0.36x}$	0.8372	1.93
DD	$Y = 1.0655e^{-0.407x}$	0.9253	1.70	$Y = 1.3698e^{-0.408x}$	0.8645	1.70

Table 25: Percentage reduction of chlorantraniliprole residue on different days of sampling in cowpea pods

Days after spray	Year-I				Year-II			
	Single dose (SD)		Double dose (DD)		Single dose (SD)		Double dose (DD)	
	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue
0	0.71	0.00	0.98	0.00	0.67	0.00	0.96	0.00
1	0.65	8.45	0.72	26.53	0.59	11.94	0.81	15.63
3	0.35	50.70	0.49	50.00	0.37	44.78	0.57	40.63
5	0.23	67.61	0.26	73.47	0.21	68.66	0.35	63.54
7	0.15	78.87	0.19	80.61	0.11	83.58	0.22	77.08
10	0.06	91.55	0.11	88.78	0.07	89.55	0.13	86.46
15	0.00	100.00	0.01	99.18	0.01	98.51	0.01	99.16

Table 26: Percentage reduction of chlorantraniliprole residue on different days of sampling in cowpea leaves

Days after spray	Year-I				Year- II			
	Single dose (SD)		Double dose (DD)		Single dose (SD)		Double dose (DD)	
	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue	Residues (mg kg^{-1})	% decrease residue
0	0.83	0.00	1.10	0.00	0.85	0.00	0.99	0.00
1	0.78	6.02	0.88	20.00	0.73	14.12	0.82	17.17
3	0.46	44.58	0.68	38.18	0.41	51.76	0.59	40.40
5	0.31	62.65	0.41	62.73	0.21	75.29	0.41	58.59
7	0.21	74.70	0.26	76.36	0.13	84.71	0.24	75.76
10	0.11	86.75	0.15	86.36	0.09	89.41	0.12	87.88
15	0.01	98.80	0.01	99.27	0.01	98.82	0.01	99.18

Table 27: Safety evaluation of day wise residues of chlorantraniliprole in cowpea pods

Days after spray	Year-I				Year- II			
	Single dose (SD)		Double the Single dose (DD)		Single dose (SD)		Double the Single dose (DD)	
	Residue (mg kg^{-1})	Dietary exposure (mg person^{-1} day^{-1})	Residue (mg kg^{-1})	Dietary exposure (mg person^{-1} day^{-1})	Residue (mg kg^{-1})	Dietary exposure (mg person^{-1} day^{-1})	Residue (mg kg^{-1})	Dietary exposure (mg person^{-1} day^{-1})
0	0.71	0.0036	0.98	0.0049	0.67	0.0034	0.96	0.0048
1	0.65	0.0033	0.72	0.0036	0.59	0.0030	0.81	0.0041
3	0.35	0.0018	0.49	0.0025	0.37	0.0019	0.57	0.0029
5	0.23	0.0012	0.26	0.0013	0.21	0.0011	0.35	0.0018
7	0.15	0.0008	0.19	0.0010	0.11	0.0006	0.22	0.0011
10	0.06	0.0003	0.11	0.0006	0.07	0.0004	0.13	0.0007
15	0.00	0.0000	0.01	0.0000	0.01	0.0001	0.01	0.0000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ICAR-Indian Institute of Vegetable Research


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EXTERNALLY FUNDED PROJECTS

PROJECT 1: NATIONAL INNOVATIONS IN CLIMATE RESILIENT AGRICULTURE (NICRA) [ICAR]

Development of F_1s for high temperature stress tolerance: Sixty high temperature tolerant F_1s which were developed during 2018–19 (9 F_1s) and 2019–20 (19 F_1s) transplanted in the field in February 2022 along with 9 F_1 hybrids of private sectors as check, and evaluated for yield and fruit quality traits at high temperature condition during summer 2022 (March–June 2022). Among above hybrids the hybrids *viz.* VRNTH-20131, VRNTH-20122, Kashi Adbhut, VRNTH-20149, VRNTH-20133, Kashi Tapas, VRNTH-20141, VRNTH-19091 and VRNTH19067 and VRNTH-20143 were found superior for their yield and fruit quality traits over other lines and private checks (Fig.1). The highest yield was recorded in VRNTH-20131 (39.44 t/ha) followed by VRNTH 20122 (37.16 t/ha).

Development of F_1s tolerant to moisture deficit condition: A total of 17 F_1s developed during 2019–20 were transplanted in the field in Oct. 2021 along with private sector hybrids as check. These lines were evaluated for moisture deficit condition in field along with control (without stress). Analysis of data revealed that VRNTH-20133, VRNTH-20131, VRNTH-20141, VRNTH-20132, VRNTH-20122, VRNTH-20114, VRNTH-20105, VRNTH-20143 and VRNTH-20142 were superior over

Fig. 1: Fruits of selected F_1s for high temperature tolerance

popular private sector hybrids in terms of yielding ability. The highest yield was in VRNTH-20133 (73.19 t/ha) followed by VRNTH 20131 (72.16 t/ha)

Evaluation and validation of exogenous application of salicylic acid and sodium nitroprusside for moisture deficit mitigation: Five moisture deficit tolerant F_1s *viz.*, VRNDTH-18-1, VRNDTH-18-2, VRNDTH-18-3, VRNDTH-18-4 and VRNDTH-18-5 along with three private sector hybrids were exposed to drought stress conditions for 21 days at vegetative and reproductive stage in field in the second consecutive years to confirm the results. The plants were treated with three different treatments: salicylic acid (SA) foliar spray (0 and 250 µM), sodium nitroprusside (SNP) foliar spray (0 and 25 µM), and the addition of both SNP and SA simultaneously under two different irrigated conditions (control and moisture deficit). Results showed that all evaluated five hybrids outperformed the popular private sector hybrids in terms of yielding ability under moisture deficit. The identified hybrids yielded between 50.92 and 61.89 t/ha. The top two hybrids (VRNDTH-18-1 and VRNDTH-18-2) produced 32 to 52% more than the most widely used hybrids of the private sectors. Also, it was shown that SA and SNP to stressed plants raised osmolyte and antioxidant activity up to non-stressed levels resulting in substantial mitigating impact.

Effect of PGR on fruit set, yield and quality attributes under high temperature cultivation: Developed hybrids of tomatoes were evaluated in field along with three popular hybrids as checks during summer season (February to June) of 2022. Four plant growth regulators (PGR) *viz.*, Proline (10 µ mol/ lit), Salicylic acid-SA (250 µ mol/ lit) Sodium-nitro-prusside- SNP (25 µ mol/ lit) and GA3 (50 ppm) were sprayed over plants thrice- 30, 45 and 60 days after planting along with unsprayed control. Maximum fruit set of 67.35% was observed in VRNTH 18283 with spray of SNP followed by VRNTH

20105. Number of fruits was maximum in VRNTH 18283 with application of SA followed by 62.9% in same with use of SNP. As far as yield is concern, maximum fruit yield of 1.834 kg/plant was registered in VRNTH 18283 with spray of SNP followed by VRNTH 20132 (1.81 kg/plant).

As far as quality was concerned, the maximum lycopene content was recorded in VRNTH-19089 + Proline combination (6.87 mg/100g) followed by Kashi Adbhut with Salicylic acid (6.50 mg/ 100g). β-carotene content was maximum in VRNTH 19089 with Proline combination (5.06 mg/100g) followed by VRNTH 18083 - GA3 (4.48 mg/100g) and VRNTH 19069 - GA3 (4.47 mg/100g). Maximum Ascorbic acid content of 35.71 mg/ 100 g was recorded in VRNTH 19067+SA and VRNTH 19072+SNP combinations, whereas maximum Acidity in fruits was noticed in VRNTH 19089 sprayed with Proline (0.77%) followed by VRNTH 19069 with GA3 (0.64%).

Development of F2-population a GBS-based SNP array: To simplify mapping investigations for high temperature tolerance in tomatoes, the Punjab chhuhara x H-88-78-1 F2-population was developed as a GBS-based SNP array, and phenotype diversity was examined. The genotype with the highest fruit set was HTMP-034, wich also showed higher values for the traits pollen viability, CCI, total chlorophyll, and carotenoid. This explains that these characters have a positive correlation with fruit set percentage which is also supported by the correlation analysis. The lines HTMP-011, 032, 034, 035, 036, 039, 040, 041, 043, 078, 081, and 089 showed superior values for the majority of the features and were shown to be able to withstand the high temperature. Therefore, these lines can be viewed to be tolerant to heat stress.

PROJECT 2: CRP ON HYBRID TECHNOLOGY (TOMATO) [ICAR]

Development of hybrids with processable quality: Hybrids were evaluated for processing trait (TSS) and yield-related traits in summer season for high temperature stress tolerance under field conditions Table 1. The hybrids namely CRPVRTH-19-18, CRPVRTH-19-26, and CRPVRTH-20-10 were found superior over private hybrids (Abhilash and Aryaman) and OP

S. No.	EL	CTD	CCI	CHL	Carotenoid	LPO	Stigma Exsertion	Tip burn	Pollen Viability	Fruit Setting
1	***HTMP-081***	HTMP-022	HTMP-177	HTMP-039	HTMP-003	HTMP-062	HTMP-101	HTMP-131	HTMP-047	HTMP-034
2	HTMP-083	HTMP-023	HTMP-197	HTMP-034	HTMP-005	HTMP-252	HTMP-034	HTMP-130	HTMP-033	HTMP-039
3	HTMP-082	HTMP-016	HTMP-151	HTMP-005	HTMP-029	HTMP-254	HTMP-107	HTMP-127	HTMP-039	HTMP-035
4	HTMP-036	HTMP-032	HTMP-094	HTMP-031	HTMP-031	HTMP-253	HTMP-172	HTMP-093	HTMP-032	HTMP-089
5	HTMP-078	HTMP-025	HTMP-011	HTMP-003	HTMP-034	HTMP-134	HTMP-043	HTMP-193	HTMP-034	HTMP-040
6	HTMP-080	HTMP-024	HTMP-181	HTMP-029	HTMP-092	HTMP-248	HTMP-105	HTMP-138	HTMP-089	HTMP-011
7	HTMP-087	HTMP-036	HTMP-166	HTMP-082	HTMP-039	***HTMP-081***	HTMP-115	HTMP-113	HTMP-041	HTMP-099
8	HTMP-084	***HTMP-081***	HTMP-161	HTMP-038	HTMP-251	HTMP-245	HTMP-111	HTMP-192	HTMP-040	HTMP-033
9	HTMP-034	HTMP-031	HTMP-179	HTMP-064	HTMP-113	HTMP-086	HTMP-162	HTMP-153	**HTMP-037**	HTMP-042
10	HTMP-011	HTMP-078	HTMP-200	HTMP-015	HTMP-170	HTMP-138	HTMP-109	HTMP-213	HTMP-049	HTMP-109
11	HTMP-076	HTMP-035	HTMP-124	HTMP-066	HTMP-253	HTMP-249	HTMP-141	HTMP-005	HTMP-043	HTMP-041
12	HTMP-035	**HTMP-037**	HTMP-034	HTMP-012	HTMP-252	HTMP-035	HTMP-110	HTMP-258	HTMP-011	HTMP-043
13	HTMP-068	HTMP-155	HTMP-064	HTMP-058	HTMP-132	HTMP-142	HTMP-129	HTMP-124	***HTMP-081***	HTMP-117
14	HTMP-079	HTMP-004	HTMP-084	HTMP-067	HTMP-248	HTMP-083	HTMP-264	HTMP-135	HTMP-010	HTMP-111
15	HTMP-025	HTMP-038	HTMP-162	HTMP-078	HTMP-250	HTMP-246	HTMP-050	HTMP-166	HTMP-181	HTMP-032
16	HTMP-085	HTMP-088	HTMP-173	HTMP-084	HTMP-257	HTMP-243	HTMP-002	HTMP-191	HTMP-070	HTMP-036
17	HTMP-122	HTMP-017	HTMP-157	HTMP-006	HTMP-261	HTMP-242	HTMP-083	HTMP-096	HTMP-067	HTMP-022
18	HTMP-072	HTMP-085	HTMP-093	HTMP-044	HTMP-247	HTMP-247	HTMP-033	HTMP-183	HTMP-036	HTMP-125
19	HTMP-012	HTMP-030	HTMP-193	HTMP-011	HTMP-255	HTMP-258	HTMP-011	HTMP-256	HTMP-094	HTMP-010
20	HTMP-096	HTMP-187	HTMP-142	HTMP-056	HTMP-254	HTMP-163	HTMP-117	HTMP-122	HTMP-020	HTMP-108

Table 1: Performance of tomato hybrids under high temperature stress (summer season)

Hybrid/Lines	Avg. fruit weight (g)	Avg. fruit length (cm)	Fruit Dia (cm)	Pericarp thickness (cm)	No. of locules	TSS	Yield/plant (kg)	Yield (t/ha)
CRPVRTH-16-4	69.2	4.3	4.36	0.52	3.2	4.2	1.06	35.33
CRPVRTH-19-18	47.1	4.34	3.72	0.38	2.6	3.8	1.27	42.33
CRPVRTH-19-26	55.2	5.1	4.14	0.5	3	4.24	1.28	42.66
CRPVRTH-20-10	57.7	4.32	4.06	0.38	3.4	4.58	1.4	46.66
ToLCV-32	49.6	4.78	4.44	0.62	2.6	4.06	0.55	18.33
VRT-34	42.4	4.14	3.84	0.52	3	4.8	0.57	18.99
Pb. Berkha-2	52.8	4.16	4.82	0.52	4.6	5.43	0.47	15.66
Swarn Gola	52.9	4.64	4.24	0.5	2.2	4.4	0.61	20.33
Abhilash	63.1	4.1	4.5	0.5	4.8	4.93	0.86	28.66
Aryaman	62.3	4.88	4	0.66	2.2	4.2	1.02	33.99
CD (0.05)	1.2	0.23	0.27	0.05	0.09	0.12	0.08	2.45
CV	2.32	1.12	1.68	2.16	1.62	1.03	1.79	4.17

lines (ToLCV-32, VRT-34, Punjab Berkha-2, and Swarn Gola). Hybrid CRPVRTH-20-10 recorded the highest yield (46.66 t/ha) with high TSS (4.56) followed by CRPVRTH-19-26 (42.66 t/ha), and CRPVRTH-19-18 (42.33 t/ha), whereas CRPVRTH-16-4 was found *at par* with the private hybrid Aryaman.

PROJECT 3: CRP ON AGROBIODIVERSITY [ICAR]

CRP on Agro-biodiversity: Okra component III: As per the activities assigned to ICAR-IIVR, Varanasi, seed viability of 6 successful inter-specific crosses carried out and seeds of all six crosses found viable which varies from 60-95 %. Maximum viability was recorded in the cross VRO-6 × VRmanihot-1 (95%) followed by VRO-6 × VRmanihot-1 (92%) and minimum viability observed in *A. moschatus* (IC-333272) × PusaSawani (36%). The seeds of 6 successful interspecific crosses were sown in pro-tray. 50% seedlings of these crosses treated with Colchicine for fertility restoration and remaining 50% plant directly transplanted in the field. Colchicine treated seedlings were transplanted after 20 days of the treatment. The fertility status of the Colchicine treated plats were compared with without colchicine treated seedlings at flowering stage. Plant of all six interspecific crosses which were not treated with colchicine found to be sterile and set fruits with seeds. On the other hand, colchicine treated plants from the successful crosses exhibited recovery of fertility with varying degree and set fruits with few to more seeds which facilitated the advancement of these crosses to subsequent generation. Back crossing of fertile interspecific crosses carried out with recurrent parents. Besides, these crosses were also characterized for morphological traits

using 25 descriptor and resistance to YVMV and OELCV diseases. There was significant variation observed among the crosses and all six were found to be highly resistant to these viral diseases. In 2022-23, seed enhancement in interspecific crosses involving *A. moschatus* ssp. *moschatus* accession IC-333272, *A. angulosus* (RCM/PK-65) and *A. manihot* ssp. *manihot* (VRmanihot-1) and *A. esculentus* (PusaSawani and VRO-6) also under taken to produce sufficient seeds. 230 Amphidiploids derived from crosses with wild species which includes 71 selfed, 46 back crossed and 113 open bulked sown and characterized using 25 descriptor traits and also evaluated for viral disease (YVMV and OELCV) resistance. Almost all the amphidiploids, except 2-3 combinations showed high degree of resistance to these diseases, also exhibited high linkage drug for various undesirable traits from wild parents.

Component I (Characterization and multiplication of brinjal): During 2022-23, first year field evaluation of 440 germplasm lines were taken along with five checks (Kashi

Fig. 2: Field evaluation of brinjal germplasm during 2022-23

Uttam, Kashi Prakash, Kashi Taru, Arka Shirish, Arka Nidhi) in augmented block design at ICAR-IIVR, Varanasi. The accessions were sown on 16/07/2022 and transplanted on 20/08/2022. Data were recorded in accordance with the minimal descriptors provided by the ICAR-NBPGR, New Delhi. Wide variation was observed for each character. Selfing was carried out for purification of accessions.

CRP-Agrobiodiversity Cucumber component I (Characterization and multiplication): During 2022-23, first year field evaluation of 126 germplasm accessions lines were taken along with three checks (Pusa Harit, Pusa Uday and Japanese long green) in augmented design at ICAR-IIVR, Varanasi. The germplasm set was sown on 06/07/2022 and transplanting on 20/08/2022. The data was recorded for 35 minimal descriptor traits as provided by ICAR-NBPGR. The promising genotypes with respect to fruiting were IC-354790, IC-354785, IC-371758, IC-421743, IC-523688, IC-354807, IC-354784, IC-354825 and IC-354829. Wide variation was found for each character. Selfing was carried out for purification of accessions. Most of the genotypes were found to be susceptible to the ToLCNDV disease.

CRP-Agro biodiversity Cucumber component II (Screening against DM): Total 300 germplasm and checks viz., Pusa Barkha, Pahari Harit, Pusa Uday, Japanese Long Green and Arka Veera were screened against the downy mildew. Downy mildew infection was recorded on a scale of 0-9 (0=0%, 1= 1-5%, 2= 6-10%, 3=11-20%, 4=21-30%, 5=31-50%, 6= 51-65%, 7= 66-80%, 8= 81-99% and 9= 100%). Out of 300 genotype only one genotype (CRPCU-133) was found highly resistant with PDI 9.77%, 16 genotypes are resistant, 24 mild resistant, 29 susceptible, and 99 highly susceptible to downy mildew were identified. On the other hand, maximum PDI found in the genotype Japanese Long Green (41.33) and PCUC-9 (40) that expressed high susceptibility to downy mildew.

PROJECT 4: AGRI-BUSINESS INCUBATOR-IIVR, VARANASI [ICAR]

To facilitate technology commercialization, development of agri-entrepreneurships and to provide Human Resource Development support for empowering entrepreneurs through training for industry-oriented vocations, an ABI unit has been established by the Council under NAIF at ICAR-IIVR, Varanasi.

Fig. 3: Organization of a Kisan Mela, orientation programme and a workshop by ABI unit at ICAR-IIVR, Varanasi

The ABI unit in association with the institute, organized a Farmers' fair on 8th January 2022 on 'Entrepreneurship Development for Vegetable Marketing and Export' for SC & ST farmers and an orientation training programme on 'Agri-Export Marketing for Cooperatives and FPOs' during 1-4 June 2022 in collaboration with Vaikunth Mehta National Institute of Cooperative Management, Pune to create awareness and to give a fillip to agri-export endeavours.The ABI unit was also instrumental in organizing a workshop in collaboration with the Institute of Pesticide Formulation Technology, Gurgaon, on 'Safe and Judicious use of Pesticides and Application of New Generation Formulation for Crop Protection in Vegetable Crops' on 9th December 2022 for creating awareness about safe use of pesticides and encouraging the use of newer and safer formulations for the purpose keeping in view the health concerns of the masses (Fig. 3).

During the year 2022, five technology commercialization license agreements were executed for commercialization of IIVR technologies as a result of the efforts undertaken in this direction by ABI unit (Fig. 4). Overall, a revenue of Rs. 12.07 lakhs was generated through licensing and royalties during this year.

A startup firm M/s FTN Agro Pvt. Ltd. and an FPO Kashiraj Agro Producer Co. Ltd. got enrolled as an incubatee of the ABI unit, ICAR-IIVR, Varanasi during 2022.


the pioneer

IIVR develops technology for making green chili powder

अब पूर्वांचल की हरी मिर्च का पावडर बनेगा हिमाचल में

Fig. 4: Signing of a technology commercialization license agreement by ICAR-IIVR, Varanasi with a private company

PROJECT 5: ZONAL TECHNOLOGY MANAGEMENT UNIT-IIVR, VARANASI [ICAR]

To help ITMUs of the zone in commercialization of technologies, showcasing of technologies, management of IP portfolio, helping in IPR related issues and to serve as a link between IPTM unit of the Council and ITMUs of the zone, a Zonal Technology Management Unit has been established by the Council under NAIF at ICAR-IIVR, Varanasi. The unit has eleven different ICAR Institutes under its umbrella *viz.* ICAR-Central Institute of Arid Horticulture, Bikaner; ICAR-Central Institute of Sub-Tropical Horticulture, Lucknow; ICAR-Central Institute of Temperate Horticulture, Srinagar; ICAR- Central Potato Research Institute, Shimla; ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand; ICAR-Directorate of Mushroom Research, Solan; ICAR-National Research Centre for Litchi, Muzaffarpur; ICAR-National Research Centre on Orchids, Pakyong, Sikkim; ICAR-National Research Centre on Seed Spices, Ajmer, ICAR- Central Island Agricultural Research Institute, Port Blair and ICAR-Indian Institute of Vegetable Research, Varanasi.

The reports from all the ITMUs in domain on management of IP portfolio, commercialization of technologies, outreach activities, capacity building in IP Management and training/ workshop/seminar etc. organized was compiled and sent to IPTM unit of the Council as and when required.

An online IPR awareness programme with the help of office of the Controller General of Patents, Designs and Trademarks was organized on 17 January 2022 in order to acquaint all the participants about issues related to IPRs. Thirty one scientists from eight Institutes participated in the programme (Fig. 5).

A market sensitization programme as 'Technology Promotion Day' for varieties/hybrids and promising lines of tomato, brinjal, chilli, pea, Indian bean, French bean and Summer squash crops was organized on 18 January, 2022 (Fig. 6) for promoting the commercialization of ICAR-IIVR technologies. The programme was attended by 40 representatives from of 16 private sector seed companies dealing in vegetable seeds. The representatives of seed-companies visited the research farm of the Institute, saw and discussed about the promising materials in these vegetables. They expressed interest in many promising materials.

Another market sensitization programme as 'Technology Promotion Day-II' for varieties/hybrids and promising lines of Summervegetables was organized on 23 May, 2022 (Fig. 7) for promoting the commercialization of ICAR-IIVR technologies for summer season. The programme was attended by around 30 representatives from of 15 private sector seed companies dealing in vegetable seeds.

The next market sensitization programme as 'Technology Promotion Day-III' for varieties/hybrids and promising lines of rainy season vegetables like cucurbits, okra, water spinach etc. was organized on 24 September, 2022 for promoting the commercialization of ICAR-IIVR technologies for rainy season. The programme was attended by around 26 representatives from of 10 private sector seed companies dealing in vegetable seeds.

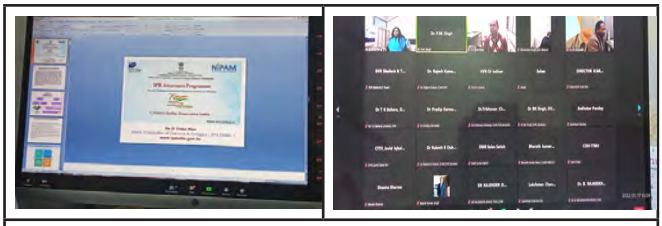

Fig. 5: Online IPR Awareness Programme organized on 17th January, 2022 at ICAR-IIVR, Varanasi

Fig. 6: Technology Promotion Day-I organized on 18th January, 2022 at ICAR-IIVR, Varanasi

Fig. 7: Technology Promotion Day-II organized on 23rdMay, 2022 at ICAR-IIVR, Varanasi

PROJECT 6: DISCOVERY OF NOVEL GENES AND QTLS CONFERRING RESISTANCE TO TOLCNDV DISEASE FROM INDIGENOUS SOURCES, GENOME-WIDE TRANSCRIPTIONAL DYNAMICS AND ALLELE MINING OF THE CANDIDATE GENES IN CUCURBITACEOUS VEGETABLES [NASF-ICAR]

Available germplasm has been categorized as resistant and susceptible in muskmelon. B-159, VRMM-170, VRMM-130, VRMM-160 and VRMM-161 identified as resistant genotypes under 2 season field evaluation data and supported by artificial

inoculation through viruliferous white flies. Development of RILs from B-159 × Kashi Madhu is in progress and presently F_2:F_3 seeds has been harvested. DNA was also isolated from the 200 F_2 population of B-159 × Kashi Madhu. Leaf sample of randomly selected 25 infected plant collected. DNA was isolated from infected plants for testing using ToLCNDV specific PCR based markers and confirmation of viral load through qPCR. For infectious clone development Susceptible line VRMM-5, Kashi Madhu sown along with resistant line B-159, VRMM-160 and VRMM-170. Inoculation has been done and experiment is in progress.

PROJECT 7: MONOECIOUS SEX EXPRESSION IN MUSKMELON (*CUCUMIS MELO* L.): INHERITANCE AND MOLECULAR MAPPING OF MONOECISM USING LINKED MARKERS [DST-SERB]

Out of 500 SSR primers, 121 and 117 found to be polymorphic for sex expression in the crosses Kashi Madhu × VRMM-170 and Kashi Madhu × B-159, respectively. Further these polymorphic SSRs were also validated using monoecious and andromonoecious bulk. DNA was isolated for 300 F_2 plants from Kashi Madhu × VRMM-170 and Kashi Madhu × B-159 each. The DNA samples from each F_2 populations were used to map monoecism using previously validated polymorphic SSRs. Besides, F_2, B_1 and B_2 population of Kashi Madhu × VRMM-170 and Kashi Madhu × B-159 also phenotyped for sex expression and fruit morphology to established inheritance pattern of monoecious sex expression and fruit shape morphology.

PROJECT 8: IDENTIFICATION OF SUITABLE VARIETIES/HYBRIDS OF CUCURBITACEOUS CROPS AND DEVELOPMENT OF PRODUCTION PROTOCOL FOR BETTER LIVELIHOOD OF RIVER BED (DIARA LAND) FARMING COMMUNITY [UPCAR]

Total 16 varieties/hybrids of 8 cucurbitaceous vegetables including bottle gourd (2), pumpkin (2), sponge gourd (2), ridge gourd (2), bitter gourd (2), muskmelon (2), water melon (2), and long melon (2) were evaluated. Bottle gourd variety Kashi Ganga and Ridhima shown significant difference between direct shown and transplanted crop for days to 50 % flowering, days to 1st harvest and duration of maturity while variety Kashi Ganga shown significant difference for equatorial length and variety Ridhima shown significant difference for average fruit weight and yield per plant. Pumpkin variety Kashi Harit and BSS-750 shown significant differences between direct sown and transplanted crops for days to 50% flowering, days to first harvest and polar length, while BSS-750 shown significant difference for equatorial length. Sponge gourd variety Kashi Shreya and Alok shown significant difference between direct shown and transplanted crops for days to 50% flowering, days to first harvest, number of fruit/plant and duration of maturity, while Kashi Shreya shown significant difference for average fruit weight and polar length and variety Alok

Fig. 9: Field view of crop

Fig. 10: Pit digging by digger

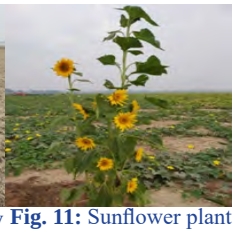

Fig. 11: Sunflower plant for better pollinationa

shown significant difference for yield/plant. Bitter gourd variety Kashi Mayuri and Prachi shown significant difference between direct shown and transplanted crops for days to 50% flowering and days to first harvest, while Kashi Mayuri is shown significant difference for polar length, equatorial length and duration of maturity and Prachi shown significant difference for number of fruit /plant and average fruit weight. Ridge gourd variety Kashi Shivani and PusaNutan shown significant difference between direct sown and transplanted crops for days to 50% flowering and days to first harvest, while Kashi Shivani shown significant difference for duration of maturity and PusaNutan shown significant difference for polar length and equatorial length. Long melon variety Super Chandraprabha and Narendra C-1 shown significant difference between direct shown and transplanted crops for days to 50% flowering, number of fruit/plant and duration of maturity, while Super Chandraprabha shown significant difference for yield/ plant and Narendra C-1 is showing significant difference for polar length and equatorial length. Watermelon variety Sugar baby and MaxX shown significant difference between direct sown and transplanted crops for days to 50 % flowering, equatorial length and duration of maturity, while Sugar baby shown significant difference for days to first harvest and MaxX shown significant difference for polar length. Muskmelon variety Kashi Madhu and Lyallpur-257 shown significant difference between direct shown and transplanted crops for days to 50 % flowering and days to first harvest, while Kashi Madhu shown significant difference for number of fruit/plant, equatorial length and duration of maturity and Lyallpur-257 shown significant difference for polar length. Grafted tomato showed early days to 50 % flowering, more number of branches per plant, more number of fruit per plant, high TSS % and high yield per plant in comparison to non-grafted plant. Honey bees are the main pollinating agent of cucurbits. The maximum infestation of *Meloidogyne incognita* was recorded in pumpkin and minimum was found in bitter gourd. The grafted tomato was not infected by nematode. For management of root knot nematodes; application of 50 g neem cake per pit at the sowing time and drenching of *Trichoderma harzianum* (2 g) + *Paecilomyces lilacinus* (2 ml) + *Pseudomonas fluorescens* (2 ml) per liter water at two to three times at 30 days interval. First dose was done at sowing time and second and third dose at 30 days interval was found most effective for nematode management (Fig. 9 to 11).

PROJECT 9: DEVELOPMENT AND EVALUATION OF ANNUAL MORINGA FOR FOOD FODDER AND NUTRITION CONTENT IN UP [UPCAR]

Total twenty genotypes were available in the mother block by the end of the 1st year. The major objective was to record the data of flowering and fruiting in these genotypes. The details of flowering and fruiting is presented in the table 2. The micro-nutrient was analysed for iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) in genotypes ODC-3, 150 GY, LSV/21-58, PD-9, 200 GY, LSV/21-92, Sel-24.

PROJECT 10: PROTEOMIC AND METABOLOMIC STUDIES ON ABIOTIC STRESS-CHALLENGED TOMATO TO DECIPHER FUNCTIONAL METABOLIC CLUES FOR PLANT RESPONSES, CROP YIELD AND NUTRITIONAL VALUES [CABin ICAR]

Metabolomics and proteomics work was performed in the CABin project 'proteomic and metabolomic studies on abiotic stress-challenged tomato to decipher functional metabolic clues for plant responses, crop yield and nutritional values'. Under the project a protocol fortripartite experimental set up (plant-pathogen-abiotic interaction) was developed and standardized. Data generation, analysis, visualization and interpretation for biological role of metabolites and proteins were assigned in metabolomics and proteomics data sets. Metabolomic data generation using LC-MS/MS was performed with plants under early blight disease-challenged and non-challenged tomato *leaves* in *Solanum lycopersicum* and *Solanum cheesmanii* comparative analysis. Metabolomic data sets were also generated on heat tolerant and susceptible fruits of 4 tomato hybrids VRNTH-19072 (heat sensitive) and VRNTH-20131, VRNTH-19067 and VRNTH-18283 (heat tolerant). In 2022-23, proteomic data was also obtained in disease challenged and non-challenged Kashi Aman plant leaves and the comparative analysis was performed.

It was recorded that significant metabolite changes associated with moderate resistance against *A. solani* in the leaves of wild species *S. cheesmaniae* grown under normal and pathogen-challenged conditions (Fig. 12). Profile of plant leaf metabolites was significantly differentiated. Both normal and diseased plants were discriminated not only by the presence/absence of specific metabolites as concluding factors, but also on the basis of the relative abundance of metabolites as important distinguishing criteria. Annotation of the metabolite features using the KEGG *S. lycopersicum* compound database led to the annotation of 3371 metabolite features with KEGG identifiers, which were enriched in a number of metabolic/biosynthetic pathways, mainly including secondary metabolites, cofactors, steroids, terpernoids, fatty acids, and brassinosteroids. Significantly up-regulated (541) and down-regulated (485) compounds distributed in different

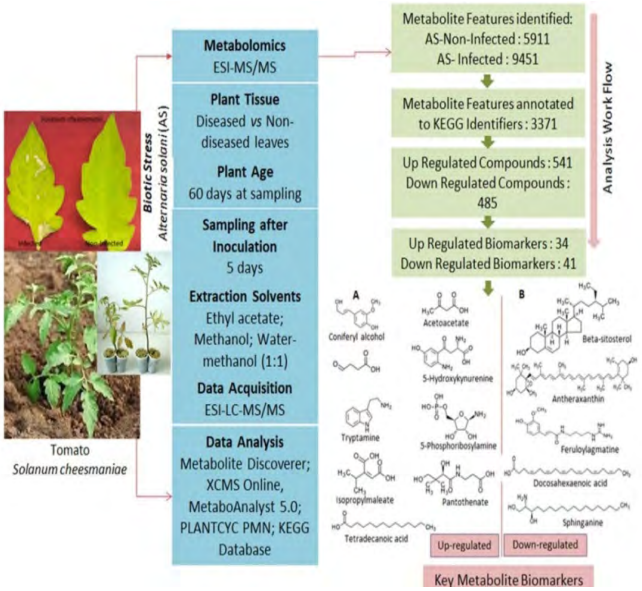

Fig. 12: Representative scheme of the experimental setup

Table 2: The details of flowering and fruiting of moringa genotypes under the project

Varieties / germplasm	flowering	No of fruits	Varieties/ Germplasm	Flowering	No of fruits
PKM-1 (TNAU)	3/3/22; 2/7/22; 16/10/2022	175	LSV/21-09	07/10/22	10
PKM-2 (TNAU)	7/3/22; 12/7/22; 20/10/22	190	LSV/21-31	7/3/22; 2/7/22; 4/9/22	60
Bhagya (GKVK)	10/3/22; 2/7/22; 7/11/22	50	LSV/21-49	7/11/22	10
Konkan Ruchira (MPKV)	20/11/2022	10	LSV/21-58	20/10/22	80
ODC-3 (Odisha)	4/9/2022	70	LSV/21-77	3/3/22; 2/7/22; 7/11/22	62
PD-1	17/11/2022	2	LSV/21-92	7/11/22	10
PD-9	17/11/2022	2	50 GY	7/11/22	10
Perennial 1 (UP)	05.01.2022	200	100 GY	7/3/22; 4/9/22	30
Perennial 2 (Bihar)	10.01.2023	-	150 GY	3/3/22; 4/9/22	70
Selection 24 (Bihar)	03/03/22; 07/10/22	800	200 GY	3/3/22; 4/9/22	31

metabolite classes play a crucial role in defense, infection prevention, signaling, plant growth and development, and survival maintenance under challenged conditions. The study has led to the identification of metabolite biomarkers and their metabolic pathways. It holds promise for developing disease-diagnostic tools based on key biomarker metabolites. Analysis and interpretation of other data sets is underway.

PROJECT 11: DUS TESTING OF VEGETABLE CROPS (JAN TO JUNE, 2022) [PPV&FRA]

Name of the crops/species earmarked for the centre: Tomato, Brinjal, Okra, Vegetable pea, French bean, Pumpkin, Bottle gourd, Bitter gourd and Cucumber.

During the period, 41 tomato, 11 brinjal, 11 bitter gourd, 12 bottle gourd, 6 cucumber and 3 pumpkin entries were evaluated under DUS testing, which includes 2 hybrids of 1st year, 38 hybrids of 2nd year and 1 farmer's variety in tomato, 11 farmer variety in brinjal, 2 hybrids of 1st year, 6 hybrids of 2nd year and 2 farmer's variety in bitter gourd, 2 hybrids of 1st year, 6 hybrids of 2nd year and 4 farmer's variety in bottle gourd, 2 hybrids of 2nd year and 4 farmer's variety in cucumber and 3 farmer's varieties in pumpkin. Monitoring of tomato and brinjal was done on 14.03.2022 however, some of the variety of brinjal had no fruit till 14.03.2022 therefore, 2nd monitoring of brinjal was done on 25.04.2022. Monitoring of bitter gourd, bottle gourd, cucumber and pumpkin was done on 29.06.2022.

Maintenance breeding was done to maintain the reference varieties. At present, a total of 375 varieties including cucumber (24), bitter gourd (25), bottle gourd (25), pumpkin (25), okra (42), brinjal (80), tomato (92), vegetable pea (40) and French bean (22) were maintained as reference collection and are being used as reference during DUS testing of candidate varieties.

PROJECT 12: DEVELOPMENT OF DUS TEST GUIDELINES FOR SPONGE GOURD [PPV&FRA]

In this project, during the year 2022 second year experiment was conducted for development of DUS test guidelines for sponge gourd. Data of 35 characters of 18 reference varieties were recorded which are under compilation. After compilation the reports along with draft will be submitted to nodal center ICAR-IARI, New Delhi and PPV&FRA, New Delhi for onward action.

PROJECT 13: DUS TESTING OF POINTED GOURD [PPV&FRA]

Initial year this project mainly focused on the maintenance of reference varieties. As per the objective reference varieties like Kashi Alankar, Kashi Suphal, Kashi Amulya, Swarna Rekha, Swarna Alaukik, VRPG-221, VRPG-220, VRPG-103, VRPG-126, VRPG-173, VRPG-219, VRPG-141, VRPG-176-1, VRPG-105, BCPG-1, BCPG-2, BCPG-4 and BCPG-5 clonally propagated and maintained separately. Data related to various crop descriptors based on the DUS guideline of pointed gourd also recorded.

PROJECT 14: DUS TESTING OF OKRA [PPV&FRA]

During the year, 43okra entries were evaluated under DUS testing, which includes 8 first year hybrids, 18 second year hybrids (9 candidates and 9 SMG hybrids), 8 typical varieties and 9 farmer's varieties. The data were recorded as per PPV&FRA guide lines. The experimental trial was monitored by an expert committee constituted by the authority on 17/10/2022. Two entries of FV, Typical (2886/2333 & 2887/2052) were in the flowering stage at the time of monitoring. These FV, Typical Variety did not produce any fruits. Maintenance breeding was done to maintain the reference varieties. At present, a total 42 reference varieties of okra were maintained as reference collection and are being used as reference during DUS testing of candidate varieties.

PROJECT 15: DUS TESTING OF BRINJAL [PPV&FRA]

During 2022-23, twelve entries including five hybrids pair set (candidate hybrids and Shimoga SMG) and seven farmer varieties were received. The entries were transplanted on 10-08-2022 in three replications and evaluated for 47 DUS characters. The reference varieties were also maintained. All five candidate hybrids were comparable with SMG set and included purple ovoid, purple cylindrical, purple globular with stripes, purple club shaped. Farmers' varieties were mostly tall, thorny included green obovate, purple cylindrical, purple ellipsoid, green cylindrical fruits. Impurity was observed in the farmers' varieties.

PROJECT 16: DUS TESTING OF CUCUMBER AND PUMPKIN [PPV&FRA]

During the year, maintenance breeding was done to maintain the reference varieties of cucumber and pumpkin. At present, 24 varieties of cucumber and 25 varieties of pumpkin were maintained as reference collection and are being used as reference during DUS testing of candidate varieties.

PROJECT 17: DUS TESTING OF TOMATO [PPV&FRA]

During the year, seed pockets of 27 tomato entries i.e, 13 (8 Candidate + 5 SMG) of 2nd year and 14 of 1st year (6 Hybrid + 4 FV, Typical + 4 Typical) were received for DUS testing at ICAR-IIVR, Varanasi. Among the 27 entries received, there was no germination in 22 TH 7 Hybrid and very poor germination observed in 22 TFV4. Related germination report was submitted on 13.10.2022. Recording of DUS characters is in progress as per DUS guidelines in tomato.

Fig. 13: DUS characterization of Brinjal entries during 2022-23

PROJECT 18: DUS TESTING OF BOTTLE GOURD AND BITTER GOURD [PPV&FRA]

During the year, a total 25 reference varieties of bottle gourd and 25 reference varieties of bitter gourd were raised for maintenance at ICAR-IIVR, Varanasi, (U.P.)

PROJECT 19: DUS TESTING OF VEGETABLE PEA AND FRENCH BEAN [PPV&FRA]

Vegetable Pea

Forty-two vegetable pea varieties were collected from different centres and maintained as reference varieties for DUS testing. These varieties were collected from various centers *i.e.* I.A.R.I. (RS) Katrain, I.I.V.R., Varanasi, IIHR, Bangalore, D.A.R.L., Pathoragarh, N.D.U.A.&T., Faizabad, G.B.P.U.A.&T., Pantanagar, H.A.U., Hisar, H.A.R.P., Ranchi, P.A.U., Ludhiana , MPKV, Rahuri, Dr. YSPHU&F, Solan, V.P.K.A.S., Almora, C.S.A.U.A.&T. Kanpur.

French bean

Twenty seven French bean varieties were maintained as reference varieties for DUS testing. These varieties were collected from various centers *i.e.* I.A.R.I., New Delhi, I.A.R.I., Regional Station, Katrain, I.I.V.R. Varanasi, Dr. YSPH&F, Solan, MPKV, Rahuri, B.H.U., Varanasi, C.S.A.U.A.&T., Kanpur, C.H.E.S., Ranchi, V.P.K.A.S., Almora, IIHR, Bangalore, IIPR, Kanpur.

PROJECT 20: NETWORK PROJECT ON PRECISION AGRICULTURE (NEPPA) [ICAR]

Development of sensor-based irrigation and fertigation modules in tomato & capsicum under polyhouse and open field condition

Sensor-based irrigation scheduling in polyhouse condition: In this study, an indeterminate tomato was grown under polyhouse condition with three sensor-based irrigation regimes e.g., irrigation at 22%, 20% and 18% soil moisture at 10 cm depth measured by wireless sensors installed at 10 cm depth. It has been observed that drip irrigation at 22% moisture level improved most of the yield parameters in tomato. The maximum no. of fruits (119.8/ plant), cluster weight (628.46 g/ cluster), fruit yields (8.72 kg/ plant or 29.03 kg/ m2) was obtained under drip irrigation at 22% moisture, however maximum lycopene (4.768 mg/ 100 g) and β-carotene (6.447 mg/ 100 g) contents were observed at 20% irrigation level. Ascorbic acid contents in fruits did not vary significantly.

Standardization of appropriate harvesting period in Capsicum: In capsicum for optimizing an appropriate harvesting stage based on quality parameters, fruits were harvested at 40, 50, 60 and 70 days after anthesis (DAA). Three different level of sensor-based irrigation scheduling (225, 20% and 18%) and three N- fertigation doses (100, 150 and 200 kg N/ha) were planned with control. Most of the quality parameters such as phenol, flavonoids, anti-oxidants, total chlorophyll and carotenoid content of the fruits were improved at 60 DAA. Maximum phenol content was reported in I_1N_2 followed by I_2N_1, whereas maximum flavonoid content if fruit was observed in I1N1 (16.5 mg RE/ 100g). Maximum antioxidant was registered under I_2N_1 followed by I_2N_3. Total chlorophyll content was higher in drip irrigation at 18% moisture + 100 kg N/ha (I_3N_1). As far as carotenoid content in fruit was concern, it was maximum with drip irrigation at 18% coupled with N-fertigation at 100-250 kg/ha.

PROJECT 21: BIOTECH KISAN (KRISHI INNOVATION AND SCIENCE APPLICATION NETWORK) HUB PROJECT [DBT]

Biotech KISAN Project is sponsored by Department of Biotechnology, Ministry of Science & Technology, Government of India and was implemented in 22 villages of 02 Aspirational districts (Chandauli & Sonbhadra) along with 01 Hub district (Varanasi) and 01 Sub-Hub district (Ghazipur) in collaboration with FAARD Foundation, Varanasi. Implementation of Biotech-KISAN project created a platform for farmers-scientists connect for providing greater awareness, technology demonstrations, trainings and capacity building along with

Fig. 14: Indeterminate tomato growing under polyhouse condition

Table 3: Effect of different sensor irrigation regime on production of tomato in polyhouse

Sensor moisture (%)	Plant ht. (m)	Fruits/ plant	Cluster wt. (g)	Yield/ plant (kg)	Yield/ m2 (kg)	Acidity (%)	Lycopene (mg/ 100 g)	β-carotene (mg/ 100 g)	Ascorbic acid (mg/ 100 g)
22%	5.45	119.80	628.46	8.717	29.03	0.69	3.241	5.195	21.50
20%	5.34	108.00	608.20	6.669	22.21	0.69	4.768	6.447	21.75
18%	5.27	104.00	454.66	6.302	20.98	0.80	3.085	4.763	20.25
Mean	5.40	110.6	563.8	7.229	24.14	0.73	3.698	5.468	21.17
SeM±	0.04	4.37	40.85	0.611	2.036	0.03	0.380	0.365	0.33
CD0.05	NS	12.10	113.15	1.693	5.639	0.08	1.115	1.071	NS

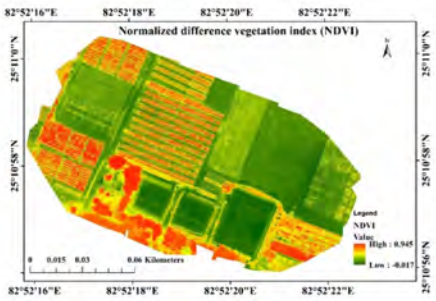

Fig. 15: Spectral image of tomato grown outside indicating NDVI pattern. Spectral image of tomato taken from multi-spectral imager indicated that NDVI values from 0.712 to 0.788. All drip irrigation regimes and N-fertigation showed relatively higher NDVI than the control plants (0.712). Hyper spectral image profile of polyhouse tomato shows low reflectance in water and N stressed plants

formation of FPOs and SHGs. Aggregation of farmers and farmer's produce has been the hall mark for enhancing crop productivity (15-20%), economic gain (20-25%), skill up gradation (60-62%), technological adoption (85-90%), and entrepreneurship development (15-20%) across farmers, districts and enterprises. Establishment of seed hubs, enhanced crop production and income through productivity gain, while proper marketing of the produce and diversification through intensification of vegetables, goatery, fisheries, mushroom production etc have been the success stories of the project. Soil nutrient analysis based application of fertilizers in field crops and introduction of polyhouse technology for growing quality nursery and high value vegetable crops enhanced resource use efficiency especially of nutrients and water and thus increased the farmer's income.

Table 4: Biochemical parameters of capsicum fruits at appropriate harvesting stage (at 60 DAA)

Treatment	Phenol (mg GAE/100g)	Flavonoids (mg RE/ 100g)	Antioxidant (%)	Total chlorophyll (µg/g)	Carotenoids (mg/g)
I_1N_1	31.6	16.5	62.1	96.7	2.6
I_1N_2	35.5	13.4	45.8	88.6	2.5
I_1N_3	29.4	14.5	65.2	115.5	4.8
I_2N_1	34.3	12.4	73.1	112.7	2.9
I_2N_2	28.8	9.3	46.4	132.7	2.8
I_2N_3	31.1	13.4	72.3	141.6	3.1
I_3N_1	33.0	12.8	53.1	173.4	4.1
I_3N_2	26.7	14.7	45.8	151.9	4.1
I_3N_3	25.3	13.2	68.5	132.4	4.3
Control	22.1	8.7	64.3	117.9	2.6
SEm±	1.33	0.75	3.47	8.07	0.27
CD 0.5%	3.65	2.06	9.53	22.20	0.74

Success Story of Demonstrated Vegetable Varieties Developed by ICAR-IIVR:

Kashi Ganga (Bottle Gourd): Mr Babulal from Gaurhai village, Sonbhadra had grown Bottle Gourd (Kashi Ganga) in 0.25 ha and harvested 118 q of Bottle Gourd which is 45.23 % higher compared to other varieties grown by farmers. He received price of Rs. 700 to 1000 per qt in local market and earned a net profit of Rs.72000/-. As the result of this successful demonstration the average income of farmers in the village increased by 16 %, mainly due to higher yield and better quality

Kashi Anmol (Chilli): Mr Vidyapati from Gaurahi, Sonbhadra had grown chilli in 0.25 ha area and harvested 5375 kg of green chilli and received a competitive price of Rs. 14 to 22 per kg and hence earned a net profit of rupees 85280/-. As the result of successful demonstration of Chilli (Kashi Anmol) in the selected village the average income of farmers increased by 16.5% as compared to other practicing varieties due to high yield, and better marketable quality.

Kashi Aman (Tomato): Demonstrations of tomato (Kashi Aman) were conducted at farmer's field in an area of 8.19 ha in the districts of Sonbhadra (Gaurahi, Bat & Hona Villages), Chandauli (Imiliya, Kharkholi & Bagahikhurd Villages), Varanasi (Jogapur & Bangalipur Villages) and Ghazipur (Jogamushahib & Karimuddinpur) which fetched an average yield of 423.5 q/ha. while the highest yield was recorded in Chandauli District i.e. 522.5 q/ha by farmer Dhanisra Devi of Kharkholi Village.

PROJECT 22: FARMER FIRST PROGRAM ON "INTERVENTION OF IMPROVED AGRICULTURAL TECHNOLOGIES FOR LIVELIHOOD AND NUTRITIONAL SECURITY ADHERING LOCAL RESOURCES AND WORKING KNOWLEDGE OF THE FARMERS" [ICAR]

Farmers FIRST project was initiated with 06 villages of Araziline block in Varanasi district, U.P. and during 2021, 03 new villages namely Tofapur, Kajichak and Nakkupur was added with an objective to enhanced crop productivity and farm income along with empower farmers/farm women in different aspects of agriculture enterprises through skill development.

The interventions carried out in this project were target specific and as per available resources and working knowledge of the people. The interventions were categorized in two modules i.e. Horticulture based and Crop based, under which successful demonstrations of vegetables and field crop were conducted at 919 farmers' field in an area of 94.6 ha in the selected clusters (Table 5). This resulted in significant increase in average yield by 19.7% and income by 31.3 %.

PROJECT 23: DEVELOPMENT AND VALIDATION OF NEED BASED TECHNOLOGY DELIVERY MODEL THROUGH FARMERS PRODUCER ORGANIZATION IN EASTERN REGION OF INDIA [ICAR]

Vegetable based technology delivery models were developed and validated during 2019 to 2022 under ICAR-NASF project "Development and validation of need based technology delivery model through FPOs in eastern region of India". There are two sub components under the model. (A) Agro-input delivery model and (B) Commercialization of value added vegetable products. Different bio-agent based products like *Kashi Jaiba Shakti,* Granule Based Trichoderma (GBT), *Kashi Bio-mix, BC- consortia* have been developed at ICAR-IIVR and found good impact in vegetable crop health. During three year project period these components have been validated at farmer's field in different vegetables. A model has been proposed for its commercialization through FPOs.

Similarly different value added vegetable products like; Bitter gourd chips, Dried moringa leaves, Dried cauliflower, Green chilli powder have been developed at ICAR-IIVR and ready for commercialization. Farmers especially rural women and

Table 5: Selected Successful Interventions Demonstrated in Farmers' Field

S.No.	Crop	Variety	Total Seed (Kg)	Seed Rate kg/ ha	Area (ha)	Prod. q/ha	No. of Farmer
Zaid Demonstration							
1	Cowpea	K. Nidhi	150	20	7.5	145.5	101
2	Bottle Gourd	K. Ganga	10	3	3.33	344.7	60
Kharif Demonstration							
3	Paddy	Pusa Sambha -1850	500	35	14.28	69.54	43
Rabi Demonstration							
4	Pea	K. Uday	2000	160	12.5	9900	174
5	French Beans	K. Rajhans	100	70	1.157	219.6	51
6	Radish	K. Adra	6	6	1	223.1	35
7	Palak	All Green	30	25	1.2	137.4	40
8	Carrot	K. Arun	5	7	0.7142	142.3	20
9	Wheat	HD-187	5000	120	41.5	52.4	103

Demonstration of bottle gourd var. Kashi Ganga in Tofapur village

Demonstration of paddy var Pusa Sambha-1850 in Dhanapur village

Demonstration of cowpea var Kashi Nidhi in Kajichak village

youths can earn profit through these cost effective technologies and vegetable wastage can also be reduced as well. Shivansh Agro Producers Co. Ltd., a leading FPO in Varanasi region has licensed the green chilli powder technology and started production since October 2022 @ 200 kg per month. Another FPO Kashi Raj Agro Producer Co Ltd licensed this technology and also became member of ABI unit of ICAR-IIVR. Using the facilities of the institute they produced green chilli powder during heavy production of chilli at local level. Similarly other value added products also have similar opportunity for commercialization through FPOs.

PROJECT 24: ESTABLISHMENT OF BIOCONTROL DEVELOPMENT CENTRE FOR PRODUCTION AND PROMOTION OF BIOAGENTS FOR THE MANAGEMENT OF SOIL BORNE DISEASES IN VEGETABLE CROPS AT ICAR-IIVR, VARANASI [RKVY]

A well-furnished very good biocontrol laboratory was established with renovation of a separate building where multiplication of resident biocontrol agents like *Trichoderma* and *Bacillus* spp. is going on. Under this project refrigerated centrifuge, vertical laminar air flow, water purification system, BOD incubator, hot air oven, electronic balance where established. The laboratory was inaugurated by Sh. Surya Pratap Shahi, Hon'ble Agriculture Minister, Govt. of Uttar Pradesh.

PROJECT 25: RESISTANCE MONITORING STUDIES IN TOMATO EARLY BLIGHT (*ALTERNARIA SOLANAI*) FOR AZOXYSTROBIN FUNGICIDE [SYNGENTA INDIA LTD.]

The tomato early blight leaves, stems and fruits samples were collected from 15-20 sites. From each site 50 to 100 leaves collected. The sampling had good representation of areas with

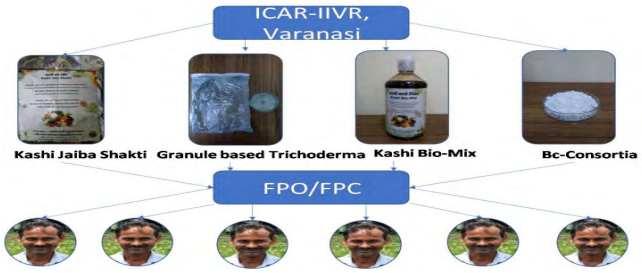

Fig. 16: Agro-input delivery model

Fig. 17: Commercialization of value added vegetable products

endemic early blight (*Alternaria solani*) occurrence and wherein Azoxystrobin is used. For this included one sample from an untreated area, where the tested fungicide had never been used *viz*. subsistence farm, low intensity area, or perhaps an organic farm that has used no fungicides for several years. Twenty-four hours after fungicide application, tomato plants are inoculated with a conidial suspension adjusted to 1×10^5 conidia per ml from 12 to 14 day-old cultures of an *A. solani* isolate grown on clarified V8 agar media. The inoculated plants are transferred to a dew chamber (22-24°C) for 24 hours. Then, plants are taken to the greenhouse and placed on moistened capillary matting. The plants are misted twice a day with a fog nozzle to maintain high humidity. The average temperature is about 24°C. Early blight symptoms develop after 7 to 14 days and disease severity is assessed by estimating the percent of infected leaf area of the first two true leaves. At least 3 replications (3 pots with 1 or 3 plants per pot) was tested for each fungicide treatment.

PROJECT 26: BASE LINE STUDY OF TOMATO POWDERY MILDEW PATHOGEN AGAINST A FUNGICIDE MOLECULE (ADEPIDYN) [SYNGENTA INDIA LTD.]

The samples were collected from tomato growing belt varanasi (U.P.). Sample collected about 10-15 tomato leaves from each site in a sealable plastic bag, immediate transportation to lab and do not add any moisture to the plastic bag exactly check infection spots on incoming sample for *Leveillula taurica* infection for further studies.

PROJECT 27: EVALUATION OF BIPM PRACTICES AGAINST SUCKING PESTS AND FRUIT FLIES *ZEUGODACUS CUCURBITAE* IN BITTER GOURD (AICRP ON BIOLOGICAL CONTROL OF CROP PESTS) [ICAR-NBAIR]

Effect of different pest management modules on bitter gourd (cv. Kashi Mayuri) were tested during the *kharif* season 2022 at the experimental farm of ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. From the table it is evident that lowest fruit fly damage (8.45%) on bitter gourd fruits were observed in the plots where Biointensive pest traps management (m_1) practices including installation of cue lure traps @ 15/ ha for mass trapping for cucurbit fruit flies, spraying of *Lecanicillium lecanii* NBAIR Vl-8 (2.5 g /L) + Neem oil (2.5

ml/L) for sucking pests and spraying of *Bacillus thuringiemsis* NBAIR Bt G4 @ 2 ml/L for leaf webber (*Diaphania indica*) were followed. BIPM treated plots were also had lowest whitefly (0.57/leaf), jassid (0.33/leaf) and cucumber moth (3.23/plant) populations among all the three treatments followed by the POP Recommendation (Jaggary 1% + Malathion 50 EC @ 2 ml/L) (m_2). The untreated control plots suffered maximum fruit fly damage (26.08%) along with highest sucking pest population i.e., white fly (2.13/leaf) and jassid (1.68/leaf). However, two important predators in bitter gourd ecosystem *i.e.,* lady bird beetles (4.13/plant) and spiders (4.21/plant) population were highest in the untreated control plots (Table 6).

Table 6: Effect of different pest management modules on major insect pests and natural enemies of bitter gourd

Treatment/ Module	Fruit fly damage (%)	Whitefly/leaf	Jassids/leaf	Cucumber moth/plant	Lady bird beetle/plant	Spider/plant
M1	8.45	0.57	0.33	3.23	2.47	2.49
M2	15.64	1.69	1.21	6.49	3.89	3.87
M3	26.08	2.43	1.68	8.16	4.13	4.21
SEm (±)	1.17	0.36	0.32	0.67	0.38	0.29
LSD (5%)	2.56	0.87	0.79	1.56	0.92	0.67


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ACHIEVEMENT OF ALL INDIA COORDINATED RESEARCH PROJECT ON VEGETABLE CROPS

During the year 2021-22, 1913 trials were conducted at 36 regular and 24 voluntary centres of AICRP on Vegetable Crops (Table 1).

The following recommendations under Crop Improvement, Crop Production and Crop Protection were made during 40th Group Meeting of AICRP (VC) held in hybrid mode at ICAR-IIVR, Varanasi from 15-17th June, 2022 (Table-2, 3 & 4).

Crop Improvement

Variety evaluation trials: Five entries of 4 vegetable crops were identified for release and notification for different agro-climatic zones of the country.

Hybrid evaluation trials: Four entries of 4 vegetable crops were identified for release and notification for different agro-climatic zones of the country.

Table 1: Details of the trials conducted during 2021-22 through AICRP (VC)

Division	Trials	No. of Trials	No. of Trials conducted at different centre
Crop Improvement	Varietal Trials	50	912
	Hybrid Trials	33	496
	Resistant Varietal Trials	10	145
Crop Production	Vegetable Production Trials	13	46
	Protected Cultivation	15	47
	Seed Production Trials	14	45
	Physiology & Biochemistry Trials	6	9
Crop Protection	Integrated pest management	32	83
	Integrated disease management	14	130
Total		187	1913

Resistant evaluation trials: One entry of Okra (YVMV) and One entry of tomato (ToLCV) were identified for release and notification for different agro-climatic zones of the country.

Production Technologies Developed (26)

Vegetable Production (11)

1. INM study in cucumber at **Junagadh** revealed that the highest fruit yield of 22.0 t/ha and B:C ratio of 3.52 was recorded with application of half Rec. NPK + FYM @ 10 t/ha + Vermicompost @ 2 t/ha + Bio fertilizers (T_{11}). Thus, the above INM treatment can be recommended for cucumber production under Agro-climatic zone VI.
2. **Srinagar, Solan, Bhubaneshwar** and **Hyderabad** centres concluded the INM experiments. All these four centres reported maximum pod yields in French bean with highest BC ratio by combined application of 75% NPK through inorganic fertilizers + 25% N through vermicompost. Therefore, the above INM package can be recommended for Agro-climatic zone-1 and V. At **Jorhat,** application of 25% NPK through inorganic source + 75% N through FYM (7.5:10:5 kg NPK/ha + 7.2 t FYM/ha) produced the maximum yield in French bean (135.17 q/ha) and BC ratio (2.53). In French bean therefore, it can be recommended as INM package for French bean production for III zone.
3. INM trial on broccoli conducted at **Nagaland**, revealed that the maximum head yield (147.31 q/ha) was recorded in T_7 i.e. Vermicompost @ 2.5 t/ha+ ½ NPK through fertilizer, however maximum B:C (3.24) and net return of Rs 3,08,566 was registered under T_3 *i.e.* FYM @ 10t/ha + ½ NPK through fertilizer. Therefore, treatment T_3 can be recommended for cultivation of broccoli under zone III.
4. Micro-nutrient study in bitter gourd was concluded at **Dharwad, Hyderabad** and **Kalyanpur**. All centres have reported maximum fruit yields and highest B:C with foliar spray of **Mixture of all** micronutrients (Boric acid + ZnSO4 + $CuSO_4$ + $FeSO_4$ + $MnSO_4$ + Ammo. molybdate). Thus, the above micronutrient formulation can be recommended for enhancing productivity of bitter gourd in Agro-climatic zone of IV, V and VIII.

Table 2: Varieties identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1	Dolichos bean (Bush)	2018/DOLBVAR-2	VRB Sem-207	IIVR, Varanasi	IV, VI
2	Dolichos bean (Pole)	2018/DOLPVAR-3	Arka Pradhan	IIHR, Bengaluru	IV
3	Pea (Edible Pod)	2018/PEDVAR-6	VPSP-906-1	VPKAS, Almora	IV
4	Sponge gourd	2018/SPGVAR-1	AHSG/2015/F5/01	CIAH, Bikaner	IV
5	Radish	2018/RADVAR-6	DPR-1	CSK HPKV, Palampur	I

Table 3: Hybrids identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1	Brinjal (Long)	2018/BRLHYB-6	IVBHL-22	IIVR, Varanasi	VII
2	Chilli	2018/CHIHYB-9	-	Pvt. Seed Comp.	VII
3	Bottle gourd	2018/BOGHYB-5	NDBGH-14-10	ANDUAT, Ayodhaya	IV
4	Pumpkin	2018/PUMHYB-5	PPH-1	PAU, Ludhiana	VII

Table 4: Resistant varieties identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1	Okra (YVMV)	2018/OKYVRES-1	VRO-119	IIVR, Varanasi	VI
2	Tomato (ToLCV)	2018/ToLCVHYBRES-7	Pusa ToLCV Hyb-6	IARI, New Delhi	V

5. Organic farming trial on amaranth at **Dharwad** showed that the highest yield of 162.36 q/ha with B:C ratio of 3.06 was recorded by application of Vermicompost @ 2 t/ha + PSB + *Azospirillum* @5 kg/ha each. Hence, this organic module can be recommended for organic production of amaranth in Agro-climatic zone VIII.
6. Under organic cultivation of spinach beet at **Kalyanpur**, the maximum green leaves yield (133.87 q/ha) and highest B:C (3.98) was reported with application of vermicompost @ 3 t/ha + PSB + *Azospirillum* (each @ 5 kg/ha). Hence, it is recommended for spinach beet production in Agro-climatic Zone- IV.
7. At **Durgapura**, the highest yield of coriander leaves (94.03 q/ha) and radish roots (237.61 q/ha) with net income of Rs. 2,55,100 /ha and B:C ratio of 4.0 was registered with use of Rec. FYM + Inorganic fertilizers + Plant protection with organic methods + IIHR microbial consortium @12.5 kg/ha. Hence, the above INM package is recommended for coriander and radish sequence in Agro-climatic zone VI.
8. Organic farming in Coriander-Radish sequence at **Nagaland** demonstrated that the maximum yield of coriander leaves (97.39 q/ha) and radish roots (349.63 q/ha) was obtained under T_5 *i.e* Vermicompost @ X + IIHR microbial consortium+ PP through organic means. The net income and B:C were however the highest in treatment T_4- Conventional practices (Rec. FYM + fertilizer + PP chemicals) + IIHR microbial consortium @ 12.5 kg/ha. Thus, treatment T_4 may be recommended for coriander-radish cultivation in Agro-climatic zone III.
9. Weed management study in cowpea at **Raipur** revealed that mulching with black polythene produced the highest yield of 86.71 q/ha with B:C ratio of 1.49. Thus, black polythene mulching can be recommended for cowpea production in Agro-climatic zone V.
10. Study on weed management in cowpea at **Hisar** revealed that the maximum pod yield of 80.5 q/ha with B:C ratio of 2.2 was obtained with pre-emergence application of Pendimethalin @ 6ml/ L+ One hand weeding 25 DAS. Similar findings were also reported at **Jorhat, Dharwad** and **Hisar** centres, Therefore, the above weed management practice can be recommended that for better weed control in cowpea for Agro-climatic zone III, VIII and VI
11. Grafting study in brinjal concluded at **Vellanikkara** revealed that highest fruit yield of 395.2 q/ha with BC ratio of 3.2 and net return of INR 4,36,820/ was obtained when Neelima hybrid was grafted on Surya rootstock. No incidence of BW and RKN were observed in this graft combination. Hence, the above graft combination can be recommended for grafted brinjal production in Agro-climatic zone VIII.

Protected cultivation (3)

1. Based on three years trials of growing parthenocarpic cucumbers under naturally ventilated polyhouse carried out at **Hisar**, the pooled data revealed that the cultivar Pant PC-2 gave the maximum yield of 4.3 kg per plant with the highest B: C ratio 2.6, which was at par with the Hilton under protected condition. Hence, it may be recommended for the protected cultivation of parthenocarpic cucumber in the climatic Zone VI.
2. At **IIVR**, three consecutive years study on fertigation in parthenocarpic cucumber revealed that fertigation @200:150:200 kg NPK/ ha is beneficial as well as economical for production of parthenocarpic cucumber in naturally ventilated polyhouse with net income of Rs 1196215/ha and B:C of 3.96. Hence, this fertilizer combination may be recommended for poly- net house cultivation of parthenocarpic cucumber in the climatic Zone IV.
3. At **Srinagar**, on the basis of study conducted for three years (2019 to 2021), the maximum fruit yield of Parthenocarpic cucumber Pusa Seedless Cucumber-6 was recorded (1194.08 q/ha) with application of 250:188:312 kg NPK/ ha. However, higher B:C ratio was recorded (5.63) with 200:150:200 kg NPK/ha). Hence treatment 200:150:200 Kg NPK/ha application is recommended for poly house cultivation of Parthenocarpic cucumber in Zone-I.

Seed production (8)

1. Seed coating with Carbendazim @ 2g/kg seed + Imidacloprid @ 2ml/kg seed + Micronutrient mixture @ 20g/kg seed before sowing was the best treatment in terms of germination count, vigour indices and B:C ratio (2.73) at **Raipur** in Knol-khol var. White Vienna, hence recommended for Chhattisgarh conditions.

2. Foliar spray with mixture of all micronutrients ($FeSO_4$ @ 0. 2% + Calcium Nitrate @ 0. 2% + Boron @ 0.1% + $ZnSO_4$ @ 0.2%) in tomato var. Kashi Amrit was found best treatment in terms of seed yield (176.7 kg/ha) and B:C ratio (3.05) at **Raipur**, hence recommended for Chhattisgarh conditions.
3. Ridge gourd seeds dried with zeolite beads up to 4% moisture content and stored in 700 gauge polythene bag maintained the better seed quality after 9 months of storage under room temperature at **Coimbatore** center, hence recommended for Tamil Nadu conditions.
4. The application of FYM @ 10 tonnes/ha + Vermicompost @ 4 tonnes/ha + Vermiwash spray (before flowering, at flowering and 15 days post flowering) @ 1:1 (v/v – water + vermiwash) was the best treatment considering seed yield and B:C ratio for organic seed production in radish (var. Chinese Pink) at Solan (B:C- 3.40) and Srinagar (B:C- 4.40), hence recommended for **Solan** and **Srinagar** conditions.
5. Foliar spray with IIHR micronutrient mixture @ 0. 25% before and after flowering along with foliar spray of NPK @ 2% before and after flowering along with recommended NPK resulted in maximum seed yield and B:C ratio in vegetable pea at Ludhiana (var. Punjab-89), Kanpur (var. Azad Pea-3) and Raipur (var. Arkel). Whereas, application of Recommended NPK + Foliar spray of IIHR micronutrient mixture @ 0. 25% before flowering + foliar spray of NPK @ 1% before flowering in pea var. Kashi Nandini resulted the highest seed yield (24.2 q/ha) and B:C ratio (3.05) with better seed quality at **Varanasi** conditions.
6. For hybrid seed production of cauliflower cv. Pusa Snowball hybrid-1, the planting of the parental lines (Female: Male) in the ratio of 2:1 at a spacing of 60 × 30 cm gave the maximum seed yield (1.74 q/ha & 1.50 q/ha, respectively) and B:C ratio (9.20 & 8.78, respectively) with good seed quality at **Katrain** and **Solan**, hence recommended for Himachal Pradesh conditions.
7. The application of IIHR micronutrient mixture @ 5.0 g/L at 30, 45, and 60 days after sowing was found superior in seed production of okra var. Arka Anamika considering highest seed yield (12.4 q/ha), seed quality parameters and B:C ratio (3.19) at Hyderabad centre, whereas the application of Sampoorna KAU micronutrient mixture @ 5.0 g/L at 30, 45, 60 days after sowing gave maximum seed yield (8.8 q/ha), seed quality parameters, and benefit cost ratio (5.5) in seed production of okra var. Arka Anamika at **Vellanikkara** center. Hence, recommended for Telangana and Kerala conditions, respectively.
8. Foliar spray of silver nitrate ($AgNO_3$) at a concentration of 500 ppm during 2 and 4-true leaf stages in parthenocarpic cucumber (var. Cu-3) was the best treatment in terms of male flower production, seed yield and B:C ratio (3.32) at OUAT, **Bhubaneswar**, hence recommended for Bhubaneswar conditions.

Physiology, Biochemistry and Processing (4)

1. Tomato line 2018/TOLCVRES-8 recorded highest TSS of 7.27 °Brix whereas highest total carotenoids and lycopene were observed in 2018/TOINDVAR-2. Antioxidant capacity (FRAP) and its related parameter, total phenols were significantly higher in line 2018/TOINDVAR-3. 2018/TOINDVAR-4, 2018/TOLCVRES-6 and 2018/TOLCVRES-6 lines have highest vitamin C content.
2. The trial which was conducted in tomato for assessing the correlation between oxalate content and acidity at PAU and IIHR, revealed that no significant correlation between these parameters.
3. Among the cherry tomato lines highest vitamin C content was found in 2018/TOCVAR-5 whereas highest total carotenoids and lycopene were observed in 2018/TOCVAR-6, 2018/TOCVAR-1, and 2018/TOCVAR-5. Antioxidant capacity (FRAP) and its related parameter, total phenols were significantly higher in line 2018/TOCVAR-2.
4. The quality assessment of seven genotypes of bitter gourd revealed that 2018/BIGVAR-4 genotype has highest recovery percent. Moreover, sensory evaluation of twenty five genotypes of dried cauliflower at the end of the storage period (shelf life 180 days) revealed that overall acceptability was best for 2019/CAUMHYB 1 line.

Protection Technologies Developed (13)

Integrated Disease Management (3)

1. **Veg. 8.23 Bio-intensive management of diseases of capsicum under poly house (2015):** At **Hessaraghatta** and **Vellanikkara**, based on the pooled data treatment (T5) with soil solarization after flooding the structure and covering it by 200 gauge transparent polysheet for three weeks, seed treatment with seed pro@10g/kg seeds, Soil drenching with seed pro(@ 5%, application of 5kg FYM fortified with 500g neem cake and 50 g *Trichoderma* sp. + 50 g *Paecilomyces lilacinus* at the time of bed preparation followed by combined soil drenching with Phyton T @5ml/l and foliar spray with Phyton T @4ml/l three times at 15 days interval beginning from 30 days after transplanting was the best treatment with significantly higher yield with benefit cost ratio (1.8 to 2.18). Despite treatment found to reduce the incidence of powdery mildew at Hessaraghatta and bacterial wilt in Vellanikkara in comparison to control significantly. Hence, this treatment may be recommended for the Hessaraghatta and Vellanikkara region.
2. **Veg. 8.26 IDM for bacterial wilt management of tomato (2018):** At **Kalyani**, treatment (T8) comprising of soil amendment with lime (300 kg/ha), seed treatment with *P. fluorescens* @ 10g/kg seed and seedling dip with *P. fluorescens* @ 1% followed by soil drenching of *P. fluorescens* @ 1% thrice at 10 days interval starting from 20 days after transplanting was found very effective in reducing bacterial wilt incidence in tomato (77.6%) in comparison to control with maximum fruit yield (194 q/ha). But the highest ICBR ratio (15.87) with the treatment (T5) Seed treatment (10g/kg seed) followed by seedling

dip @1% with *Pseudomonas fluorescens*. Hence, this trial may not be considered for recommendation for this region.

3. At **Vellanikkara, Solan** and **Bhubaneswar**, treatment (T7) comprising of soil application of bleaching powder @15kg/ha before transplanting, soil amendment with lime depending upon pH of the soil to make soil neutral, seedling root dipping by streptocycline @ 200ppm before transplanting and drenching of copper oxychloride @ 0.3% thrice at 10 days interval starting from 20 days after transplanting is found with maximum reduction in bacterial wilt incidence. Further, same treatment (T7) has recorded the maximum fruit yield at both the centres and higher benefit cost ratio (2.5 to 3.64). This treatment T7 may be recommended for the Vellanikkara, Solan and Bhubaneswar region in the management of bacterial disease in tomato.

Insect Pest Management (9)

9.6.2 Evaluation of different pest management modules against vector and sucking pests management of Bitter gourd

1. In bitter gourd (cv. Kashi Mayuri), the integrated pest management module comprising seed treatment with Imidacloprid 48 FS @ 5 g/kg of seed and installation of yellow sticky traps @ 25-30/ha, border crop with maize, spraying of Azadirachtin 300 ppm @ 5 ml/L, Thiamethoxam 25 WG @ 1 g/3 L, Imidacloprid 70 WG @ 1 g/12 L, Cyantraniliprole 10.26 OD @ 1.8 ml/L, Neem oil (0.5%) + *Lecanicillium lecanii* @ 2.5 g/L and Neem oil (0.5%) + *Beauveria bassiana* @ 2.5 g/L from 20 DAS onwards till 70 DAS each at 10 days intervals harbored lowest whiteflies population (0.63 leaf^{-1}) with maximum of 70.14 per cent reduction over control. Furthermore, the highest healthy fruit yields (167.7 q ha^{-1}) were recorded from the IPM module. In terms of return, maximum net profit of ₹71211 was obtained from the IPM module with the highest incremental cost-benefit ratio of 1:5.18 followed by BIPM module (1:4.99) **under IIVR, Varanasi condition**. The number of predatory lady bird beetles and polyphagous spiders were also higher in this module.
2. At **Rahuri condition**, the Integrated Pest Management Module comprising the above mentioned treatments in bitter gourd (cv. Phule Green Gold) is also recommended. The said IPM module had least population of thrips *i.e.*, (0.97-3.08 thrips/plant) and whitefly (0.77-1.57 whitefly/plant) along with maximum marketable yield of bitter gourd (161.05 q/ha) with 57.82% increase in yield over control and observed B:C ratio of 1:2.68.

9.1.3 Evaluation of biopesticides and insecticides for management of sucking pests complex in brinjal

1. In Brinjal (cv. Kashi Taru) at **IIVR, Varanasi** spraying of Azadirachtin 300 ppm @ 5 ml/L in combination with *Lecanicillium lecanii* @ 2.5 g/L was found effective with 71.26, 52.58, 53.30 and 55.49% reduction in sucking pests population *viz*., mites, whiteflies, aphids and leaf hoppers, respectively and 28.16% increase in marketable yield with C:B ratio 1:4.23. However it was found statistically on par with chemical treatments such as Spiromesifen @ 1 ml/L with 76.18 % reduction in mite population with 55.62, 58.24 and 64.02% reduction in whiteflies, aphids and leaf hoppers population and 20.49 % increase in marketable yield with C:B ratio 1:3.93 followed by Diafenthiuron 50 WP @ 1 g/L.

9.6.4 Evaluation of some entomopathogenic fungi and their compatibility with neem oil against sucking pests of cucumber

1. At Rahuri condition *Lecanicillium lecanii* @ 5 g/L, was found significantly superior for controlling of whitefly population in cucumber whereas, imidacloprid 17.8 SL @ 0.33 ml/L and *Metarhizium anisopliae* @ 5 g/L were observed promising for control of aphids and thrips. So, *L. lecanii*, imidacloprid 17.8 SL and *M. anisopliae* were effective with 255.31; 252.15; 249.49 q/ha yield, respectively, with C:B ratio of 1:2.55; 1:2.52; 1:2.49, respectively.

9.5.4 Development and evaluation of IPM modules for tomato pin worm *Tuta absoluta*

1. In tomato, the chemical module comprising the spraying of lamda cyhalothrin 5 EC @ 0.6 ml/L at 30 DAT, followed by indoxacarb 14.5 SC @ 1 ml/L, rynaxypyr 20 SC @ 0.3 ml/L, novaluron 10 EC @ 1.5 ml/L each at 10 days interval found to be the best management practice for *Tuta absoluta* on tomato under **IIHR, Bengaluru** conditions with CB Ratio of 1:4.37.

9.9.2 Management of Root-knot nematodes (*M. incognita*) on tomato under open field conditions

1. The pooled analysis of three years (2017-18 to 2019-20) trials at **PAU, Ludhiana** revealed that in tomato, Seed treatment with 20 g of *Bacillus amyloliquefaciens* + substrate treatment for nursery (10 g/ kg of substrate) + Application of 5 tons of FYM enriched with 5 kg *B. amyloliquefaciens* /ha was found to significantly reduce final soil root knot nematode population (*Meloidogyne incognita* race 2) by 42.04%, and root galling index by 43.21% with an increase of 21.79 % in marketable yield giving C: B ratio 1:1.21.
2. Pooled analysis of experiment in tomato conducted at **ICAR-IIHR, Bengaluru** for three years (2017-18 to 2019-20) revealed that seed treatment with bacterial bioagents, *Bacillus amyloliquefaciens* at 20 g/kg seed, substrate treatment at 10 g/kg cocopeat and soil application of 5 tons FYM enriched with either of them at 5 kg/ha recorded significantly higher yield (26.37 – 27.96 % increase over control) and lower nematode population (*Meloidogyne incognita* race 2) in tomato (74.23 – 74.86 % decrease) with cost benefit ratio of 1:1.91 to 1: 1.93 under Bangalore conditions.

9.10.1 Management of Root-knot nematodes (*M. incognita*) in cucumber under protected conditions

1. Planting African Marigold 45 days before planting + Application of bio-agents (2 kg *Paecilomyces lilacinus*, 2 kg *Trichoderma viride*, 2 kg *Pseudomonas fluorescens*) enriched neem cake (1 ton) / ha + drenching bio-agent enriched neem cake suspension 10% once in 10 days showed maximum reduction in soil nematode population (*Meloidogyne incognita* race 2) by 49.75% as well as Root gall index by 44.50% with 25.9 per cent increase in yield with B:C ratio 1:1.23 at PAU, Ludhiana.
2. Planting African Marigold 45 days before planting + Application of bio-agents (2 kg *Bacillus subtilis*, 2 kg *Bacillus pumilus*, 2 kg *Bacillus amyloliquefaciens*) enriched neem cake (1 ton) / ha + drenching bio-agent enriched neem cake suspension 10% once in 10 days recorded the maximum decrease of *M. incognita* race 2 population (70.84 – 76.13 % roots and soil) and increase in cucumber yield (23.29%) compared to untreated control, under protected conditions with cost benefit ratio of 1:2.11 at ICAR-IIHR, Bengaluru.

Breeder Seed Production of Vegetable Crops

During the year 2021-22, an indent of 2542.500 kg breeder seed for 238 varieties of 27 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi for *Kharif*, 2022 and the same have been allotted to 25 coordinating centres for undertaking the production. However 2077.080 kg breeder seed accepted by the 20 coordinating centres for 193 varieties of 27 vegetable crops. A total of 2083.850 kg of Breeder Seed has been produced against the indents and its reports sent to the Deputy Commissioner (Seed) DAC, GOI, New Delhi for onward supply to the indenters.

Apart from this, an indent of 11608.900 kg breeder seed for 158 varieties of 27 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi for Rabi, 2022 and the same have been allotted to 18 coordinating centres for undertaking the production. However 10718.190 kg breeder seed accepted by the 14 coordinating centres for 158 varieties of 27 vegetable crops. A total of 10572.263 kg of Breeder Seed has been produced against the indents and its reports sent to the Deputy Commissioner (Seed) DAC, GOI, New Delhi for onward supply to the indenters.

During the year 2022-23, an indent of 1682.380 kg breeder seed for 168 varieties of 28 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi for *Kharif*, 2023 and the same have been allotted to 22 coordinating centres for undertaking the production. However, 1563.530 kg breeder seed accepted for production by the 24 coordinating centres for 130 varieties of 26 vegetable crops. A total of 1914.080 kg of Breeder Seed has been produced during *kharif*, 2022 against the indents and its reports sent to the Deputy Commissioner (Seed) DAC, GOI, New Delhi for onward supply to the indenters.

Apart from this, an indent of 8029.310 kg breeder seed for 132 varieties of 32 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi for Rabi, 2023 and the same have been allotted to 18 coordinating centres for undertaking the production. Actual production of breeder seeds of vegetable crops are awaited.


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KRISHI VIGYAN KENDRAS

KRISHI VIGYAN KENDRA, KUSHINAGAR

Training Programmes : Krishi Vigyan Kendra, Kushinagar organized **106** need based on/off–campus training programs comprising diverse aspects of production technologies of cereals, oilseeds, pulses, vegetables, livestock, value addition, household food security, and women empowerment benefitting a total of **3706** participants comprising **798** female and **2908** male farmers, rural youth and extension functionaries.

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	76	1761	654	2415
Rural youths	3	73	6	79
Extension functionaries	14	524	32	556
Sponsored	13	550	106	656
Total	106	2908	798	3706

Frontline demonstration : Front line demonstrations were conducted in **167.8 ha** area at **1022** farmers field on Paddy, Mustard, Lentil, Onion, Green Gram, Brinjal, green fodder, Oyster Mushroom and Balance Diet through Nutritional garden etc.

Frontline Demonstrations Summary

Enterprise	No. of Farmers	Area (ha)	Units/Animals
Oilseeds	164	36	-
Pulses	388	65	-
Cereals	201	56.8	-
Fruit	7	10.0	-
Total	760	167.8	-
Livestock & Fisheries	62		62
Other enterprises	200	-	200
Total	262	-	262
Grand Total	1022	167.8	262

Frontline Demonstration conducted by KVK, Kushinagar

S. No.	Crop	Technology demonstrated	Horizontal spread of technology				
			No. of farmers	Area in ha	Demo Yield	Check Yield	Yield Increase %
1.	Paddy	Seed treatment	34	12	38.9	32.7	8.4
2.	Paddy	Biological Pest Mgt.	12	5	39.2	34.6	8.8
3.	Paddy	Drum Seeder	16	6.0	44.55	36.2	23.6
4.	Paddy	Drum Seeder	18	6.0	45.12	37.2	21.29
5.	Wheat	Zero Tillage	3	1.0	40.2	33.8	18.9
6.	Wheat	Zero Tillage	4	2.0	41.4	34.2	21.05
7.	Wheat	ST	7	3.0	40.9	34.0	20.2
8.	Mustard	Line sowing	43	10.0	16.3	12.8	27.3
9.	Mustard	Line sowing	90	21.0	Result Awaited		
10.	Sesame	Line sowing	31	5.0	8.0	6.2	29.03
11.	Lentil	Line sowing	65	10.0	12.4	8.5	45.8
12.	Onion	Line sowing	8	0.4	278.8	228.2	22.17
13.	Onion	Line sowing	7	0.4	286.7	231.4	23.8
14.	Sugarcane + cowpea	Intercropping	12	1.0	(Sugarcane) Result awaited		
15.	Brinjal	HYV	12	1.0	462.8	372.0	24.4
16.	Brinjal	Pheromone trap	10	1.0	Result awaited		
17.	Brinjal	HYV	12	1.0	645.5	488.6	32.1

18.	Pigeon pea	Line sowing	75	10.0	19.4	12.5	55.2
19.	Lentil	Line sowing	139	20.0	Result Awaited		
20.	Banana	-	7	10.0	738.8	625.5	18.2
21.	Green Gram	Line sowing	57	10.0	11.4	8.6	32.5
22.	Black Gram	Line sowing	21	5.0	12.5	9.2	35.8
23.	Pigeon pea	Line sowing	31	10.0	Result Awaited		
24.	Nutritional garden	Balance Diet through Nutritional garden	100	0.50	376.2	225.4	66.9
25.	Wheat 2022-23	Zero tillage	10	1.6	Result Awaited		
26.	Wheat 2022-23	Zero tillage	8	1.6	Result Awaited		
27.	Cow 2022	Use of leguminous green fodder(Barseem) to increase milk production	10	10	7.23	6.10	18.52
28.	Cow 2022	Mineral Mixture and Dewormer	17	17	7.96	7.029	13.24
29.	Cow 2022	Use of green fodder (Jowar)	35	35	7.5	6.64	12.95
30.	Wheat 2022-23	Zero tillage	10	1.6	Result Awaited		
31.	Wheat 2022-23	Zero tillage	8	1.6	Result Awaited		

Technology Assessment and Refinement

Thematic areas	Crop/ Enterprise	Name of the technology assessed	No. of trials	No. of farmers
IPM	Sugarcane	Low sugarcane yield due to borer infestation	1	10
	Brinjal	Low yield of brinjal due shoot and fruit borer infestation	1	10
Integrated Crop Management	Litchi	Nutrient management in litchi orchards	1	10
	Banana-Cauliflower	Intercropping of cauliflower with banana for increasing income per unit area.	1	10
	Chilli	Mulching in chilli	1	8
Resource Conservation Technology	Rice- Sugarcane-Potato	Assessment of diversification on socio economic status of farmers..	1	10
	Wheat	Residue management in wheat by happy seeder machine.	1	10
Women and child care	Childrens	Enrichment of wheat flour with oilseed flours for supplementary feeding.	1	30
Total			08	98

OFT 01: Low yield of wheat due to burning of crop residue and deterioration of soil health

KVK, Kushinagar conducted OFT in the year 2021-22 and on effect of sowing by happy seeder in wheat crop assessed the technology on residue management in wheat by happy seeder machine. Result show that T1 gave higher yield of 42.6 q/ha with BC ratio 2.76:1 in comparison to T0 that is 34.3q/ha with BC ratio 1.94:1 while the result of OFT conducted on 2022-23 is awaited.

OFT 02: Low income per unit area - mono cropping

KVK, Kushinagar conducted OFT in year 2021-2022 and 2022-23 on effect of intercropping of cauliflower (Kashi Gobhi 25) with banana (G-9) at ten farmer's field to enhance the total income per unit area of the farmers. Farmers usually grow banana as a mono-crop. The observations recorded are as follows:

OFT 03: Low economic return per unit area without mulching

KVK, Kushinagar conducted OFT in year 2021-2022 on effect of mulching in chilli. A total 08 farmer's fields were selected covering an area of 1 hectare. The observations recorded are as follows:

OFT 04: Low sugarcane yield due to borer infestation

KVK, Kushinagar conducted OFT in year 2022-2023 for assessment of Sugarcane borer management under AESA based IPM module involving the recommended use of chlorantraniliprole @ 375ml/ha, use of Neem cake post irrigation, Trichogramma egg parasitoid and timely use of light

Table of OFT 02: Low income per unit area - mono cropping

Details of Technology	No. of farmers	Average Yield (q/ha.)	Average Gross cost (Rs./ha.)	Average Gross return (Rs./ha.)	Average Net return (Rs./ha.)	B:C Ratio
T_1 – banana cultivation as mono-cropping (G-9)	10	752.6	218560.0	677340.0	458780.0	3.1:1
T_2 –Intercropping of cauliflower (Kashi Gobhi 25) with banana (G-9) 2021-22		Cauliflower 138.7 + Banana 785.4	252340.0	1039238.0	786898	4.1:1
T_2 –Intercropping of cauliflower (Kashi Gobhi 25) with banana (G-9) 2022-23	7	Result Awaited				

Table of OFT 03: Low economic return per unit area without mulching

Details of Technology	No. of farmers	Average Yield (q/ha.)	Average Gross cost (Rs./ ha.)	Average Gross return (Rs./ha.)	Average Net return (Rs./ha.)	B:C Ratio
T_1 – without mulching chilli cultivation.	08	158	118200	379200	261000	3.20:1
T_2 – Use of organic mulch in chilli cultivation		195	126560	487500	360940	3.85:1

trap. A total 06 farmer's fields have been covered over an area of 1 hectare. The results are awaited as the trial is ongoing.

OFT 05: Low yield of brinjal due shoot and fruit borer infestation

KVK, Kushinagar conducted OFT in year 2022-2023 for assessment of brinjal due shoot and fruit borer under AESA based IPM module involving the recommended use of chlorantraniliprole @ 375ml/ha, use of Neem cake, Trichogramma egg parasitoid and timely use of light trap. A total 09 farmer's fields have been covered over an area of 1 hectare. The results are awaited as the trial is ongoing.

OFT 06: Nutrient management in litchi orchards

KVK, Kushinagar conducted OFT in year 2022-2023 for assessment of balanced use of nutrients (1.0 kg N + 0.5 kg P + 1.0 kg K per tree/year) + borax @ 0.25 % spraying @ 15 day interval at the time of fruiting + PSB @ 5 kg/ha with FYM 50 kg per tree /year for qualitative and quantitative production of litchi from existing orchards (2022-23) . The results are awaited as the trial is ongoing.

OFT 07: Protein- energy malnutrition among children (up to 6 year age)

KVK, Kushinagar conducted OFT in year 2021-2022 on effect of wheat flour with oilseed flours for supplementary feeding among children of age up to 6 years. Total 30 children were selected and provided wheat flour with 10% linseed flour for supplemental feeding for 45 days @ 100 gm per day. The observations recorded are as follows:

Extension Activities: To expedite the process of transfer of technology, the KVK organized 11 kisan gosthis wherein 1417farmers participated. KVK participated in 3 exhibitions for awareness creation of farmers benefitting a total of 4675 farmers. A total 115 scientific visits to farmer's field visits by KVK officials and 101 diagnostic visits were made by the KVK scientists along 1942 S.M.S. for the benefit of farmers. 93 lectures were delivered as resource person benefitting more than 4664 farmers of Kushinagar and adjoining districts. 1472 farmers visited KVK during 2022.

Table of OFT 07: Protein- energy malnutrition among children (up to 6 year age)

Detail of Trial	No. of Respondent	Gain in weight	Gain in height	Frequency of getting ill	Acceptability of food by children*
T_0- Farmer practice(only wheat flour)	30	3.28 %	1.43 %	Once in 21 days	8 (liked very much)
T_1- Enrichment of wheat flour with 10% linseed flour and feeding for 45 days@ 100 g per day		5.64 %	2.61 %	Once after 78 day	9 (Extremely liked)
*On Hedonic Scale					

Nutritional Analysis

Detail of Trial	Protein (%)	Fat (%)	Ash (%)	Energy (Kcal/100g)
T_0- Farmer practice (only wheat flour)	10.57	2.19	1.40	361
T_1- Enrichment of wheat flour with 10% linseed flour and feeding for 45 days@ 100 g per day	13.60	2.35	1.95	362

Extension Programmes

Activities	No. of Programmes	No. of Farmers	No. of Extension Personnel	Total
Advisory Services	103	295	11	306
Field visit	62	401	9	410
Diagnostic visits	101	1613	14	1627
Farmers visits to KVK	197	1416	56	1472
Kisan Ghosthi	11	1315	102	1417
Self –help groups	1	10	2	13
Exhibition / Kisan Mela	3	4521	154	4675
Scientists' visit to farmers field	115	578	22	600
Plantation Programme	9	203	9	212
Lecture delivered	93	4452	212	4664
Method Demonstrations	3	42	3	45
Important Day -Celebration (International Women's Day, World Environment Day, etc)	9	541	62	563
Total	707	15387	656	16043

Mobile Advisory Services

Message Type	Type of Messages						
	Crop	Livestock	Weather	Marketing	Awareness	Other enterprise	Total
Text only	380	79	1128	94	227	3	1911
Voice only	3	7	17	4	-	-	31
Voice & Text both							
Total Messages	383	86	1145	98	227	3	1942
Total farmers Benefitted	2210	578	5874	1567	294	200	10723

Seed & Planting Material Production

	Quintal/Number	Value Rs.
Seed (q)	1710.79	436284
Planting material (No.)	23797	200615.3
Fishery production	3.14(q)	55705.44
Livestock Production	0.82(q)	24600.0
Orchard		188000.0
Total	1714.75 q & 23797 (No.)	905204.74

KRISHI VIGYAN KENDRA, DEORIA

Training Programmes: To help agricultural communities improve their knowledge in various subject areas, a total of 22 training courses were organized with 572 participants, including 263 farmers and 309 farm women.

Details of On and off campus Training Programmes

Clientele	No. of courses	Male	Female	Total participants
Farmers & farm women	22	263	309	572
Total	22	263	309	572

Front Line Demonstration: During the year, FLD programmes for oilseed, pulses, cereals, and vegetable crops, as well as CFLD for pulses and oilseeds, were implemented in 484 farmer fields totaling 97.4 ha.

Details of Front Line Demonstration

Enterprise	No. of Farmers	Area (ha)
Oilseeds	78	20
Pulses	252	60
Cereals	30	10
Vegetables	124	7.4
Total	484	97.4

OFT (On Farm Trials): Three on Farm Trails (OFTs) were conducted on 10 farmers field at adopted villages of KVK, Deoria for assessment of selected technologies on agriculture and allied field.

OFT 1: Problem definition: Lower income from banana as us usual planting method

Technology assessed or refined (as the case may be): High density planting of banana with double row system.

Glimpses of Activities in KVK, Kushinagar

Intercropping of lentil with sugarcane

Scientific visit at Wheat field

International Women's Day

CFLD in mustard

SCSP programme training

World Soil Day

Kisan Diwas Celebration

Honorable Agriculture Minister visit at KVK Kushinagar

Director IARI, visit at KVK Kushinagar

Performance of Frontline demonstrations conducted by KVK, Deoria

Crop	Thematic Area	Technology demonstrated	Variety	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase in yield	BCR (R/C)	
						Demo	Check		Demo	Check
Mustard	Varietal Evaluation	Introduction of HYV	Pusa Tarak	5	1	19.2	16.6	15.66	3.73	3.22
	Varietal Evaluation	Introduction of HYV	PM 30	5	1	18.8	16.6	13.25	3.65	3.22
	Varietal Evaluation	Introduction of HYV	RH 749	145	37.5	20.2	16.6	21.69	3.92	3.22
Pigonpea	Varietal Evaluation	Introduction of HYV	RA 1	33	12	18.61	14.74	26.25	3.15	2.5
	ICM	HYV+ ridge sowing	RA 1	22	6.4	18.9	14.89	26.93	3.2	2.5
Chickpea	Varietal Evaluation	Introduction of HYV	Pusa 547	3	0.1	19.47	16.1	20.93	2.41	1.99
	Varietal Evaluation	Introduction of HYV	GNG 2171	33	10.5	20.9	16.1	29.81	2.59	1.99
Lentil	Varietal Evaluation	Introduction of HYV	IPL 316	50	13	16.8	12.6	33.33	2.45	1.84

FLD on Other crops

Category & Crop	Thematic Area	Name of the technology	No. of Farmers	Area (ha)	Yield (q/ha)		% Change in Yield	BCR (R/C)	
					Demo	Check		Demo	Check
Paddy	Varietal Evaluvation	Introduction HYV (Pusa Sambha 1850)	5	1	43.6	35.7	22.12	2.21	1.93
Wheat	Varietal Evaluation	Introduction of HYV (HD 2967)	7	2	50.8	43.5	16.78	2.14	1.83
	ICM	Introduction of HYV (HD 2967)	25	10	51.3	43.5	19.93	2.16	1.83
Cowpea	Varietal Evaluation	Introduction of HYV Kashi Kanchan (Zaid 22)	26	2.2	124	103	20.39	1.55	1.28
Vegetable pea	Varietal Evaluation	Introduction of HYV Kashi Mukti (Rabi 2021-22)	30	1.56	98	88	18.07	2.67	2.26
	Varietal Evaluation	Introduction of HYV Pusa Pragati	6	0.15	94	83	13.25	2.57	2.26
Ridge gourd	Varietal Evaluation	Introduction of HYV Kashi Shivani (Zaid 22)	28	1.2	82	75	9.33	1.26	1.16
Okra	Varietal Evaluation	Introduction of HYV Kashi Kranti (Zaid 22)	24	2	135	105	28.57	1.6	1.25

Performance of High density planting of banana with double row system

Technology Option	No. of trials	Yield (qt./ha)	Increase in yield (%)	Net Return (Rs./ha)	B:C Ratio
Planting of banana at 1.8x1.8 m spacing (3086 plants/ha Farmers Practice)	5	738.6	18.92	654870.00	3.65
Doubled row planting at 1.5x1.5x 2.0 m spacing (3750 plants/ha Recommended Practice)		878.4		791580.00	4.01

Performance of HYV Mustard (Giriraj) with thinning @ 30 DAS + Application of Sulphur 20 kg/ha

Technology Option	No.of trials	Yield (qt./ha)	Increase in yield (%)	Net Return (Rs./ha)	B:C Ratio
Use of low yielding old variety	5	16.8	23.80	57830.00	3.22
HYV (Giriraj) + thinning @ 30 DAS + Sulphur 20 kg/ha		20.8		77540.00	3.81

ICAR-IIVR-KVK, Deoria in Uttar Pradesh conducted on-farm trial to refine the effect of high density planting on net return in bananas. The planting of banana as double row planting system of Doubled row planting at 1.5x1.5x 2.0 m spacing (3750 plants/ha) realized a net return of Rs. 7.91 lakh/ha as compared to the recommended practice with net returns of Rs. 6.54 lakh/ha (20.87% increase in net return per ha) with the BC ratio 4.01 and 3.65 respectively.

OFT 2: Problem definition: Lower income of mustard due to use of low yielding old variety with high plant density and no use of Sulphur 20 kg/ha.

Technology assessed or refined (as the case may be): High yielding variety Giriraj with low seed rate 4.0 kg /ha)

ICAR-IIVR-KVK, Deoria in Uttar Pradesh conducted an on-farm trial to **asses** the effect of high yielding variety Giriraj with low seed rate on net return in mustard. The sowing of HYV of mustard (Giriraj) with thinning @ 30 DAS + applying Sulphur 20 kg/ha as basal dose realized a net return of Rs. 77540.00/ha as compared to the recommended practice Rs. 57830.00/ha with 34.08% increase in net return per ha.

Extension Activities: Two hundred thirty two extension activities were held by the KVK, including advising services, diagnostic visits, Kisan Ghosthi, exhibitions, method demonstrations, and celebrations of important and special days. Thirty nine program were covered by in print/ electronic media.

Details of Extension Programmes by KVK, Deoria

Activities	No. of programs	No. of farmers	No. of Extension Personnel	Total
Advisory Services	41	274	6	321
Diagnostic visits	67	315	12	394
Field Day	02	47	6	55
Group discussions	05	189	7	201
Kisan Ghosthi	7	271	10	288
Film Show	09	223	8	240
Self -help groups	07	230	6	243
Kisan Mela	01	512	16	529
Exhibition	04	2300	15	2319
Scientists' visit to farmers field	71	292	6	369
Method Demonstrations	05	123	6	134
Celebration of important days	04	256	4	264
Special day celebration	02	59	6	67
Others (pl. specify)	7	78	5	90
Total	232	5169	113	5514

Production of Seed/Planting Material and Bio-Products by KVK, Deoria

A. SEED PRODUCTION

Enterprise	Name of crop	Name of Variety	Quantity (q)	Value (Rs)	Distributed to No. of farmers
Cereals	Paddy	Kala Namak	5.2	46800	70
	Grand Total		5.2	46800	70

B. PLANTING MATERIAL PRODUCTION

Enterprise	Name of crop	Quantity (No.)	Value (Rs)	Distributed to No. of farmers
Vegetables	Brinjal	6545	4303.5	122
	Chilli	6212	3382	105
	Tomato	6506	5008.3	130
	Cabbage	675	691	16
	Cauliflower	3432	2673.6	52
	Broccoli	800	640	17
	Cucumber	151	755	1
	Bottle gourd	801	4041	159
	Bitter gourd	575	2935	107
	Sponge gourd	938	4690	163
	Pumpkin	259	1295	69
	Others	537	1593	43
	Total	27431	32007.4	984
Fruits	Aonla	0		
	Litchi	2	120	1
	Papaya	111	2775	14
	Total	113	2895	15
Ornamental	Marigold	75	60	1
	Total	75	60	1
Medicinal & Aromatic	Others	27	270	7
	Total	27	270	7
	Grand Total	27646	35232.4	1007

Glimpses of Activities in KVK, Deoria

OFT on Performance of High density planting of banana with double row system

CFLD of Mustard var. 749

CLFD of Lentil var. IPL 316

CFLD of Chick Pea Var. GNG 2171

FLD of Pea Var. Kashi Mukti

Monitoring of FLD Wheat var. HD 2967 by DDG (AE), Dr. A.K. Singh

On Campus Training

Training of Rural Youth

Kisan Mela

KRISHI VIGYAN KENDRA, BHADOHI

Training Programmes: To help agricultural communities improve their knowledge in various subject areas, a total of 116 training courses were organized with 4027 participants, including 1751 farmers and 2306 farm women benefiting.

Frontline demonstrations:- During the year, FLD programmes for oilseed, pulses, cereals, and vegetable crops, as well as CFLD for pulses and oilseeds, were implemented in 680 farmer fields totaling 248.88 ha.

Details of On and off campus Training Programmes

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	100	1409	2191	3600
Rural youths	07	67	75	112
Extension functionaries	02	37	30	67
Sponsored Training	05	193	07	200
Vocational Training	02	45	03	48
Total	116	1751	2306	4027

Frontline demonstrations

Enterprise	No. of Farmers	Area (ha)	Units/Animals
Oilseeds	60	26	2
Pulses	139	43.225	4
Cereals	164	44.93	7
Vegetables	85	3.25	4
Other crops	-	-	-
Hybrid crops	-	-	-
Total	448	117.405	17
Livestock & Fisheries	133	14.07	889
Other enterprises	92	-	92
Total	232	131.475	981
Grand Total	680	248.88	908

Technology Assessment & Refinement

Category	No. of Technology Assessed & Refined	No. of Trials	No. of Farmers
Technology Assessed			
Crops	4	35	44
Livestock	2	20	20
Various enterprises	2	20	20
Total	8	75	84
Technology Refined			
Crops	-	-	-
Livestock	2	85 (429 Animal treated)	-
Various enterprises	-	-	-
Total	2	85	85
Grand Total	10	160	169

Extension Programmes

Category	No. of Programmes	Total Participants
Extension activities	826	8030
Other extension activities	9	1550
Total	835	9580

Seed & Planting Material Production

	Quintal/Number	Value Rs.
Seed (q)	15.21	58952
Planting material (No.)	13610.24	15041.50
Bio-Products (kg)	3.55	24440
Livestock Production (No.)	227	68100
Fishery production (No.)	0.35	6278

Mobile Advisory Services

Message Type	Type of Messages						
	Crop	Livestock	Weather	Marketing	Aware-ness	Other enterprise	Total
Text only	195	98	102	36	29	5	465
Voice only		84	700				784
Voice & Text both		65					65
Total Messages		247	802	36	29	5	1314
Total farmers Benefitted							91789

TECHNOLOGY ASSESSMENT AND REFINEMENT IN DETAIL

Value Addition In Sorghum

OFT 1: Problem definition: Farm women suffering from digestion problems and unaware about uses of sorghum in the diet.

Technology assessed or refined (as the case may be): Increase household consumption of and value addition in sorghum.

Sorghum, a nutrient rich crop has not yet as popular as maize or bajra. Due to its soothing effects, it supports digestive systems and is good for diabetic patients also. KVK, Bhadohi conducted an On-farm trial to increase household consumption of sorghum through value added products. On farm trial was conducted at 10 farm women's field. After completion of the OFT, post data was collected. Different technologies were provided and appreciated by farm women and their family members.

HORTICULTURE

OFT 2: Problem definition: Low yield of brinjal due to inappropriate selection of brinjal variety.

Technology assessed or refined (as the case may be): Evaluation of high yielding variety of brinjal.

Result: An OFT was conducted at five farmers field in brinjal for assess the higher yield. The brinjal variety Kashi Sandesh and local adopted by farmers was sown in month of July with full package and practices. At the time of harvesting yield was recorded 485.8 q/ha and net income was Rs. 632020/ha with cost benefit ratio was 7.54 while farmers practices variety yield was recorded 328.5 q/ha and net income was 404400 with cost benefit ratio was 5.58.

OFT 3: Problem definition: Low yield of Onion due to deficiency of Sulphar

Technology Assessed or Refined (as the case may be): Effect of Sulphar after application of 20Kg/ ha.

Results: An OFT was conducted at the field of 19 farmers in onion for assess the higher yield. The sulphar was applied at the time of field preparation before transplanting@20kg/ha with full package of practices. At the time of harvesting yield was recorded 182.6 q/ha as compared to check 156.4 q/ha, while B:C ratio was 4.30 as compare to check 3.77.

PEST AND DISEASES MANAGEMENT

OFT 4: Problem definition: Low yield in brinjal due to Phytoplasma

Technology assessed or refined (as the case may be): Management of little leaf in Brinjal

Value addition in Sorghum

Technology Option	No. of trials	Results
OFT-1: Increase household consumption of and value addition in Sorghum	10	In Bhadohi district, farm women did not include sorghum in their diet and did not do value addition in the sorghum. KVK, Bhadohi planned and conducted an On Farm Trial at 10 farm women's field. Different technologies were demonstrated at farm women's place. Farm women made different value added products. The technologies were very much appreciated by farm women and their family members.
OFT-2: Nutritional supplement for growing children(up to 6 years) : Sattu	10	In Bhadohi district, farm women did not include sattu as supplementary food in their growing children's diet. KVK, Bhadohi planned and conducted an On Farm Trial at 10 farm women's field. 10 malnourished children were selected on the basis of their height and weight according to their present age. OFT continued for 60 days. Pre test data: Weight (Average)= 11.38kg Height (Average)= 35.79" **After intervention** Post test data: Weight (Average)= 12.45kg Height (Average)= 38.12"

OFT 3- Performance of brinjal variety

Technology Option	No. of trials	Yield (t/ha)	Cost of Cultivation (Rs)	Gross income(Rs)	Net Income (Rs)	B:C Ratio
T_1 Pant Rituraj	5	328.5	88350	492750	404400	5.58
T_2 Kashi Shandesh		485.8	96680	728700	632020	7.54

OFT 4- Effect of Sulphar in Onion

Technology Option	No. of trials	Yield (t/ha)	Cost of Cultivation (Rs)	Gross income(Rs)	Net Income (Rs)	B:C Ratio
T_1 No use of Sulphar	19	156.4	82900	312800	229900	3.77
T_2 Use of Sulphar @20kg/ ha		182.6	84900	365200	280300	4.30

OFT 5- Effect of tetracycline and thiomethaxam in control of little leaf disease in Brinjal

Technology Option	No. of trials	Incidence of little leaf (%)	Yield (qt./ha)	% Increase in yield over farmer's practice
Farmer practice (No use of proper chemical)	5	32	218	-
Seed treatment with tetracycline @ 500 ppm for 20 minutes + spay of tetracycline @ 500 ppm + spray of thiomethoxam @ 1 gm/3 liter water		06	320	46.8

OFT 6- Effect of Emamectin benzoate in management of pod borer in pigeon pea

Technology Option	No. of trials	Pod damage (%)	Yield (qt./ ha)	% Increase in yield over farmer's practice
Farmer practice (Indicriminate use of insecticides for management of pod borer in Chick pea)	6	18	13.5	-
Use of NPV 250 LE/ha + use of bird perches + spraying of Emamectin benzoate @ 100 gm/ha		8	16	18.5

OFT 7- Live Stock Enterprises

Technology Option	Group	No. of trials	No of Animal	No. of Animal in Heat	% of Animal Conceived	Lactation Period (Days)	Net profit/ animal/day	Net Profit/ animal/ lact	Cost/ Benefit Ratio
Farmers Practices(No use of Mineral Mixture and derwormer in Schedule)	T1	10	10	2	0	240	Rs. 80/days	19200	2.16
Use of Mineral Mixture @50gm/day/animaland Dewormer	T2	9	10	7	70	300	Rs. 105/days	41500	

OFT 8- Technology assessed or refined

Technology Option	Group	No. of trials	No of Animal	% of twins birth	% of Singlet Kid	Profit/herd (100 goat)/year	Profit after use of Technology
Farmers Practices (No use of selective breeding)	T1	10	150	10	77	291000	114000
Use of quality male Goat for breeding in herd.	T2	11	678	42	52	405000	

Results: Brinjal (eggplant) is an important vegetable crop of Eastern Uttar Pradesh and high incidence of little leaf disease resulting in yield loss. Brinjal assessed with the Seed treatment with tetracycline @ 500 ppm for 20 minutes + spay of tetracycline @ 500 ppm + spray of thiomethoxam @ 1 gm/3 liter water reduced the percentage of disease incidence from 32 to 06 and yield was increased by 46.8%.

OFT-6: Problem definition: Low yield due to pod borer in infestation in Chick Pea

Technology assessed or refined (as the case may be): Management of pod borer in Chick Pea. Chick pea is an important pulse crop of Bhadohi, Uttar Pradesh and high infestation of pod borer resulting in yield loss. OFT on use of NPV 250 LE/ha + use of bird perches + spraying of Emamectin benzoate is being conducted along with farmers' practice.

LIVE STOCK ENTERPRISES

OFT- 7: Problem definition: High incidence of Anoestrus in dairy cattle resulting in lower productivity and profitability of dairying

Technology assessed or refined (as the case may be): Management of fertility in crossbreed cows in Bhadohi District.

KVK, Bhadohi conducted trial to find out suitable control measure for anoestrus and repeat breeding in dairy animal as nutrition supplementation and deworming play a vital role in the normal reproductive activity. The technology recommended was fine-tuned by including Mineral mixture @ 30-50gm/day/animal for 30 days before that proper deworming with broad spectrum anthelmentic were recommended for enhancement of availability of mineral mixture in body for normal reproduction cycle.

OFT- 8: Problem definition: Non-descript and local breed of Goat with low body weight kid and small kid size in Bhadohi District affect production and productivity.

Technology assessed or refined (as the case may be): Improvement of local breed of goat by selective breeding.

KVK, Bhadohi conducted trial to find out suitable method of breed improvement by selective breeding and providing technological inputs like schedule deworming and vaccination in the herd.

Glimpses of Activities in KVK, Bhadohi

Chickpea Field Day at Udaykaranpur

CFLD of Mustard var. 749

CLFD of Rajendra Arhar -1 at Bhaktapur

Vanraja Chick distribution under SCSP

Hon'ble MP, Sri Virendra Singh 'Mast' Participated in Hon'ble PM live stream on 17 Nov 2022

Kisan Samman day Gosthi on 23rd Dec 2022

SAC meeting chaired by Director IIVR

SHGs formation on food processing

Input distribution under NICRA Project


भा.कृ.अनु.प.- भारतीय सब्जी अनुसंधान संस्थान
ICAR-Indian Institute of Vegetable Research


भा.कृ.अनु.प.- भारतीय सब्जी अनुसंधान संस्थान
ICAR-Indian Institute of Vegetable Research

INSTITUTIONAL ACTIVITIES AND TRANSFER OF TECHNOLOGIES

Livelihood Security of Tribals under Scheduled Tribes Component (Earlier Tribal Sub Plan)

Demonstrations of different vegetable crops were conducted under Tribal Sub Plan (TSP) programme. Bottle gourd (Kashi Ganga) demonstrated in 23.33 acre yielded 3733.28 q. Brinjal (Kashi Sandesh) demonstrated in 41.66 acre yielded 11666.76 q. Carrot (Kashi Arun) demonstrated in 3.57 acre yielded 285.68 q. Chilli (Kashi Anmol) demonstrated in 78.12 acre which yielded 6250.00 q. Other vegetable crops like French bean (Kashi Rajhans), palak (All green), pea (Kashi Ageti), radish (Kashi Ardra), tomato (Kashi Aman) and seasonal kitchen garden packets were demonstrated for nutritional security of the tribal people. Apart from vegetables, oilseed crop like mustard (RH-749) was demonstrated in 66.66 acre yielded 640.00 quintal. Cereal crops like wheat (DBW-252) demonstrated in 166.66 acre and paddy (Improved sambha) was demonstrated in 274.07 acre area. For the welfare of the farming community 80 piece sprayer machine and 150 piece storage beans were distributed among the beneficiaries.

Livelihood Security of Scheduled Caste under Scheduled Castes Sub Plan (SCSP) Component

"Scheduled Castes Sub-Plan" has been implemented by ICAR-IIVR including its 3 KVKs among 2417 SC families from 35 villages in Varanasi, Mirzapur, Sonbhadra, Chandauli, Bhadohi, Deoria and Kushinagar districts of Uttar Pradesh with an objective to promote economic development through improved agricultural technologies. During 2022, scientists of the institute and SMS of KVKs regularly visited to their respective villages and arranged technical discussions with

Table: Demonstrations under TSP programme

S.N.	Crop	Variety	Seed (Kg)	Seed Rate (Kg/Acre)	Area (Acre)	Yield (q.)
1	Bottle gourd	K. Ganga	28	1.200	23.333	3733.28
2	Brinjal	K. Sandesh	5	0.120	41.667	11666.76
3	Carrot	K. Arun	10	2.800	3.571	285.68
4	Chilli	K. Anmol	12.5	0.160	78.125	6250
5	French bean	K. Rajhansh	50	30.000	1.667	133.36
6	Mustered	RH-749	100	1.500	66.667	640
7	Palak	All green	25	10.000	2.500	190
8	Pea	K. Ageti	1000	56.000	17.857	857
9	Radish	K. Adra	10	2.800	3.571	285.68
10	Tomato	K. Aman	12.5	0.100	125.000	25000
11	Wheat	DBW-252	8000	48.000	166.667	4000
12	Paddy	Improved Sample	3837	14.000	274.071	5455.109
13	Kitchen packets	Piece	200		17.482	

Demonstration of pea (Kashi Ageti)

Distribution of seed of wheat (DBW-252)

Demonstration of kitchen garden

farmers in which they have provided an elaborate knowledge about good agriculture practices for *Rabi*, *Kharif* and *Zaid* season crops. Field demonstrations were also organised to demonstrate the performance of improved vegetable varieties. During the year 2022 seeds of paddy (var. MTU 7029; 32.3 q), wheat (var. HD 2967 & Karan Vandana; 65 q), maize (var. PL 1008; 15.04 q), black gram (var. PU1; 4.16 q), gram (var. RVG 202; 5q), lentil (var. IPL 316; 3.7 q), pea (Azad Pea-3; 35 q), groundnut (var. GGG-32; 30.45 q), mustard (var. RH 749; 2.1 q), onion (0.6 q), Cowpea (var. Kashi Nidhi; 4.45 q), Okra (var. Kashi Kranti & Kashi Lalima; 2.63 q), Bottle gourd (var. Kashi Bahar, Kashi Ganga & Narendra Rashmi; 0.335 q), Bitter Gourd (var. Kashi Mayuri & Kashi Pratishtha; 0.155 q), Sponge gourd (var. Kashi Rakshita, Kashi Shreya & Kashi Jyoti; 0.37 q) and pumpkin (0.25 q) were distributed among farmers. Apart from seeds, agricultural implements like Knapsack sprayer (435), Plastic crates (424), plastic storage bins 120 kg & 50 kg capacity (568), Sickle (658), Spade (658) were also distributed to selected SC farmers. Seedlings of chilli and brinjal (5000), Kitchen garden packets (100), micronutrients (36.5 q) and NPK fertilizer (15 q) were also distributed among selected farmers. Training programmes on different aspects of agricultural/vegetable production/protection practices has been also organized.

भारतीय सब्जी अनुसंधान केंद्र में किसानों को मिला सब्जी का बीज

रोहनिया। आराजी लाइन विकासखंड क्षेत्र के शाहंशाहपुर स्थित भारतीय सब्जी अनुसंधान संस्थान में बुधवार को संस्थान के निदेशक डॉ टी.के. बेहेरा के दिशा निर्देश में अनुसूचित जाति उप योजना के अंतर्गत किसानों को जाड़े की मौसम में लगने वाली भिंडी, नैनुवा, करेला, लौकी, चौलाई, कुमहड़ा सहित 10 तरह की सब्जियों के मिनी पैकेट व वॉटर सॉल्युबल फर्टिलाइजर वितरण किया गया।कार्यक्रम में मुख्य रूप से डॉ राजेश कुमार, डॉ भुवनेश्वरी, डॉ ज्योति देवी, डॉ नकुल गुप्ता, डॉ विद्या सागर, अमरेश चंद्रशेखर इत्यादि लोग शामिल रहे।

भारतीय सब्जी अनुसंधान संस्थान, वाराणसी के वैज्ञानिकों द्वारा बीज का किया गया वितरण

स्वतंत्र प्रभात

सीखड़। मंगलवार को भारतीय सब्जी अनुसंधान संस्थान, वाराणसी के निदेशक डॉ. तुषार कान्ति बेहेरा के दिशा निर्देशन में अनुसूचित जाति उप योजना के अन्तर्गत ग्राम सभा गौरैया में मक्का का संकर बीज किस्म एन एस सी 1008पी, नेनुआ किस्म काशी श्रेया, काशी ज्योति, लौकी काशी गंगा व कुम्हणा किस्म काशी हरित के बीज का वितरण किया गया तथा संस्थान से आए वैज्ञानिकों द्वारा वितरण किए गए बीजों के उत्पादन तकनीकी के बारे में और रोग नियंत्रण के बारे में बखूबी रूप से जानकारी दिया। इस अवसर पर संस्थान के प्रधान वैज्ञानिक, डॉ त्रिभुवन चौबे, डॉ. राजेश कुमार सिंह, वरिष्ठ वैज्ञानिक डॉ. शैलेश कुमार तिवारी , डॉ. जयदीप हालदार, वैज्ञानिक राजीव कुमार, वाई पी-हु श्री सर्वेश मिश्र ग्राम पंचायत के प्रधान अश्वनी कुमार मिश्र उर्फ धनंजय, नागेन्द्र तिवारी सहित सैकड़ों किसान एवं ग्रामीण जनता उपस्थित रही।

Glimpses of distribution of seed, planting materials and farm equipments among SC farmers

ICAR- IIVR, Varanasi in NEH region for Promotion of Vegetable-based farming systems under NEH Component

Training

SN	Activity-training (topic)	Achievements	State	District	Village
1	Training cum input distribution programme	15 persons were trained and 55 percentage increase in potential productivity of component crops in project areas.	**Assam**	Karbi Anglong, Jorhat	Sarthe Tokbi, Hemlai, Selenghat
2	Improved Nursery techniques of vegetable crops. IDM in Vegetable crops. Importance of Soil health in vegetable production. Importance of soil health in vegetable production.	50 persons were trained and 55 percentage increase in potential productivity of component crops in project areas.	**Tripura**	Dhalai , Tripura West, Gomati, Kowhai, South Tripura	East Gandacherra Dumburnagar College of Agriculture, Tripura Dalakbazar, KVK Gomati, Prabin&Nabin Farmers' Club, Ramchandraghat BPACL, Bagma, Gomati
3	Training on promotion of winter vegetable cultivation and nursery management, Scientific cultivation of winter vegetables, Scientific cultivation of winter vegetables	Distribution, training and demonstration of organic cultivation of vegetable.	**Nagaland**	Wokha, Peren, Chumukedima Dimapur	Renthan ,Lotsu Beisumpuikam, Medziphema, Sucunoma, Molvam
4	Training cum awareness on organic cultivation of Okra var. Kashi Lalima, Organic cultivation of garden pea and demonstration, Training on Vermicomposting & Production technology	Improvement in knowledge & attitude of stakeholders. Improvement in knowledge & attitude of stakeholders. 96 persons were trained and 35 percentage increase in potential productivity of component crops in project areas.	**Sikkim**	West Sikkim, Gyalshing, Soreng District	Kabirthan, Barang, Okhrey, Upper Bhareng
5	Vegetable seed distribution cum farmers training.	Mrs. Indira Moyong, a farmer of Siluk village, Arunachal Pradesh earned ₹ 6,000/ from pumpkin harvested from 15 plants after 2 pickings. 45 % increase in potential productivity of component crops in project areas.Trainees made acquainted with line sowing of vegetable besides broadcasting method.	**Arunachal Pradesh**	Lower Dibang Valley, East Siang, Lohit	Desali, Hunli, Siluk Ledum, Tusa Gaon
6	Training cum vegetable seeds distribution. Awareness cum vegetable seeds distribution programme .Awareness cum Vegetable seeds distribution programme	54 persons were trained and 40 percentage increase in potential productivity of component crops in project areas.	**Manipur**	Chandel Ukhrul Pherzawl	Chakpikarong. Halang ,Pherzawl
7	Training cum input distribution programme	43 participants were benefitted from inputs and training programmes.	**Mizoram**	Serchhip	Thenzawl

Demonstration

S.NO	Activity-Demonstration (name)	Achievements	State	District	Village
1	On farm demonstration of Kashi Lalima	Farmers were first time exposed and demonstrated variety Kashi Lalima and many growers were attracted towards this variety for cultivation and produce were also sold out at premier price in comparison to local green bhendi.	Sikkim	West Sikkim	Barang
2	Garden pea var. Kashi Nandini demonstrated for earliness and higher yield.	Vegetable pea variety Kashi Nandini performed well than the other existing varieties with respect to days to first harvesting, quality green pod yield (65 q/ha) and also fetches higher returns.			Kyongsa

Input supplied

SN	Name of input	Achievements	State	District	Village
1	Vegetable Pea var Kashi Nandini,Kitchen garden packet, French bean var Rajhans, Pumpkin var Kashi Harit, Okra var Kashi Kranti , Ridge gourd var Kashi Khushi Cowpea var Kashi Nidhi Okra var Kashi Lalima Bitter gourd var BG-10 Cauliflower var Kashi Gobhi-25	Quality seed/planting materials were distributed for demonstration/ nutritional garden. Varieties performed well and farmers were by high yield and quality produce in addition to regular supply of fresh vegetables for their domestic purposes.	**Tripura**	Dhalai, West Tripura, Gomati	East Gandacherra, Dumburnagar Block, Boalkhali, Raisyabari Block Dalakbazar, KVK Gomati
2	Radish var Kashi Hans	105 beneficiaries were benefitted.	**Nagaland**	Wokha	Renthan ,Lotsu
				Peren	Beisumpuikam
				Chumukedima	Medziphema,
				Dimapur	Sucunoma, Molvam
3	Tomato var Kashi Adarsh ,Tomato var Kashi Vishesh, Cowpea var Kashi Nidhi , Carrot var Kashi Arun, Carrot var Kashi Krishn, Radish var Kashi Hans Palak var Allgreen Okra var Kashi Chaman Cauliflower var Kashi Gobhi-25, Chilli var Kashi Anmol, Bitter gourd var Kashi Pratishtha, Sponge gourd var Kashi Shreya, French bean var Kashi Rajhans, Satputia var Kashi Khushi, Pumpkin var Kashi Harit Sem var Kashi Khushal, Kitchen garden packets.	200 beneficiaries were benefitted for commercial cultivation as well as for their own nutritional security.	**Arunachal Pradesh**	Lower Dibang Valley, East Siang, Lohit	Desali, Hunli, Siluk Tusa Gaon,Ledum
4	Vegetable pea var Kashi Ageti, Palak var All green ,Tomato var Kashi Chayan ,Brinjal var Kashi Sandesh (H), Sem 207 ,Okra var Kashi Lalima, Chilli var Kashi Anmol, Ash gourd var Kashi Surabhi, Bottle gourd var Kashi Bahar (H) ,Bitter gourd var BG-10 ,Carrot var Kashi Krishna.	Quality seed /planting materials were distributed for demonstration/ nutritional garden. Varieties performed well and farmers were by high yield and quality produce in addition to regular supply of fresh vegetables for their domestic purposes.	**Manipur**	Chandel, Ukhrul, Chandel Pherzawl	Chakpikarong ,Halang, Chakpikarong, Pherzawl

Glimpses of various activities in NEH region







Organization of Kisan Mela and Veg-Expo 2022

ICAR-Indian Institute of Vegetable Research, Varanasi organized Kisan Mela and Veg-Expo 2022 on 08 January, 2022. The theme of the programme was 'Entrepreneurship development in Vegetable marketing and export for Schedule Caste and Schedule tribes stakeholders'. Around 1200 Schedule caste and Schedule tribes farmers from four district Varanasi, Mirzapur, Sonbhadra and Chandauli of Eastern Uttar Pradesh participated in the programme. The Kisan Mela and Veg-Expo was inaugurated by Dr. Panjab Singh, Ex-Secretary, DARE & DG (ICAR). Dr. Sanjay Kumar, Director, ICAR-IISS, Mau; Sh. C.B. Singh, AGM, APEDA, Varanasi; District Horticulture Officer, Varanasi and other dignitaries present during the occasion. Director of the Institute Dr. T.K. Behera discussed the farmers related scheme implemented by the Institute. Dr. Sanjay Kumar told the role of quality seed in increasing agricultural production and productivity. Sh. C.B. Singh during his address told that there is lot of opportunity of vegetable export from Varanasi region and during current year 2000 MT of agricultural produce exported from Varanasi region. Chief Guest, Dr. Panjab Singh emphasizes the importance of FPOs and creation of Seed hub in the region. Technical session on different aspect of agriculture like organic farming, techniques of quality seed production, integrated pest and disease management in vegetables, mushroom production, bee keeping, post-harvest management in vegetables etc. were organized during the occasion. Technologies and products have been displayed by various KVKs, FPOs, and private organizations. Institute publication 'Sabji Kiran' and extension bulletin 'Sabjiyo Me Madhumakhi Palan Se Mithas Bhi Aay Bhi' released during the occasion. Small implements like Dibbler, Wheel hoe, Corn Sheller etc. were also distributed to the farmers.




"National Youth Day" was celebrated

ICAR-Indian Institute of Vegetable Research, Varanasi celebrated "National Youth Day" on the birthday of Swami Vivekananda on 12th January, 2022. Dr. T.K. Behera, Director of the Institute informed that Government of India in the year 1984 first time announced to celebrate the birth anniversary of Swami Vivekananda, since then "National Youth Day" is celebrated all over the country on 12th January every year. All the scientists and employees of the Institute participated in the program and remembered Swami Vivekananda. During the programme, the Director and employees of the institute covered 5 km walk aimed at making life healthy by removing obesity, laziness, stress and anxiety.

Organization of Technology extension day

ICAR-Indian Institute of Vegetable Research, Varanasi and ZTMU organized Technology Extension Day for Brinjal, chilli, tomato, peas, beans, kidney beans and pumpkin on 18 January, 2022. Dr. T.K. Behera, Director and team of Institute Scientists discussed in detail with the representatives of seed companies about the improved varieties in vegetables, seed quality parameters and marketing. Director emphasized on public-private partnership for extension of technologies and improved varieties of vegetables to the farmers and beneficiaries. Dr. P.M. Singh discussed with the representatives of seed companies about characteristics of Institute developed vegetables varieties and hybrids and also about procedures for licensing. On this occasion, around 50 representatives from seed companies like- J.K. Agri Genetics Ltd., Namdhari Seeds, Ankur Seeds, Seed Works International Pvt. Ltd., Tierra Seed, East-West Seed, VNR. Seeds Pvt. Ltd., Nuziveedu Seeds, FTN Agro Pvt. Ltd., Mahyco Pvt. Ltd. and Trimurti Seeds Pvt. Ltd. participated in the event. The event showcased various improved varieties which were evaluated and selected by the representatives of the private sector as per the requirement of their company. A discussion was also organized between the representatives of seed companies and scientists of the institute in which the participants also emphasized on researching some other specific properties as per the demand of the market.

Celebration of National Girl Child Day

ICAR-Indian Institute of Vegetable Research, Varanasi has organized National Girl Child Day on 24th January, 2022 at Govt. Girls' Inter College, Jakhini, Varanasi, Uttar Pradesh

under the guidance of the Director of the institute. The girl students of class-XI were scintillated about the importance of vegetables which are rich sources of vitamins, minerals, dietary fibres and antioxidants as they are pivotal for the proper functioning of the human body. The scope of agriculture for higher studies and its entrepreneurship was also discussed. The students also enthusiastically interacted during the event. Kitchen garden seed packets comprising seeds of spinach, okra, bottle gourd, pumpkin, sponge gourd, cowpea etc. for summer season vegetables were also distributed among the students to promote inclusion of vegetable in their daily diets.

Organization of winter school on "Underexploited Vegetables: Unexplored treasure trove for Food, Nutritional and Economic Security"

ICAR-Indian Institute of Vegetable Research, Varanasi has organized 21 days winter school on "Underexploited Vegetables: Unexplored treasure trove for Food, Nutritional and Economic Security" during 2-22 February, 2022 at ICAR-IIVR, Varanasi. The main objective of the training programme was to focus on nutritional, medicinal and economical importance of underexploited vegetables. Apart nutritional and medicinal importance, the participants were also exposed on historical and spiritual importance, potential, genetic resources diversity, nutritional, phytochemical compositions, organic protocols, microgreens as smart nutria-rich healthy food, processing and value addition, ITKs, application of ICTs and suitability of these crops in small farming system, modern irrigation techniques, application of biotechnological & bioinformatics tools in systemic study of the underutilized vegetables. A total of 25 faculty/ scientist/SMS and other participants from across the country participated in the training programme. The Chief Guest for inaugural programme of the training was Dr. A.K. Singh, DDG (Horticultural Science), ICAR, New Delhi. Dr. Vikramaditya Pandey, ADG, ICAR, New Delhi and Dr. Ramesh Chand, Director, Institute of Agricultural Sciences, B.H.U. also grace the occasion as special Guests. Dr. T.K. Behera, Director, ICAR-IIVR during his welcome address emphasized on organizing such training programs keeping in view the importance of under-utilized vegetables. A series of lectures, practical sessions and field visit on various aspects Underexploited Vegetables included in the training programme. Presiding over the valedictory function Vice chancellor, Jannayak Chandrashekhar University, Ballia, Uttar Pradesh Prof. Kalplata Pandey emphasized to explore the unexploited potential of underutilized vegetables on various aspects like adoption to biotic and abiotic stresses, nutritional and therapeutic uses, climatic resilience and scaling up of these crops at commercial level. Training was concluded with distribution of certificate to the participants.

Celebration of 4th World Pulses Day

ICAR-Indian Institute of Vegetable Research, Varanasi Celebrated 4th World Pulses Day on 10th February, 2022. The World Pulses Day presents a unique opportunity to increase public awareness about pulses and to play a meaningful role in improved cultivation of pulses for better production, better nutrition, better environment and better life. The Chief Guest of the function was Dr. M.N. Singh, Professor, Institute of Agricultural Sciences, B.H.U., Varanasi. Welcoming the Chief Guest, Dr. T. K. Behera, Director, ICAR-IIVR told about the inclusion of pulses in the diet and its benefits. He also informed that research work is being carried out in the Institute on many pulse vegetables like peas, vegetable soybean, bakla, guar. The Chief Guest in his address said that India is the largest producer, importer and consumer of pulses in the world. Pulses are the only abundant source of protein in this country with a vegetarian diet and its cultivation increases crop diversity as well as soil fertility. Therefore, he emphasized on increasing the productivity of pulses through research. On this occasion, all the heads of Divisions, Scientists, officials, students and about 100 farmers were present.

International Women's Day Celebration

'International Women's Day' was celebrated at ICAR-Indian Institute of Vegetable Research, Varanasi on 8th March 2022. More than 50 women farmers from Araziline block along with all the scientist, SRF and young professional of the Institute attended the event. On this occasion, the Director of the Institute, Dr. T. K. Behera suggested to form SHGs and Farmer Producer Organizations for the empowerment of women, which will provide employment and livelihood to women through the use of technology in the globalized world. Under agricultural diversification, hybrid seed production of vegetables, mushroom production, bee keeping, pisciculture, dairy, adoption of post-harvest technology and value addition were encouraged, so that women could get employment, livelihood, food and nutritional security. At the end of the programme, women farmers were honored by giving them vegetable seeds and agricultural machinery.

MoU Signed with Ms. Holten King, Himachal Pradesh for Preparation of Green chilli powder

ICAR-Indian Institute of Vegetable Research, Varanasi has developed the technology for making green chili powder, whose patent is also in the name of Indian Vegetable Research Institute, Varanasi. So far, red chili powder is easily available in the market, while green chili powder is not available. Green chili powder can be stored safely for several months at room

temperature. Institute's Director, Dr. T. K. Behera discussed its quality standards and marketing with Mr. Yashoda Nand Gupta, representative of Ms. Holten King Company. Dr. Behera said that the Institute is promoting public-private partnership to take its advanced technologies to the beneficiaries. An agreement was signed on Tuesday, April 5, 2022, between ICAR-Indian Vegetable Research Institute, Varanasi and Una, Himachal Pradesh based company Ms. Holten King. As per the agreement, ICAR-Indian Institute of Vegetable Research, Varanasi will transfer the technology for making Green Chilli Powder to Ms. Holten King Company and Ms. Holten King Company will use this technology to make Green Chilli Powder and made available in the market.

Celebration of World Bee Day

World Bee Day was celebrated at ICAR-Indian Institute of Vegetable Research, Varanasi on 20th May, 2022. During the program, Dr. T.K. Behera, Director said that beekeeping is a low-cost profitable venture for increasing the productivity of agricultural and horticultural crops and increasing the income of farmers. Beekeeping provides honey, wax, pollen and royal jelly, alongwith increase in biological diversity of pollination in crops. Head of the Division, Crop Protection, Dr. K.K. Pandey told that honey has been accepted as medicine in Ayurveda and medical science. Honey is the main source of vitamins and mineral salts (calcium, magnesium, potassium). Honey also makes the human immune system effective and powerful. Speaking on the occasion, Dr. Pratap Diwekar, Scientist informed that Rs 1,000 can be obtained from one beehive, thus farmers can double their income by adopting beekeeping along with farming. On this occasion, all the heads of Divisions, Scientists, students and about 20 farmers were present.

8th International Day of Yoga celebrated

8th International Day of Yoga was celebrated at ICAR-IIVR, Varanasi on 21 June 2022 with theme "Yoga for humanity". All the employees including scientists, technical, administration and supporting staff of the Institute had participated in this event. Director had emphasized the importance of yoga in daily life and research activities. He also suggested follow the yoga on regular basis.

Okra variety Kashi Chaman fetched bumper yield at farmer's field

Okra variety Kashi Chaman has been developed at ICAR-Indian Institute of Vegetable Research, Varanasi in the year 2019 which can be cultivated in both summer and rainy season. This variety is tolerant to Yellow Vain Mosaic Virus (YVMV)

and Okra Enation Leaf Curl Virus (OELCV) diseases which are the most dangerous diseases for okra crop and a major problem in okra cultivation. The yield potential of this variety is 21.66% more in its sector. Due to it's yield potential this variety is becoming popular in Uttar Pradesh, Bihar, Odisha and has already covered around 10 thousand ha area at farmer's field and one of them is Shri. Upendra Singh Patel from Bangalipur village, Araziline block, Varanasi.

Shri Patel had sown seeds of okra variety Kashi Chaman in 10 biswa (0.3 acre) land and followed scientific package of practices for okra production and used recommended fertilizers and chemicals as suggested by the scientists. First flush of okra fruit was harvested 46 days after sowing. After that he had taken regular harvest of 35 to 40 kg okra in 3 to 4 days interval and had taken 19 harvests up to last week of October with total yield 668 kg in 90 days duration form 0.3 acre of land with net profit of Rs. 21,376/- after deducting cost of cultivation and transportation cost to the market.

Teacher's Day and Rajbhasha Workshop "Azadi ka Amrit Mahotsav and Rajbhasha" organized

ICAR-Indian Institute of Vegetable Research, Varanasi has organized Teacher's Day and Rajbhasha Workshop "Azadi ka Amrit Mahotsav and Rajbhasha" on 05th September, 2022. Dr. T. K. Behera, Director of the Institute had informed that for promotion of Rajbhasha, vegetable research results has been published in Hindi and farmers have been trained in Hindi to increase the country's agricultural production. Chief guest Acharya Dr. Rachna Sharma, Government Women's College, B.L.W., Varanasi, told the importance and role of Rajbhasha poets, playwrights, essayists and journalists in getting freedom. She also mentioned the contribution of Mr. Pratap Narayan Mishra, Mr. Balamukund Gupta, Mr. Maithilisharan Gupta, Mr. Bhartendu Harishchandra, Mr. Mahavir Prasad Dwivedi, Mr. Makhan Lal Chaturvedi, Mrs. Subhadra Kumari Chauhan, Mr. Jaishankar Prasad and Mr. Suryakant Tripathi 'Nirala' in achieving the country's independence. When Mr. Mohandas Karamchand Gandhi came to India from Africa and started the Champaran movement, at that time he felt that Hindi could be the language of communication with people across the country. On the occasion of Teacher's Day, she also emphasized there is a need to pay more attention towards quality teaching, research analysis and writing.

Visit of Additional Secretary, Ministry of Agriculture and Farmers Welfare, Government of India and Farmer-Scientist interface

A Farmer-Scientist interface was organized on 22nd September, 2022 at ICAR-Indian Institute of Vegetable Research, Varanasi in the august presence of Dr. Abhilaksh Likhi, Additional Secretary, Ministry of Agriculture and Welfare, Government of India. Dr. T.K. Behera, Director welcomed the Guest and appraised about the research activities being carried out in the Institute. While visiting the research field of the Institute, the Dr. Likhi discussed with the farmers related to agriculture production and marketing and also emphasized the importance of soil quality and drip irrigation. Dr. Likhi mainly emphasized on giving special attention to mushroom production, cherry tomato, babycorn and beekeeping and advised the Institute to make projects in these areas. Apart from this, the Chief Guest called upon Institutions to provide technical assistance and bring FPOs into the mainstream to promote agri startups. Some farmers also shared their experiences on vegetable production on this occasion. During the discussion, Joint Secretary, Ministry of Agriculture and Welfare, Government of India; Shri Priya Ranjan, Commissioner Horticulture, Government of India; Dr. Prabhat Kumar and Tarannum Kadarbhai, Liaison Officer Indo-Dutch COEs expressed their views. All the Heads of Divisions, Scientists, progressive farmers, FPOs and officials from agriculture department were present during Farmer-Scientist interface.

ICAR-Indian Institute of Vegetable Research, Varanasi Celebrated 32nd Foundation Day

ICAR-Indian Institute of Vegetable Research, Varanasi celebrated its 32nd Foundation Day on 28 September, 2022. The programme was presided over by Prof. Gautam Kalloo, former Vice- Chancellor, JNKVV, Jabalpur and former DDG (Crop and Horticulture Science). In his presidential address, he appreciated the work of scientists at Institute and advised on the use of new technologies like gene editing, drones, artificial intelligence and geotagging. The Chief Guest of the program Dr. A.K. Singh, DDG (Horticulture Science), ICAR, New Delhi talked about promoting natural and organic farming. He called upon to develop export and quality oriented varieties of vegetables for earning foreign exchange alongwith nutritional security. Special Guest Dr. Major Singh, Member, A.S.R.B., New Delhi said that maximum number of FPOs should be formed in this area and exposure visits of the farmers should be made in states like Maharashtra to see their marketing system for profit maximization. On this occasion, former Directors of the Institute, Dr. Mathura Rai and Dr. P.S. Naik shared his experience and appreciated the work being done by the Institute. Earlier, Dr. T.K. Behera, Director, ICAR-IIVR, while welcoming the Guests, told about the research and development work being done in the institute. He explained the benefits to the farmers through extension programs like Farmer's First and SCSP scheme. On this occasion 'Sabji Kiran' and 'Sabji Hindi Shabd Kosh' published by the Institute were released. For outstanding work at Institute Dr. Rajesh Kumar in scientific category, Mr. Roshan Lal in administrative category, Mr. Madan Lal Vishwakarma in technical category, Mr. Motilal Kushwaha in Krishi Vigyan Kendra and Mr. Shivaji Mishra in supporting category were awarded with certificates. Directors of other ICAR Institutes Dr. Sanjay Kumar and Dr. Alok Srivastava were also present on the occasion. The programme was attended by all scientists, technical staff, officers, retired members, and representatives from the media in institute's auditorium.

Organized 26th meeting of ICAR Regional Committee-IV

The 26th meeting of ICAR Regional Committee IV was held on 07 November 2022 at the ICAR-Indian Institute of Vegetable Research, Varanasi. The meeting was attended by Shri. Surya Pratap Shahi, Hon'ble Minister for Agriculture, Agricultural Education and Research, Govt. of U.P.; Shri. Dinesh Pratap Singh, Hon'ble Minister of Horticulture, Agricultural Marketing, Agricultural Foreign Trade and Agricultural Export, Govt. of U.P.; Shri. Baldev Singh Aulakh, Hon'ble Minister of State for Agriculture, Agricultural Education and Research, Govt. of U.P.; Shri. Dharmpal Singh, Hon'ble Minister of Animal Husbandry and Dairy Development, Govt. of U.P.; Dr. Himanshu Pathak, Secretary, DARE and DG, ICAR, New Delhi; Shri. Manoj Kumar Singh, Additional Secretary (Rural Development and Panchayati Raj) and Agriculture Production Commissioner, Govt. of U.P.; Vice-Chancellors of various Agricultural Universities of Bihar, Jharkhand and Uttar Pradesh and various officers related to the fields of Agriculture, Animal Husbandry, Fisheries from Bihar, Jharkhand and Uttar Pradesh. Secretary, DARE and DG, ICAR, New Delhi presented the status and progress of agriculture and allied sectors in the states of Uttar Pradesh, Bihar and Jharkhand. In this meeting, a detailed discussion was held about the problems related to agriculture, animal husbandry, fisheries and their solutions in the states of Bihar, Jharkhand and Uttar Pradesh. During the occasion, institute publications were also released by the dignitaries. The 26th meeting of ICAR RC IV concluded with the vote of thanks proposed by Dr. P.K. Agrawal, ADG (TC), ICAR, New Delhi.

Organized Kisan Pathshala

A one-day Kisan Pathshala was organized by the Indian Institute of Vegetable Research, Varanasi on 09 December 2022, for doubling the income of chilli farmers through awareness and training program. Training program was organized at chilli field of the institute to increase the income of farmers through chilli production and protection techniques. About 250 farmers from villages around Varanasi district participated in this programme. On this occasion various topics like diversification through chilli, organic farming, value addition, selection of improved species, pest, disease, virus management were discussed so that the income could be increased by reducing the cost of chilli cultivation. Dr. T.K. Behera, Director gave various information to the farmers about the benefits of using improved varieties and ensuring good quality seed. The coordinator of the program Dr. Rajesh Kumar provided detailed information about the species and special qualities of different types of chilli planted on the chilli field. Suggestions were also given by the scientist to the farmers to

deal with the problem of black thrips. The farmers involved in the Pathshala expressed their happiness on getting detailed information about the advanced cultivation of chillies and also expressed their desire to organize more such programs in future.

Organized AICRP (Vegetable Crops) Golden Jubilee National Symposium on New Opportunities in Vegetable Production for Sustainable Development

ICAR-IIVR, Varanasi organized three days AICRP (Vegetable Crops) Golden Jubilee National Symposium on New Opportunities in Vegetable Production for Sustainable Development during 20-22 December, 2022. The Symposium was inaugurated by Chief Guest Shri. Surya Pratap Shahi, Hon'ble Minister for Agriculture, Agricultural Education and Research, Govt. of U.P.

In his address, He explained the importance of vegetables and fruits in the country's food and nutritional security. Moving towards self-sufficiency in the production of vegetables, worth Rs 11 thousand crore of vegetables were exported during 2021-22. He suggested for research to solve the problem of such farmers whose crops get damaged due to pests and diseases before the completion of the crop period. The Special guest, Dr. Panjab Singh, Ex-Secretary, DARE & DG (ICAR) said that our country is second with 342 million tonnes of Horticulture production, in which 60 percent share is of vegetables. He called upon the farmers to double their income by including vegetables in their crop cycle. Dr. A.K. Singh, DDG (Horticulture), ICAR, New Delhi while welcoming the participants appreciated the Indian Institute of Vegetable Research for their role in increasing vegetable production in the country. He informed that in the last 50 years, more than 500 varieties and more than 400 technologies related to vegetable production have been developed under All India Coordinated Research Project (Vegetable Crops). Scientists associated with All India Coordinated Research Project (Vegetable Crops) Dr. Kirti Singh, Dr. Vishnu Swaroop and Dr. G. Kalloo were honoured on this occasion. The Director of the Institute, Dr. T. K. Behera, while thanking the dignitaries and participants, assured to do research according to the needs of the farmers. More than 200 scientists, students from different ICAR Institutes, State Agricultural Universities, private companies and more than 300 farmers participated in the event. Some of the major recommendations that emerged from the Symposium were- Development of climate smart horticulture methods using IOT, AI, drone technology etc., development of high temperature tolerant varieties, development of technologies for remote areas, impact assessment of developed technologies, development of state wise/vegetable wise maps, integrated pest management based on agro-ecosystem analysis, development and promotion of plant based pesticides, strengthening of post-harvest management, etc. There were broadly seven inter-linked thematic areas - 1. Reaching the marginalized farmers and their growth through vegetable-based diversified agriculture 2. Contributions of AICRP-VC in sustainable vegetable development 3. Innovative techniques for vegetable breeding 4. Plant health management 5. Vegetable production system, Value addition and Export promotions 6. Quality seeds and planting materials and Protection of plant varieties & Farmers' rights 7. Extension, technology diffusion and Public-private partnership.

AWARDS, HONOURS AND RECOGNITIONS

Awards

- CHAI Achievers Award-2022 conferred on Dr. Tusar Kanti Behera by Confederation of Horticulture Association of India (CHAI) at CSAUA&T, Kanpur, Uttar Pradesh on 28th May, 2022.
- 2nd Best oral presentation award conferred on Shailesh K Tiwari in 2nd Indian Horticulture Summit -2022 by Society for Horticulture Research and Development at Navsari Agricultural University, Navsari, Gujarat on 29 April 2022.
- Best oral presentation award conferred on Yerasu Suresh Reddy on "Pyramiding of late blight and ToLCV resistance genes in tomato for augmenting the productivity in tomato" in the technical session 'Conservation and improvement of plant genetic resources' of National Symposium on "Self-Reliant Coastal Agriculture" during 11-13 May, 2022 organized by ICAR-Central Coastal Agricultural Research Institute (CCARI), Old Goa, Goa.
- Best poster award conferred on Karkute SG, Mukhtar M, Yadav A, Sevanthi AM, Gaikwad K, Solanke AU on "The von Willebrand factor domain A containing gene vWA36 confers blast resistance in rice" in International Symposium on Advances in Plant Biotechnology and Nutritional Security at NASC complex, New Delhi during 28-30 April 2022.
- Best Poster Award conferred on Nakul Gupta, P M Singh, Rajesh Kumar, Jyoti Devi, Vidya Sagar, Vikas Singh, B K Singh, T Chaubey, Chandra Shekhar and T K Behera on "Role of Zeolite beads in maintaining the physio-biochemical seed quality of vegetable soybean, moringa and carrot during storage" in the AICRP (VC) Golden Jubilee National Symposium during 20-22 December, 2022.
- Best Poster Award conferred on P. Karmakar in the AICRP (VC) Golden Jubilee National Symposium during 20-22 December, 2022.
- Best Poster Award conferred on Rakesh K Dubey, J.Devi, R.K.Singh and M.K.Singh on paper "Aquatic Vegetables for Food, Nutritional Security and Sustainable Development" in the AICRP (VC) Golden Jubilee National Symposium during 20-22 December, 2022.
- Best poster presentation award conffered on Sangeeta, Krishna R, Karkute SG, Krishnan N, Singh AK on Complexity of begomoviruses and beta satellite populations associated with tomato leaf curl disease in western India in AICRP (VC) Golden Jubilee National Symposium on New Opportunities in Vegetable Production for Sustainable Development during December 20-22, 2022 at ICAR-IIVR, Varanasi.
- Best poster presentation award conferred on T Chaubey, Vidya Sagar, R K Singh, C S Chanotiya, S Pandey, Priyanshu Singh, R K Dubey, Pradip Karmakar, D P Singh, P M Singh and T K Behera on Novel volatile compounds and single recessive gene govern aroma in sponge gourd (Luffa cylindrica L. Roem) in AICRP (Vegetable Crops) Golden Jubilee National Symposium (2022) organized by AICRP-VC at ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi, U.P., India, 20 - 22 December, 2022.
- Diamond Achievers Award conferred on Dr. S.N.S. Chaurasia on 11 September 2022.
- Dr. Harbhajan Singh Memorial Award-2022 conferred on Dr. Pradip Karmakar by ISVS, Varanasi, Uttar Pradesh (India).
- Dr. Jaydeep Halder awarded "Best Oral Presentation" for the research paper on "Ecofriendly options to okra shoot and fruit borer (*Earias vittella* F.) control and their economic analysis" in the National E-Conference on Biotic Stress Management Strategies for Achieving Sustainable Crop Production & Climate Change held at ICAR-National Research Centre of Integrated Pest Management, New Delhi, India during 19-21 May, 2022.
- Dr. Jaydeep Halder awarded "Meritorious Scientist Award" from the Society of Plant Protection Sciences (SPPS), ICAR-National Research Centre for Integrated Pest Management, New Delhi, India during May, 2022 for significant contribution in Entomology.
- Dr. Vijaya Rani was conferred "Dr. M. S. Swaminathan Award" for Outstanding Doctoral Research in Agriculture and Allied Science 2021 under the Natural Resource Management & Agricultural Engineering category on 22-24th August 2022 at the International Conference on "Advances in Agriculture and Food system towards Sustainable Development Goals (AAFS- 2022)" at University of Agricultural Sciences, Bangalore.
- Fellow of SHRD-2020 conffered on Dr. Tribhuvan Chaubey by Society for Horticulture Research and Development, Ghaziabad (UP) for outstanding contribution in the field of Vegetable Science.

- First prize for exhibition and demonstration stall of ICAR-IIVR technologies in the Farmer's fair of ICAR-Indian Institute of Seed Science, Mau on 15th March 2022displayed by Dr Shubhadeep Roy.
- Mahima Young Scientist Award conferred on Dr. Rajeev Kumar in 2022.
- Outlook Swaraj Outstanding Scientist Award-2022 conferred on Dr. Pradip Karmkar by ISHRD, Uttarakhand (India).
- Outstanding Horticulture Scientist Award- 2021 conferred to Dr. Shailesh K Tiwari on 27th April, 2022 by Society for Horticulture Research and Development, Ghaziabad (UP).
- Young Scientist Award conferred on Dr. S.G. Karkute for outstanding contribution in the field of Biotechnology by Agro Environmental Development Society (AEDS), Rampur, Uttar Pradesh (India) on 30th October 2022.

Honours & Recognitions

- Fellow of CHAI conferred on Dr. Tusar Kanti Behera by Confederation of Horticulture Association of India (CHAI) at CSAUA&T, Kanpur, Uttar Pradesh on 28th May, 2022.
- Dr. P.M. Singh was conferred fellowship of Indian Society of Vegetable Science-2021.
- IAHS Fellowship-2022 conffered on Dr. Jagesh Kumar Tiwari by Indian Acedemy of Horticultural Sciences, New Delhi (India) for outstanding contribution in the field of Vegetable Science.
- Dr. Jaydeep Halder became "Fellow of Royal Entomological Society" (FRES) for the significant contribution in the field of entomology by the Royal Entomological Society, United Kingdom during October, 2022.
- Dr. Nagendran K became Fellow of the Indian Society of Vegetable Science in 2021.
- National Acedemy of Biological Sciences (NABS) Associate Fellowship -2019 conffered to Dr. Jagesh Kumar Tiwari by National Acedemy of Biological Sciences (NABS) Chennai (India) on 25th January 2023 for outstanding contribution in the field of Vegetable Science.
- National Acedemy of Biological Sciences (NABS) Fellowship-2019 conffered on Dr. RK Singh by National Acedemy of Biological Sciences (NABS), Chennai (India) on 25th January 2023 for outstanding contribution in the field of Vegetable Science.
- Dr Swati Sharma acted as Member of Judging Committee for Flower, foliage, bonsai and vegetable entries in Pt. Madan Mohan Malaviya Memorial Flower Showheld at Malaviya Bhavan, BHU, Varanasi on 25 Dec 2022.
- Dr. Anant Bahadur gave invited talk on "Abiotic stress management in vegetables through grafting technology" in 2nd Indian Horticulture Summit: Horticulture for prosperity and health security at NavsariAgril. University, Navsari Gujarat held during 27-29 April, 2022.
- Dr. Hare Krishna was inducted as the Fellow of the Indian Society for Arid Horticulture in 2022.
- Dr. Hare Krishna was nominated to the Editorial Board of Indian Journal of Horticulture in 2022.
- Dr. Jagesh Kumar Tiwari recognized as Editor, Vegetable Science, and Editorial board member of Crop Design (Elsevier), Frontiers in Plant Science and Frontiers in Horticulture.
- Dr. Rakesh K Dubey recognized as Editorial board member of International Journal of Bio-resource and Stress Management (IJBSM). and journal of Natural Resources and Development.
- Dr. S.N.S. Chaurasia was invited as Chairman, Judging Committee for Flower, foliage, bonsai and vegetable entries in Pt. Maha Mana Madan Mohan Malaviya Memorial Flower Show held at Malaviya Bhavan, BHU, Varanasi on 25-12-2022.
- Dr. Shailesh K Tiwari nominated as Member of Institute Technology Management Unit of ICAR-Central Institute of Subtropical Horticulture, Lucknow.
- Dr. Swati Sharma served as editorial board member for journal Trends in Horticulture, United States in 2022.
- Dr. Vikas Singh recognized as Editorial board member, Integral Krishi Darpan, Integral University, Lucknow.

Registration of Unique Germplasm

- VRCAR-252 (INGR22088, black carrot): A petaloid-CMS line of black carrot with better combining ability and heterotic potential has been registered as Unique Germplasm by the PGRC, ICAR-NBPGR, New Delhi on 8th July 2022.
- VRCAR-214 (INGR22160): A petaliod-CMS line of red carrot with better combining ability, heterotic potential and lycopene content has been registered as Unique Germplasm by the PGRC, ICAR-NBPGR, New Delhi on 8th December 2022.

HUMAN RESOURCE DEVELOPMENT

Training and Capacity Building

Training

Name of IIVR Scientists/KVKs SMS	Title of training	Duration	Held at
Shailesh K Tiwari	Intellectual Property Awareness program for staff of ICAR-IIVR, Varanasi	17 January, 2022	ICAR-IIVR, Varanasi
	Intellectual Property Awareness program for staff of ICAR-IIVR, Varanasi	05 August, 2022	ICAR-IIVR, Varanasi
Bhuvaneswari S	Intellectual property awareness/training program	17 January, 2022	Intellectual property office, India (virtual mode)
	Data visualization using R	9-11 March, 2022	NAARM, Hyderabad (virtual mode)
Swati Sharma	Underexploited vegetables: Unexplored treasure trove for food, nutritional and economic security	02-22 February, 2022	IIVR, Varanasi
Yerasu Suresh Reddy	Prediction of Non-Coding RNA	16-18 February, 2022	ICAR-IASRI, New Delhi (virtual mode)
Rakesh K Dubey	Online Collaborative Training Programme on Capacity Building on Labour Laws and Migration	13-17September, 2022	V.V. Giri National Labour Institute, NOIDA & National Institute of Agricultural Extension Management (MANAGE), Hyderabad.
Shubhadeep Roy	Gender Responsive Plant Breeding and Seed Systems in South Asia (Part-1)	12-17 September, 2022	ICRISAT, Hyderabad
	Gender Responsive Plant Breeding and Seed Systems in South Asia (Part-2: Social Science Module)	26-30 September, 2022	Virtual

Training and Skill Development of Farmers and Field Functionaries conducted

Sl. No.	Name of training programme	Date	Sponsored by	No. & Nature of participants
1.	Organic Vegetables Farming and Management	04-07 January, 2022	ATMA, Sheikhpura	20 Farmers
2.	Organic Vegetables Farming and Management	04-07 January, 2022	ATMA, Rohtara	22 Farmers
3.	Intellectual Property Awareness program for staff of ICAR-IIVR, Varanasi	17 January, 2022	Intellectual Property Office India	50
4.	Improved Vegetable cultivation and management	15-19 February, 2022	ATMA, Madhubani	22 Farmers
5.	Vegetables Cultivation Techniques	03-08 March, 2022	ATMA, Muzaffarpur	33 Farmers
6.	Orientation training programme on Agri export marketing for cooperatives and FPOs	01-04 June, 2022	VAMNICOM, Pune	37 FPO personel
7.	Vegetable cultivation for livelihood and nutritional security	06-10 June, 2022	ATMA, Dhanbad, Bihar	50 Farmers
8.	Advancement in vegetable producation	21 June, 2022	ISARC-APQAT	47 Farmers

9.	Improved vegetable production	21-24 June, 2022	Mobile Agricultural School and Services (MASS), Jharkhand	50 Farmers
10.	Improved vegetable production	05-08 July, 2022	DDA, Fatehpur	50 Farmers
11.	Molecular Breeding and Protected Cultivation of Vegetable Crops	11-16 July, 2022	NAHEP and CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur	10 (Ten) PG students. Exposure-cum- training of PG students for Six Days
12.	Course Coodinator: "Molecular Breeding and Protected Cultuvation of Vegetable Crops"	11-16th July, 2022	ICAR-NAHEP sponsored Centre for Advanced Agricultural Science & Technology on Protected Agriculture and Natural Farming (CAAST-PANF)	PG Students
13.	Intellectual Property Awareness program for staff of ICAR-IIVR, Varanasi	05 August, 2022	Intellectual Property Office , India	50
14.	Improved cultivation of vegetables	02 September, 2022	DISE, Pratapgarh	32 Officials
15.	Vegetables Cultivation Techniques	02 September, 2022	DISE, Maharajganj	32 Farmers/ Rural Youth
16.	Advanced production technology in vegetables	14-15 September, 2022	Omkar SewaSansthan, Amethi, UP	46 Farmers/ Rural Youth
17.	Vegetables Cultivation Techniques	23 September, 2022	IRRI	12 Farmers
18.	Improved vegetable production technologies	26-30 September, 2022	ATMA, Gaya, Bihar	22 Farmers
19.	Vegetables Cultivation Techniques	27 September, 2022	Actech Deformation	23 Farmers
20.	Scientific vegetable production technologies	22-26 November, 2022	ATMA, Madhepura, Bihar	25 Farmers
21.	Scientific vegetable production technologies	28-30 November, 2022	ATMA, Kishanganj, Bihar	21 Farmers
22.	Awareness cum training programme on doubling of Farmers' income through Advanced Production & Protection Technologies of Chilli as Kisan Pathsala	09 December, 2022	ICAR-IIVR,Varanasi	50 Farmers
23.	Improved vegetable production technologies	12-14 December, 2022	ATMA, Arwal, Bihar	15 Farmers
24.	Prasanskrit padarth ki technology, branding, bikri taknik, utpad hetu kachche maal ka chayan, prakar evam bajaar ki shamta	13-15 December, 2022	PMFME, Rajkiya Khadya Vigyan Prashikshan Kendra	30 entrepreneurs

Training and Skill Development of ICAR/SAUs/State/KVKs Officials conducted

Name of the Programme	Date	Sponsored by	No. & Nature of Participants
21 days Winter School (ICAR)	02-22 February, 2022	ICAR, New Delhi	25 Faculties/ Scientist/ SMS KVKs
Capacity building of the Agriculture Development Officers of Assam on vegetable based farming system	07 April, 2022	IRRI South Asia Regional Centre (ISARC), Varanasi	24 Officers
IP awareness training programme under National Intellectual Property Awareness Mission	17 January, 2022	ICAR-IIVR, Varanasi and Indian Patent Office, New Delhi	-

Seminar/symposium/conference/workshop attended

Name of Scientist	Title of seminar/ symposium/ conference/ workshop	Duration	Held at
All the Scientists of IIVR	AICRP (VC) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development	20-22 December, 2022	ICAR-IIVR, Varanasi
T.K. Behera	Attended the Scientist Leader Convention organized by CSIR-NBRI, Lucknow	26-27th March, 2022	CSIR-IICT, Hyderabad
	Attended the RKVY- SLSC meeting under the chairmanship of Chief Secretary, Govt. of Uttar Pradesh in virtual mode	29th April, 2022	IISR, Lucknow
	Participated 'Regional Conference on Prioritization of Crop-Specific Technologies for Sustainable Profitability. Presented Key Note Address on the topic "Prioritizing Horticultural Crops Technologies for Sustainable Profitability in the State of Uttar Pradesh" in the Theme 4: Horticultural & Other Cash Crops Session.	30th April, 2022	IISR, Lucknow
	Participated and presented Key Note Address as speaker in the National Symposium on Self-reliant costal Agriculture	11-12th May, 2022	ICAR-CCARI, Goa
	Participated in the National Conference on Climate Resilient and Sustainable Development of Horticulture and Co-chaired the Technical Session-4 "Innovations in Production System Management for Vegetables, Tubers, Spices and Flowers for Climate Resilience and Sustainability" and presented keynote address on Biotechnological Approaches for Climate Resilient Vegetable Crops Development.	28-29th May, 2022	CSAUA&T, Kanpur
	Participated in the Review Meeting of IIVR & IIHR under the chairmanship by Hon'ble Agriculture Minister and presented the Institute Achievement	07th June, 2022	New Delhi
	Organized XXXX Annual Group Meeting of AICRP on Vegetable Crops in Hybrid Mode.	15-17th June, 2022	ICAR-IIVR, Varanasi
	Participated meeting discussed and finalized "Road Map for Agriculture and Allied Sector in Uttar Pradesh"	24th June, 2022	Yojna Bhawan, Lucknow
	Attended Selection Committee meeting for selection of the posts of Deans/Directors of different disciplines at Dr. YS Parmar University of Horti. & Forestry, Solan as Member of the Selection Committee	25th July, 2022	YSPUH&F, Solan
	Organized Review Meeting of CRP on Agro biodiversity for Vegetable Crops as Chairman	08th August, 2022	ICAR-IIVR, Varanasi
	Participated and Delivered an Expert Talk on "Current Status of Vegetable seed Industry in India" in the National Training on "Quality Seed Production of Vegetables"	14th November, 2022	NSRTC, Varanasi
	Visited the tribal village and conducted Kisan Gosthi & distributed vegetable kitchen garden packets of IIVR	15th November, 2022	ICAR RCER Research Centre Ranchi
	Organized as convener Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development"	12-14th Dec., 2022	ICAR-IIVR, Varanasi
	Participated in the 84th Scientific Advisory Committee Meeting of the NHRDF under the chairmanship of Dr. A. K. Singh, Dy. Director General (Horticultural Science)	24th December, 2022	NHRDF, Bagwani Bhawan, New Delhi
Suhas G Karkute	International symposium on advances in plant biotechnology and nutritional security	28-30 April, 2022	PTCA (India) and NIPB, New Delhi

Anant Bahadur	National symposium on Agro-physics for smart agriculture.	23 February, 2022	NAAS, New Delhi
	Second Indian Horticulture Summit-2022:Horticulture for prosperity and health security	27-29 April, 2022	Navsari Agriculture University, Navsari, Gujarat
	One-day seminar on Noni and Wellness	31 May, 2022.	ISNS and World Noni Research Foundation at Jaunpur UP
	XXXX Group Meeting of All India Coordinated Research Project (Vegetable Crops)	15-17 June, 2022	ICAR-IIVR, Varanasi (Online)
A.N. Tripathi	National seminar on CRTSAIA-22 Climate resilient technology for sustainable agriculture, innovation approaches	26 March, 2022	Centurian University of Technology and Management, Odisha (online)
	National seminar on IPRAOC-2022 Promotion of IPR in agriculture	7-8 April, 2022	VKS College of Agriculture, BAU, Sbour (Bihar)
	National e-conference on Biotic stress management strategies for achiving sustainable crop production and climatic resilience	19-21 May, 2022	ICAR-NCIPM, New Delhi (online)
	11 agro chemical conference on policy landscape for a flourishing agrochemical industry	23 June, 2022	FICCI, New Delhi
	Farmers workshop on shakbhaji utpadan evm fasal surakhsha	7-8 August, 2022	Chief development Officer (CDO), Varanasi
Bhuvaneswari S	One day workshop on '*Patra lekhan me rajbhasha ke prayog ko badava'*	25 March, 2022	Rajbhasha karyanvayan Samiti, ICAR-IIVR, Varanasi
	One day webinar on "Genome editing in vegetable crops for Improvement of quality and stress"	26 April, 2022	ICAR-IIVR, Varanasi (Virtual mode)
	40th Group Meeting of AICRP (VC)	15-17 June, 2022	ICAR-IIVR, Varanasi (Virtual mode)
Shailesh K Tiwari	2nd Indian Horticulture Summit -2022 at Navsari Agriculture University, Navsari, Gujarat	27-29 April, 2022	Society for Horticulture Research and Development
	40th Group meeting od AICRP (VC) held online at ICAR-IIVR, Varanasi	15-17 June, 2022	AICRP (VC), ICAR-IIVR, Varanasi
Manjunatha T. Gowda	Workshop on 'Computational Biology-Genomics, Metagenomics /Microbiome and Proteomics,'	29 April, 2022	Academy of Microbiological Sciences & Association of Microbiologists of India and ICAR - IARI, New Delhi
	AICRP (Vegetable Crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development"	20-22 December, 2022	ICAR-IIVR, Varanasi
Jaydeep Halder	National Symposium on "Self-reliant coastal Agriculture"	11-13 May, 2022	ICAR-Central Coastal Agricultural Research, Ela, Old Goa
	National E-Conference on "Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience"	19-21 May, 2022	ICAR-National Research Center on Integrated Pest Management, New Delhi-110012
Yerasu Suresh Reddy	National Symposium on self-reliant coastal agriculture	11-13th May, 2022	Association for Coastal Agricultural Research (ACAR) and ICAR- Central Coastal Agricultural Research Institute (ICAR-CCARI), Goa
	40th group meeting of AICRP-VC	15-17th June, 2022	AICRP-Vegetable crops, at ICAR-IIVR, Varanasi (virtual mode)
	18th Annual Review Meeting of DUS centres	10-11, November, 2022	Protection of Plant Varieties and Farmers' Rights Authority, New Delhi

S.K.Singh	AICRP annual group meeting held during 5-7 June, 2022	05-07 June, 2022	ICAR-IIVR, Varanasi
Jyoti Devi	40th Annual Group Meeting of AICRP (VC) (Virtually mode)	15-17June, 2022	ICAR-IIVR, Varanasi (UP).
BK Singh	40th Group Meeting of AICRP (VC)	15-17th June, 2022	ICAR-IIVR, Varanasi, UP (Virtual)
Tribhuvan Chaubey	XXXX Annual Group Meeting of AICRP on Vegetable Crops (Virtual mode)	15-17 June, 2022	ICAR-IIVR, Varanasi, UP
Jagesh Kumar Tiwari	40th Annual Gruop Meeting of AICRP (Vegetable Crops) at ICAR-IIVR, Varanasi	15-17 June, 2022	AICRP-Vegetable crops, at ICAR-IIVR, Varanasi (virtual mode)
	18th Annual Review Meeting of DUS centres	10-11 November, 2022	Protection of Plant Varieties and Farmers' Rights Authority, New Delhi
Vikash Singh	40th Annual Gruop Meeting of AICRP (Vegetable Crops) at ICAR-IIVR, Varanasi	15-17 June, 2022	AICRP-Vegetable crops, at ICAR-IIVR, Varanasi (virtual mode)
Rakesh K Dubey	40th Annual Group Meeting of AICRP (VC) (Virtually mode)	15-17June, 2022	ICAR-IIVR, Varanasi (UP).
B. R. Reddy	40th Annual Gruop Meeting of AICRP (Vegetable Crops) at ICAR-IIVR, Varanasi	15-17 June, 2022	AICRP-Vegetable crops, at ICAR-IIVR, Varanasi (virtual mode)
SNS Chaurasia	40th Group Meeting of All India Coordinated Research Program (Vegetable Crops)	15-17 June, 2022	ICAR-IIVR, Varanasi (Online)
	Hindi Karyashala	05 September, 2022	ICAR-IIVR Varanasi
	PrantiyaBhasayan evom Rajbhasha ka Mahatwa	30 December, 2022	ICAR-IIVR Varanasi
Achuit Kumar Singh	International Conference on Recent Advances In Horticulture Research-2022 (ICRAHOR-2022).	8-9 August, 2022	Amity University, Noida, U.P.
	Global Okra Round Table (GORT)	10-12 October, 2022	Indian Agriculture Research Institute (ICAR-IARI), New Delhi
Vijaya Rani	62nd Annual International Conference of Association of Microbiologists of India (AMI) on "Microbes and Society: Current Trends and Future Prospects (MSCTFP-2022)"	21-23 September, 2022	University of Mysore, Mysore, Karnataka
	Rajbhasha Karyashala	5 September, 2022	ICAR-IIVR, Varanasi
Hare Krishna	6thInternational Symposium (ISMF&MAP)	24-26 November, 2022	Uttar Banga Krishi Viswavidyalaya, Cooch Behar (WB)
Rajeev Kumar	International Conference on "Recent Advances in Research and Innovations in Life Sciences	17-19 November, 2022	Mata Gujri Mahila Mahavidyalaya, Jabalpur
Govind Pal	Workshop on 'Safe and Judicious Use of Pesticides and Application of New Generation Formulation for Crop Protection in Vegetable Crops'	09 December, 2022	ICAR-IIVR, Varanasi

PUBLICATIONS

Research Papers

1. Arya V, Narayana S, Tyagi, Raju SVS, Srivastava CP, Sinha T and Divekar P 2022. DNA barcoding of fruit flies associated with cucurbit ecosystem and combination of Cue-Lure and Methyl Eugenol in trap is not effective for mass trapping of responsive fruit flies. *Phytoparasitica* 50:683–695 [NAAS - 7.44]
2. Behera TK, Singh J, Dubey RK and Tiwari SK 2022. Vegetable genetic resources to mitigate nutritional insecurity in India. *Indian J. Plant Genetic Resour.* 35(3): 110-116. [NAAS – 5.54]
3. Bhardwaj DR and Singh AK 2022. Genetical Contribution and Combining Ability Analysis in Bitter gourd (*Momordica charantia* L.). *Inter. J. Plant Soil Sci.* 34(23): 372-380. [NAAS – NA]
4. Bhardwaj DR and Singh AK 2022. Heterosis and Inbreeding Analysis in Bitter Gourd (*Momordica charantia* L.). Journal of Plant Science Research 38 (2): 1-10. [NAAS – 4.10]
5. Chaubey T, Sagar V, Singh RK, Chanotiya CS, Pandey S, Singh PM, Karmakar P, Singh J, Singh B, Singh DP, Pandey KK and Behera TK 2022. Volatile compounds governed by single recessive gene impart aroma in sponge gourd (*Luffa cylindrica* L. Roem). *Plants* 11: 2881. [NAAS – 9.94]
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9. Divekar PA, Rani V, Majumder S, Karkute SG, Molla KA, Pandey KK, Behera TK and Govindharaj GPP 2022. Protease inhibitors: An induced plant defense mechanism against herbivores. *Journal of Plant Growth Regulation*, pp: 1-17. [NAAS Score- 10.17]
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11. Gowda CB, Kumar A, Akhtar J, Mishra GP, Tiwari SK, Kumar R and Javeria S 2022. Evaluation of bio-control agents for management of fruit rot and its effect on seed quality in chilli. *Indian J. Hort.* 79(4): 450-457. [NAAS – 6.00]
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13. Gupta N, Jain SK, Tomar BS, Anand A, Singh J, Sagar V, Kumar R, Singh V, Chaubey T, Abd-Elsalam KA and Singh AK 2022. Impact of foliar application of ZnO and Fe_3O_4 nanoparticles on seed yield and physio-biochemical parameters of cucumber (*Cucumis sativus* L) seed under open field and protected environment *vis a vis* during seed germination. *Plants* 11: 3211. [NAAS – 9.94]
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22. Krishna R, Ansari WA, Soumia PS, Yadav A, Jaiswal DK, Kumar S, Singh AK, Singh M and Verma JP 2022. Biotechnological interventions in tomato (*Solanum lycopersicum*) for drought stress tolerance: achievements and future prospects. BioTech 11 (4): 48. https://doi.org/10.3390/biotech11040048. [NAAS – 8.89]
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11(02):51-58. [NAAS- 4.38]
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45. Sardana HR, Narayan Bhat M, Singh N and Halder J 2022. On farm implementation of sustainable IPM technology and its economic analysis for bitter gourd involving farmers' centred approach in Haryana. *Indian Journal of Entomology*: e22216. DOI. No.: 10.55446/IJE.2022.666. [NAAS - 5.08]
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47. Sharma S, Chaurasia SNS, Singh J, Tiwari S, Kole B and Behera TK 2022. Bioactive properties and enzymatic activities in long and round eggplant (*Solanum melongena* L.): Inferences for processable traits. *Sci. Hortic.* 302: 111170. [NAAS – 10.34]
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52. Singh AK, Mishra P, Kashyap SP, Karkute SG, Singh PM, Rai N, Bahadur A and Behera TK. 2022. Molecular insights into mechanisms underlying thermo-tolerance in tomato. *Frontiers in Plant Sciences*,doi:10.3389 / fpls.2022. 1040532. [NAAS – 12.63]
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56. Singh P, Singh AK, Singh BK, Pal AK, Chaubey T, Singh RK, Singh T and Chaturvedi VD 2022. Evaluation of physical and chemical mutagens on various genotypes of brinjal (*Solanum melongena* L.) in M2 generation. *Veg. Sci.* 49(1): 47-51. [NAAS – 4.93]
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Popular Articles

1. Behera TK, Karkute SG, Singh AK 2022. Biotechnological interventions and their role in sustainable development of vegetable crops. In AICRP (Vegetable crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development at ICAR-IIVR, Varanasi during December 20-22, 2022.
2. Behera TK, Singh R, Singh PM and Singh SK 2022. S*abjiyon ki rasayan rahit kheti*. *Sabji Kiran*, 16(1):1-4.
3. Bhardwaj DR, Behera TK, Gautam KK, Reddy YS and Kumar S 2022. *Fasal chakr me sabjio ka samavesh kare*. *Sabji Kiran*, 16(1): 75-77
4. Chatterjee M and Halder J 2022. Lady bird beetles: the most colourful and graceful predators of various phytophagous insects. *Agriculture Letters*, 3(01):23-24.
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6. Chaurasia SNS, Anant Bahadur and Behra TK. 2023. *Bina Miatti Ke Sabjiyon ki Kheti: Bhawishya ki Sambhawanayen*. In Smarika, Pradeshik Phal Shakbhanji avomPushp pradershani, pp: 32-36.
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8. Chaurasia SNS, Sharma S, Bahadur A, Krishna H and Singh S 2022. *Agro start-ups ke liye hydroponics vidhi se Sabjiyan ugayen*. *Sabji Kiran*, 16(1):33-38.
9. Devindrappa, Holajjer P, Bandi S, Revanasidda, Gowda MT, Prabhulinga T 2022. Marigold (*Tagetes* spp.): A potential crop for combating plant parasitic nematodes in the agricultural eco-system. *Agriculture and Food: e-News Letter* 4(2):240-241.
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13. Khati Priyanka, B Jiwan, Parihar Manoj, Bisht Jaydeep Kumar, Lakshmikant, Bhinda Singh, Kumari Asha, Rani Vijaya 2022. *Rog prabandhan mein sukshmjivon ka yogdan. Madhya Bharat Krishi (May)*, pp: 55.
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Golden Jubilee National Symposium New Opportunities in Vegetable Production for Sustainable Development, 20-22 December, 2022, pp: 27.

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51. Singh Achuit K and Krishna Ram 2022. Gene editing initiatives for trait development in okra (*Abelmoschus esculentus* L. Moench). *In: Global Okra Round Table (GORT) organized by Advanced Training in Plant Breeding (ATPBR) and ICAR – Indian Agriculture Research Institute (ICAR-IARI), New Delhi, October 10-12, 2022*, pp: 47.
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54. Singh PM, Singh N, Tiwari SK and Roy S 2022. ABI and ZTMU unit of ICAR-IIVR promoting entrepreneurship in vegetable sector. *In: AICRP (Vegetable Crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development" held at ICAR-IIVR, Varanasi, 20-22 December, 2022*, pp: 25
55. Singh R, Gupta N, Singh PM, Kumar R, Singh V, Chaubey T and Behera TK 2022. Contract seed production of vegetable crops at IIVR: A entrepreneurship option for doubling farmer income. *In: AICRP (Vegetable Crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development" held at ICAR-IIVR, Varanasi, 20-22 December, 2022*, pp: 26.
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61. Suresh Reddy Yerasu, Prasanna HC, Kashyap Sarvesh P, Nagendran K and Singh AK 2022. Pyramiding *Ty-2, ty-5* and *Ty-6* genes in the back ground of *Ty-3* containing Kashi Aman. *In: AICRP (Vegetable Crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development" held at ICAR-IIVR, Varanasi, 20-22 December, 2022*, pp: 161.
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Manish K, Mishra Lokesh K, Singh S K, Singh PM and Behera TK 2022. Breeding for processing tomato in India: Current status on new germplasm, elite breeding lines and hybrids. *In: AICRP (Vegetable Crops) Golden Jubilee National Symposium on "New Opportunities in Vegetable Production for Sustainable Development" held at ICAR-IIVR, Varanasi, 20-22 December, 2022*, pp: 111-112.

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64. Tripathi AN 2022. Detection identification and management of important bacterial and fungal diseases of solanaceous vegetable crops. *In book of souvenir and abstracts national e- conference on biotic stress management strategies for achieving crop production and climate resilience, 19-21 May, 2022*, pp: 21-22
65. Tripathi AN 2022.Promotion of intellectual property rights in agri-horticulture and its relevance: Indian perspectives. *In abstract book- cum -Souvenir, National conference on Inteelectual Property Rights in Agriculture: Opportunities and challenges, 7-8 April, 2022*, pp: 72-73.
66. Tripathi AN, Bahadur A, Pandey S and Behera TK 2022. Detection and inplanta mass screening of gummy stem blight resistance cultigens of cucurbites. *In: book of abstracts AICRP (VC) Golden jubilee national symposium on new opportunities in vegetable production for sustainable development, 20-22, December, 2022*, pp: 189-190.

Extension Folder

1. Singh N, Pandey S, Singh BK, Halder J and Behera TK 2022. *ICAR-IIVR at A Glance*. ICAR-IIVR Folder, pp: 1-6.

Radio Talks (AIR): 11

TV Talk: 04

APPOINTMENTS, TRANSFERS, PROMOTION, SUPERANNUATION AND RESIGNATION

Appointment

- Dr. Sudhakar Pandey, Principal Scientist joined as ADG-FVS & MP (Hort.), ICAR-New Delhi w.e.f. 09.12.2022.

Joining on Transfer

- Dr. Jagesh Kumar Tiwari, Senior Scientist (Hort. - Veg. Sc.) from CPRI, Shimla joined at ICAR-IIVR, Varanasi on 04.04.2022.
- Dr. Hironmay Das, Senior Scientist from CIAE, Bhopal joined at ICAR-IIVR, Varanasi on 31.08.2022.

Supperannuation

- Dr. R.B. Yadava, Principal Scientist, ICAR-IIVR, Varanasi superannuated from services on 31.10.2022.
- Sh. Y.P. Singh, Senior Technical Officer, ICAR-IIVR, Varanasi superannuated from services on 31.10.2022.

Promotion

- Dr. B.K. Singh promoted from Rs. 37400-67000 + RGP 8000 to Rs. 37400-67000 + RGP 9000 w.e.f. 03.09.2022 as Senior Scientist, ICAR-IIVR, Varanasi.
- Ms. Shweta Kumari promoted from Rs. 15600-39100 + RGP 6000 to Rs. 15600-39100 + RGP 7000 w.e.f. 05.04.2022 as Scientist, ICAR-IIVR, Varanasi.
- Dr. Subhdeep Roy promoted from Rs. 15600-39100 + RGP 7000 to Rs. 15600-39100 + RGP 8000 w.e.f. 05.04.2022 as Senior Scientist, ICAR-IIVR, Varanasi.
- Dr. Jaydeep Halder promoted from Rs. 15600-39100 + RGP 8000 to 37400-67000 + RGP 9000 w.e.f. 21.04.2021 as Senior Scientist, ICAR-IIVR, Varanasi.
- Dr. Pratap Divekar promoted from Rs. 15600-39100 + RGP 6000 to Rs. 15600-39100 + RGP 7000 w.e.f. 10.06.2022 as Scientist, ICAR-IIVR, Varanasi.
- Dr. Manjunath Gowda T. promoted from Rs. 15600-39100 + RGP 6000 to Rs. 15600-39100 + RGP 7000 w.e.f. 21.06.2022 as Scientist, ICAR-IIVR, Varanasi.
- Dr. Pradeep Karmakar promoted from Rs. 15600-39100 + RGP 7000 to Rs. 15600-39100 + RGP 8000 w.e.f. 03.09.2022 as Scientist, ICAR-IIVR, Varanasi.
- Sh. K.K. Gautam promoted from Rs. 15600-39100 + RGP 6000 to Rs. 15600-39100 + RGP 7000 w.e.f. 03.09.2022 as Scientist, ICAR-IIVR, Varanasi.
- Sh. Rameshwar Singh promoted from Rs. 15600-39100 + 6600 to Rs. 15600-39100 + 7600 w.e.f. 25.04.2022 as CTO, ICAR-IIVR, Varanasi.
- Sh. Ashok Kumar Singh promoted from Rs. 15600-39100 + 6600 to Rs. 15600-39100 + 7600 w.e.f. 25.04.2022 as CTO, ICAR-IIVR, Varanasi.
- Sh. Y.P. Singh promoted from Rs. 15600-39100 + 5400 to Rs. 15600-39100 + 6600 w.e.f. 25.04.2022 as ACTO, ICAR-IIVR, Varanasi.
- Sh. A.P. Singh promoted from Rs. 15600-39100 + 5400 to Rs. 15600-39100 + 6600 w.e.f. 27.08.2022 as ACTO, ICAR-IIVR, Varanasi.
- Dr. P.C. Singh promoted from Rs. 9300-34800 + 4600 to Rs. 9300-34800 + 5400 w.e.f. 05.05.2022 as T-6, ICAR-IIVR, Varanasi.
- Sh. Ajay Tiwari promoted from Rs. 9300-34800 + 4600 to Rs. 9300-34800 + 5400 w.e.f. 05.05.2022 as T-6, ICAR-IIVR, Varanasi.
- Sh. Arun Pratap Singh promoted from Rs. 9300-34800 + 4600 to Rs. 9300-34800 + 5400 w.e.f. 05.05.2022 as T-6, ICAR-IIVR, Varanasi.
- Sh. V.V. Diptikar promoted from Rs. 9300-34800 + 4600 to Rs. 9300-34800 + 5400 w.e.f. 05.05.2022 as T-6, ICAR-

Classified Abstracts of Expenditure (2022)

ICAR-Indian Institute of Vegetable Research (plan)

(In Lakhs)

Sub-head	Plan	
	Provision made inRE	Expenditure
Establishment Charges	1700.00	1700.00
Wages	-	-
O.T.A.	-	-
T.A.	25.00	-
Other Charges (Contingency)	496.08	496.08
H.R.D.	0.61	-
Works	82.00	-
Equipment	14.17	-
Library	0.34	-
Vehicle	8.69	-
Annual Repairs /Maintenance	-	-
Furniture & Fixture	19.73	-
Information Technology	4.29	-
TSP NEH	73.17	-
Total	**2494.08**	**2494.08**

Revenue generation

(In Lakhs)

Particulars	Target	Revenue generation
IIVR	28.00	87.25

Krishi Vigyan Kendra (plan)

(In Lakhs)

KVKs	RE	Expenditure
KVK, Kushinagar	133.95	133.89
KVK, Deoria	98.95	74.04
KVK, Sant Ravidas Nagar	173.95	163.85
Total	406.85	371.78

Externally Funded Projects

(Rs. In lakhs)

Name of project	Funding agency	Duration of projects	Allocation & Expenditure 2022	
			Allocation	Expenditure
Crop Improvement				
National Innovations in Climate Resilient Agriculture (NICRA)	ICAR	2017 - 2023	38.00	37.95
CRP on Hybrid Technology Project	ICAR	2021 - 2026	15.60	15.57
CRP on Agrobiodiversity	ICAR	2017 - 2023	16.00	16.00
Agri Business Incubator (ABI)	ICAR	2017 - 2023	3.50	3.44
Zonal Technology Management Unit (ZTMU)	ICAR	2017 –2023	6.00	5.99
Discovery of novel genes and QTLs conferring resistance to ToLCNDV disease from indigenous sources, genome-wide transcriptional dynamics and allele mining of the candidate genes in Cucurbitaceous vegetables.	NASF, ICAR	2022-2023	12.28	9.16
Monecious sex expression in muskmelon (Cucumis melo L.): Inheritance and molecular mapping of monoecisum using linked markers.	DST-SERB	2019 - 2023	4.00	1.50
Identification of suitable varieties/hybrids of cucurbitaceous crops and development of production protocol for better livelihood of river bed (diara land) farming community.	UPCAR	2009-2023	6.13	6.13
Development and evaluation of annual moringa for food fodder and nutritional content in U.P.	UPCAR	2020-2023	3.04	3.04
Proteomics and metabolomics of stress-challenged tomato for functional metabolic clues of plant responses, crop quality and yield	CABin ICAR	2021-2023	20.00	19.00
Dus Testing of Vegetable Crops	PPV&FRA	Jan. to June, 2022	6.24	5.82
Development of DUS test guidelines for Sponge Gourd (Luffa cylindrical)"	PPV&FRA	2022-2023	8.10	5.61
DUS Testing in Pointed gourd	PPV&FRA	2021-2023	5.95	3.28
DUS testing of Okra	PPV&FRA	2022-2023	5.50	5.49
DUS testing of Brinjal	PPV&FRA	2022-2023	5.50	4.70
DUS testing of cucumber and pumpkin	PPV&FRA	2022-2023	6.13	4.18
DUS testing of Tomato	PPV&FRA	2022-23	6.13	4.12
DUS testing of Bitter gourd and Bottle gourd	PPV&FRA	2022-2023	5.50	5.20
DUS testing of Vegetable pea and French bean	PPV&FRA	2022-2023	5.50	5.38
Crop Production				
Network Project on precision Agriculture (NePPA)	ICAR	2021-2026	16.36	16.60
Biotech Kisan (Kisan Innovationm and Science Application Network) Hub Project	DBT	2020-2023	63.00	63.00

Farmer FIRST Program on "Intervention of Improved Agricultural Technologies for Livelihood and Nutritional Security Adhering Local Resources and Working Knowledge of the Farmers	ICAR	2016-2026	45.00	43.80
ICAR-NASF Project "Development and validation of need based delivery model through Farmer Producer organization (FPO) in Eastern Region of India".	ICAR	2019-23	5.85	5.85
NASF Sensor-based integrated vertical farming for horticultural crops and aquaponics system	ICAR	-	-	-
Crop Protection				
Establishment of biocontrol development center for production and promotion of bioagents to manage soil-borne diseases in vegetable crops	RKVY	2021-2023	165.50	140.30
Establishment of a referral Laboratory for pesticide residue analysis in vegetable crop	RKVY	2022-2023	333.00	-
Resistance monitoring studies in tomato early blight (*Alternaria solanai*) for azoxystrobin fungicide	Syngenta India Ltd	2021-2023	15.00	12.00
Base line study of tomato powdery mildew pathogen against a fungicide molecule (Adepidyn)	Syngenta India Ltd	2022-2024	15.88	-
Evaluation of BIPM practices against sucking pests and fruit flies Zeugodacus cucurbitae in bitter gourd (AICRP on Biological control of crop pests)	ICAR-NBAIR	2018 - 2021	2.01	1.36

Staff Strength

(as on 31.12.2022)

S.N.	Category	Sanctioned Strength	Staff in Position	Vacant
(A) SCIENTIFIC				
1.	Director	01	01	-
2.	Scientist	44	34	10
3.	Senior Scientist	12	09	03
4.	Principal Scientist	01	01	-
5.	HoD	03	-	03
6.	HoRC	01	-	01
7.	PC	01	-	01
	Total	**63**	**45**	**18**
(B) TECHNICAL				
1.	Category-I	11	10	01
2.	Category-II	15	10	05
	Total	**26**	**20**	**06**

(C) ADMINISTRATIVE				
1.	Chief Administrative Officer	01	01	-
2.	Dy. Dir. (F)/ Comptroller	01	-	01
3.	Principal Private Secretary	01	-	01
4.	Administrative Officer	01	01	-
5.	Finance & Accounts Officer	01	01	-
6.	Assistant Administrative Officer	03	03	-
7.	Assistant Finance & Accounts Officer	01	-	01
8.	Private Secretary	02	01	01
9.	Assistant	09	04	05
10.	Personal Assistant	03	01	02
11.	U.D.C.	04	-	04
12.	L.D.C.	05	01	04
	TOTAL	**32**	**13**	**19**
SKILLED SUPPORTING STAFF				
1.	S.S.S	16	15	01
	TOTAL	**16**	**15**	**01**
	Grand Total	**137**	**93**	**44**

Staff Strength of Krishi Vigyan Kendras
(as on 31.12.2022)

KVK Sargatia, Kushinagar

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	-	01
2.	Subject Matter Specialist	06	04	02
3.	Farm Manager	01	01	-
4.	Programme Assistant	01	01	-
5.	Programme Assistant (Computer)	01	-	01
6.	Assistant	01	-	01
7.	Stenographer Gr. III	01	-	01
8.	Driver (T-1)	02	02	-
9.	SSS	02	-	02
	Total	16	08	08

KVK Deoria

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	-	01
2.	Subject Matter Specialist	06	03	03
3.	Farm Manager	01	01	-
4.	Programme Assistant	01	-	01
5.	Programme Assistant (Computer)	01	-	01
6.	Assistant	01	-	01

7.	Stenographer Gr. III	01	-	01
8.	Driver (T-1)	02	02	-
9.	SSS	02	-	02
	Total	16	06	10

KVK Bhadohi

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	01	-
2.	Subject Matter Specialist	06	05	01
3.	Farm Manager	01	01	-
4.	Programme Assistant	01	01	-
5.	Programme Assistant (Computer)	01	-	01
6.	Assistant	01	-	01
7.	Stenographer Gr. III	01	-	01
8.	Driver (T-1)	02	01	01
9.	SSS	02	-	02
	Total	16	09	07

Staff in Position
(as on 31.12.2022)

Sl. No.	Name	Designation	Email
1.	Dr. Tusar Kanti Behera	Director	directoriivr@gmail.com
Director's Cell			
2.	Sh. Ajay Uniyal	Personal Assistant	Ajay.uniyal1@gmail.com
Project Coordinator Cell			
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Division of Vegetable Improvement			
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Division of Vegetable Production			
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60.	Sh. Ramji Giri	Administrative Officer	ramji.giri@icar.gov.in
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74.	Sh. S.K. Singh	Chief Technical Officer	sksinghiivr@gmail.com
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75.	Sh. M.L. Vishwakarma	Technical Officer	madanlalvishwa@yahoo.in
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76.	Sh. Sanjay Singh	Technical Officer	
77.	Sh. Rajendra Kumar	Senior Technical Assistant	-
78.	Sh. Manoj Kumar	Senior Technical Assistant	
79.	Sh. Ram Ashrey	Senior Technical Assistant	-
Skilled Supporting Staff (SSS)			
80.	Sh. Shiv Kumar	SSS	-
81.	Sh. Kailash Singh	SSS	-
82.	Sh. S.P. Mishra	SSS	-
83.	Sh. Naraini Singh	SSS	-
84.	Sh. S.K. Pandey	SSS	-
85.	Sh. Arun Kumar	SSS	-
86.	Sh. Ramraj	SSS	-
87.	Sh. Suresh Kumar Yadav	SSS	-
88.	Sh. Suresh Kumar	SSS	-
89.	Sh. Virendra Prasad Gond	SSS	-
90.	Sh. Kamlesh Kumar Singh	SSS	-
91.	Sh. Anil Kumar Suman	SSS	-
92.	Sh. Ram Kunwar Chaubey	SSS	-
93.	Sh. Jata Shankar Pandey	SSS	-
94.	Sh. Shivajee Mishra	SSS	-

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108.	Sh. Ajay Tiwari	Farm Manager	ajitiwariiivr@gmail.com
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118.	Sh. D.P. Singh	Programme Assistant	dpsinghkvk@rediffmail.com
119.	Sh. Sanjay Kumar Yadav	(T-2) Driver	sanjay8765275294@gmail.com
120.	Sh. Pramod Paswan (up to 14-07-22)	(T-2) Driver	pramodpaswan1084@gmail.com

Research Advisory Committee

Annexure I

Dr. T.A. More Ex- Vice Chancellor MPKV, Rahuri	Chairman
Dr. Subodh Joshi Former PS Division of Vegetable Science IARI, New Delhi	Member
Dr. M. Prabhakar, Former Head Division of Vegetable Crops IIHR, Bengaluru	Member
Dr. Pratibha Sharma Former Head IARI, New Delhi	Member
Dr. D. Patnayak PS, NIPB, New Delhi	Member
Dr. N.K. Pandey Head Division of Social Science, CPRI, Shimla	Member
Asstt. Director General (HS-I) ICAR, Krishi Anusandhan Bhawan-II, New Delhi	Ex- officio Member
Dr. T.K. Behera Director ICAR-IIVR, Varanasi	Ex- officio Member
Dr. Sudhakar Pandey Principal Scientist ICAR-IIVR, Varanasi	Member Secretary

Institute Management Committee

Annexure II

Dr. T.K. Behera Director ICAR-IIVR, Varanasi	Chairman
Sh. J.K. Singh Nominee Director of Horticulture, Govt. of UP, 2-Sapru Marg, Lucknow	Member (ex-officio)
Director of Horticulture Govt. of Bihar, IInd Floor, Krishi Bhawan Mithapur, Patna, Bihar-800001	Member (ex-officio)
Dr. Amit Singh Nominee Vice Chancellor, NDUA&T, Ayodhya	Member (ex-officio)
Dr. H.C. Prasanna Principal Scientist, ICAR-IIHR, Bengaluru	Member (DG Nominee)
Dr. Achuit Kumar Singh Principal Scientist, ICAR-IIVR, Varanasi	Member (DG Nominee)
Dr. Arvind Nath Singh Principal Scientist, ICAR-IISS, Mau	Member (DG Nominee)
Dr. Ram Ashray Principal Scientist Division of Post-Harvest Technology, ICAR-IARI, New Delhi	Member (DG Nominee)
Dr. Vikramaditya Pandey ADG I/C (Hort. Sci.-I) Horticulture Division of ICAR, New Delhi	Member (DG Nominee)
Shri D.K. Agnihotri Sr. Finance & Accounts Officer ICAR-CISH, Lucknow	Member (Nominee of AS&FA, DARE/ICAR)
Shri Sujit Kumar Singh CAO, ICAR-IIVR, Varanasi	Member Secretary
Dr. P.M. Singh Principal Scientist & I/C Head Crop Improvement Division, ICAR-IIVR, Varanasi	Special Invitee
Dr. S.N.S. Chaurasia Principal Scientist & I/C Head Crop Production Division, ICAR-IIVR, Varanasi	Special Invitee
Dr. K.K. Pandey Principal Scientist & I/C Head Crop Protection Division, ICAR-IIVR, Varanasi	Special Invitee
Dr. Neeraj Singh Principal Scientist, ICAR-IIVR, Varanasi	Special Invitee
Dr. Rajesh Kumar Principal Scientist, ICAR-IIVR, Varanasi	Special Invitee
Shri Gaurav Srivastava F&AO, ICAR-IIVR, Varanasi	Special Invitee

List of Ongoing Research Projects

Annexure III

A. Institutional

MEGA PROGRAMME-1: INTEGRATED GENE MANAGEMENT			
Mega-Programme Leader: Dr. P.M. Singh			
Code	**Title of the project**	**P.I.**	**Co-PIs & Associates**
1.1	Genetic Improvement of Tomato	YS Reddy	N. Rai and Jagesh K. Tiwari **Associates:** PA Divekar (Insects), KK Pandey (Diseases), K Nagendran (Viruses), Swati Sharma (Processing screening) and M Gowda T (Nematodes)
1..2	Genetic Improvement of Brinjal	SK Tiwari	Suhas G Karkute **Associates:** PA Divekar (Insects) and AN Tripathi (Diseases)
1.3	Genetic Improvement of Chilli	Rajesh Kumar	Indivar Prasad, Achuit K. Singh, DP Singh and Suhas G Karkute **Associates:** KK Pandey (Diseases), K Nagendran (Viruses), Kuldeep Srivastava (Insects) and M Gowda T (Nematodes)
1.4	Genetic Improvement of Vegetable Pea	Jyoti Devi	RK Dubey **Associates:** AN Tripathi (Diseases), and PA Divekar (Insects)
1.5	Genetic Improvement of Cowpea	B R. Reddy	N Rai **Associates:** PA Divekar (Insects), AN Tripathi (Diseases) and K. Nagendran (Viruses)
1.6	Genetic Improvement of Indian bean and French bean	N Rai	BR Reddy, Rajeev Kumar, SK Singh **Associates:** Sudarshan Maurya (Diseases) and PA Divekar (Insects)
1.7	Genetic Improvement of seed propagated gourds (Bitter gourd, Bottle gourd and Ash gourd)	DR Bhardwaj	TK Behera and Sudhakar Pandey, **Associates:** Vikas Singh (RRS), KK Pandey (Diseases), Kuldeep Srivastava (Insects), and M Gowda T (Nematodes)
1.8	Genetic Improvement of Luffa [Sponge gourd, Ridge gourd and Satputia]	T Chaubey	Sudhakar Pandey and RK Dubey **Associates:** DP Singh (pathway mapping aromatic line) and J Halder (Insects)
1.9	Genetic Improvement of Pumpkins and Cucumber	Sudhakar Pandey	DR Bhardwaj, T Chaubey and Vikas Singh **Associates:** J Halder (Insects), AN Tripathi (Diseases) and K Nagendran (Viruses)
1.10	Genetic Improvement of Melons	T K Behera	Sudhakar Pandey, Pradip Karmakar and Vikas Singh **Associates:** K Nagendran (Viruses) and Sudarshan Maurya (Diseases)
1.11	Genetic Improvement of Okra	Pradip Karmakar	Achuit K Singh and Vidya Sagar **Associates:** J Halder (Insects), and K Nagendran (Diseases/Viruses)
1.12	Genetic Improvement of Cole crops and Root crops	B K Singh	P Karmakar and Bhuvaneswari,S. Associates: Kuldeep Srivastava (Insects) and Sudarshan Maurya (Diseases)
1.13	Biotechnological interventions including transgenics for managing stresses in vegetables	Achuit Kumar Singh	Sudhakar Pandey, DP Singh, SK Tiwari, YS Reddy, Jyoti Devi, Vidya Sagar, Indivar Prasad, Jagesh K. Tiwari and Suhas G. Karkute **Associate:** K Nagendran
1.14	Genetic Improvement of Underexploited & Future vegetables [Leafy vegetables, aquatic vegetables, sweet corn, baby corn, cluster bean, winged bean, Faba bean, vegetable soybean etc.]	R K Dubey	RK Singh, B K Singh, Jyoti Devi, YS Reddy, Vidya Sagar, Indivar Prasad and Swati Sharma. **Associates:** P.A Divekar (Insects) and AN Tripathi (Diseases)

1.15	Genetic Improvement of clonally propagated & perennial vegetables [Pointed gourd, spine gourd, ivy gourd, sweet gourd, basella, moringa etc.]	Vikas Singh	DR Bhardwaj, P Karmakar and Vidya Sagar **Associates:** J Halder (Insects) and Sudarshan Maurya (Diseases)
MEGAPROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES			
Mega-Programme leader: Dr. P.M. Singh			
2.1	Priming, coating, ovule conversion and seed enhancement	PM Singh	Rajesh Kumar, T Chaubey, Vikas Singh and Nakul Gupta **Associate:** J Halder and AN Tripathi
2.2	Pollination studies for seed augmentation in vegetables including support of honeybees	Rajesh Kumar	PM Singh, T Chaubey, Nakul Gupta, J. Halder and PA Divekar **Associate:** AN Tripathi
2.3	Drying and storage studies on vegetable seeds	Nakul Gupta	PM Singh, Rajesh Kumar and S. Roy
MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT			
Programme Leader: Dr. SNS Chaurasia			
3.1	Technologies for protected vegetable production	SNS Chaurasia	Hare Krishna, R.B. Yadava (upto 31/10/22), Anant Bahadur, Swati Sharma and Rajeev Kumar **Associates:** KK Pandey, Kuldeep Srivastava
3.10	Agronomic biofortification studies in vegetable crops	RB Yadava (upto 31/10/22) Hare Krishna (w.e.f. 01/11/2022)	Hare Krishna and Rajeev Kumar
3.11	Development of Agro-techniques for organic farming in vegetable crops	SK Singh	RB Yadava (upto 31/10/22), Swati Sharma and Rajesh Kumar Singh **Associates:** KK Pandey, Jaydeep Halder, A.N Tripathi, Vijaya Rani and Kuldeep Srivastava
3.12	Improving water productivity of vegetable crops sequence through drip irrigation system	Anant Bahadur	**Associates:** Jaydeep Halder
3.13	Enhancing productivity, quality and tolerance to biotic and abiotic stresses in vegetables by grafting technology	Anant Bahadur	Hare Krishna, Rajeev Kumar **Associates:** AN Tripathi
3.17	Bio-regulator induced drought stress tolerance in Okra (*Abelmoschus esculentus*)	Rajeev Kumar	Anant Bahadur and Pradip Karmakar
MEGA PROGRAMME-4: POST HARVEST MANAGEMENT AND VALUE ADDITION			
Programme Leader: Dr. Swati Sharma			
4.4	Influence of polyamines on postharvest senescence and quality of high value vegetables	Swati Sharma	Hare Krishna
MEGA PROGRAMME 5: PRIORITIZATION OF R&D NEEDS AND IMPACT ANALYSIS OF TECHNOLOGIES DEVELOPED BY ICAR-IIVR			
Programme Leader: Dr. Neeraj Singh			
5.4	Empowering rural youth for vegetable based entrepreneurship	Shubhadeep Roy	Neeraj Singh
5.5	Economic impact assessment of IIVR developed technologies	Govind Pal	Neeraj Singh and Shubhadeep Roy
5.6	Development and promotion of nutri- garden module for rural households	Neeraj Singh	SNS Chaurasia and Shubhadeep Roy
MEGA PROGRAMME-6: INTEGRATED PLANT HEALTH MANAGEMENT			
Programme Leader: Dr. K.K. Pandey			
6.1	Bio-intensive management of major insect pests of vegetables in the current scenario of weather change	Kuldeep Srivastava	Jaydeep Halder, PA Divekar, K Nagendran and Sujan Majumder **Associates:** Neeraj Singh

6.2	Toxicological investigations on the novel insecticide molecules and plant origin insecticides against major insect pests of vegetables.	PA Divekar	Kuldeep Srivastava, Jaydeep Halder, Sujan Majumder and Manjunatha Gowda T (*w.e.f.* 19.8.2022).
6.3	Biological control of major insect pests of vegetable crops	Jaydeep Halder	Kuldeep Srivastava, AN Tripathi, P.A. Divekar, Suhas Karkute and Manjunatha Gowda T (*w.e.f.* 19.8.2022).
6.4	Development of effective integrated management package for important fungal diseases of vegetable crops	KK Pandey	Vijaya Rani, AN Tripathi and Anurag Chaurasia
6.5	Bio-prospecting of microorganisms associated with vegetables against plant pathogens	Sudarshan Maurya	KK Pandey, AN Tripathi, Anurag Chaurasia and Vijaya Rani
6.6	Management of important bacterial diseases of vegetable crops	AN Tripathi	Vijaya Rani
6.7	Characterization of viruses infecting vegetable crops and their management	K. Nagendran	KK Pandey **Associates**: Achuit K Singh
6.9	Management of plant parasitic nematodes infecting vegetable crops	Manjunatha Gowda T (w.e.f.19.8.2022)	KK Pandey, Jaydeep Halder, **Associate:** Shubhadeep Roy
6.10	Pest and disease dynamics and behavior modifying strategies for major insect pests of important vegetable crops in relation to changing weather scenario	PA Divekar	Jaydeep Halder, Kuldeep Srivastava and Sudarshan Maurya
6.12	Bio-management of postharvest diseases in major vegetable crops	Vijaya Rani	Sudarshan Maurya and Sujan Majumder **Associate:** Swati Sharma
6.13	Residue dynamics, safety evaluation and decontamination of chlorantraniliprole, deltamethrin, azoxystrobin and kresoxim methyl in tomato, brinjal and chilli	Sujan Majumder	Vijaya Rani, PA Divekar, KK Pandey and J Halder

(B). Externally Funded

Division of Crop Improvement			
S.N.	**Title of the project**	**P.I.**	**Co-PIs & Associates**
1.	National Innovations in Climate Resilient Agriculture (NICRA)	P.M. Singh	N.Rai, Anant Bahadur and Achuit Kumar Singh
2.	CRP on Hybrid Technology Project	N. Rai	Y. S. Reddy
3.	CRP on Agrobiodiversity	S.K. Tiwari	Sudhakar Pandey, P. Karmakar, Vidya Sagar and Bhuvaneswari S.
4.	Agri Business Incubator (ABI)	P.M. Singh	SK Tiwari, Shubhdeep Roy and Neeraj Singh
5.	Zonal Technology Management Unit (ZTMU)	P.M. Singh	SK Tiwari, Shubhdeep Roy and Neeraj Singh
6.	Discovery of novel genes and QTLs conferring resistance to ToLCNDV disease from indigenous sources, genome-wide transcriptional dynamics and allele mining of the candidate genes in Cucurbitaceous vegetables	Sudhakar Pandey	T.K. Behera, Pradip Karmakar, Achuit Kumar Singh and Vidya Sagar
7.	Monecious sex expression in muskmelon (Cucumis melo L.): Inheritance and molecular mapping of monoecisum using linked markers	Pradip Karmakar	-
8.	Identification of suitable varieties/hybrids of cucurbitaceous crops and development of production protocol for better livelihood of river bed (diara land) farming community.	Sudhakar Pandey	K.K. Pandey, R.K. Dubey and Rajneesh Srivastava

9.	Development and evaluation of annual moringa for food fodder and nutritional content in U.P.	Vidya Sagar	R.B. Yadav (up to 31.10.2022)
10.	Proteomics and metabolomics of stress-challenged tomato for functional metabolic clues of plant responses, crop quality and yield	D.P. Singh	Sudarshan Maurya and Y.S. Reddy
11.	Dus Testing of Vegetable Crops	Sudhakar Pandey	T. Chaubey
12.	Development of DUS test guidelines for Sponge Gourd (Luffa cylindrical)"	T. Chaubey	Sudhakar Pandey and R.K. Dubey
13.	DUS Testing in Pointed gourd	Pradip Karmakar	-
14.	DUS testing of Okra	Pradip Karmakar	Vidya Sagar
15.	DUS testing of Brinjal	S.K. Tiwari	Bhuvaneswari S.
16.	DUS testing of cucumber and pumpkin	Sudhakar Pandey	T. Chaubey
17.	DUS testing of Tomato	Y.S. Reddy	Jagesh Kumar Tiwari
18.	DUS testing of Bitter gourd and Bottle gourd	D.R. Bhardwaj	Nakul Gupta
19.	DUS testing of Vegetable pea and French bean	B.R. Reddy	R.K. Dubey
Division of Crop Production			
20.	Network Project on precision Agriculture (NePPA)	Anant Bahadur	Hare Krishna, Rajeev Kumar. S.K. Singh and Swati Sharma
21.	Biotech Kisan (Kisan Innovation and Science Application Network) Hub Project	Neeraj Singh	-
22.	Farmer FIRST Program on "Intervention of Improved Agricultural Technologies for Livelihood and Nutritional Security Adhering Local Resources and Working Knowledge of the Farmers	Neeraj Singh	Shubhadeep Roy, S.K. Singh and D.R. Bhardwaj
23.	ICAR-NASF Project "Development and validation of need based delivery model through Farmer Producer organization (FPO) in Eastern Region of India"	Shubhadeep Roy	Neeraj Singh, Hare Krishna, Sudarshan Maurya and A.N. Tripathi
24.	NASF-Sensor-based integrated vertical farming for horticultural crops and aquaponic system	Hare Krishna	Anant Bahadur and Swati Sharma
Division of Crop Protection			
25.	Establishment of biocontrol development center for production and promotion of bioagents to manage soil-borne diseases in vegetable crops	K.K. Pandey	Sudarshan Maurya, K. Nagendran and Vijaya Rani
26.	Establishment of a referral laboratory for pesticide residue analysis in vegetable crop	Sujan Majumder	K.K. Pandey, Sudarshan Maurya, Nagendran K. and Pratap Divekar
27.	Resistance monitoring studies in tomato early blight (*Alternaria solanai*) for azoxystrobin fungicide	A.N. Tripathi	-
28.	Base line study of tomato powdery mildew pathogen against a fungicide molecule (Adepidyn)	A.N. Tripathi	-
29.	Evaluation of BIPM practices against sucking pests and fruit flies Zeugodacus cucurbitae in bitter gourd (AICRP on Biological control of crop pests)	J. Halder	-

Distinguished Visitors

Annexure IV

Dr. Panjab Singh Ex-Secretary, DARE & DG (ICAR)	08 January, 2022
Dr. Sanjay Kumar Director, ICAR-IISS, Mau	08 January, 2022
Sh. C.B. Singh AGM, APEDA, Varanasi	08 January, 2022

Dr. A.K. Singh DDG (Horticulture Science), ICAR, New Delhi	2 February, 2022
Dr. Vikramaditya Pandey ADG I/C, ICAR, New Delhi	2 February, 2022
Dr. Ramesh Chand Director, Institute of Agricultural Sciences, B.H.U.	2 February, 2022
Dr. M.N. Singh Professor, Institute of Agricultural Sciences, B.H.U., Varanasi.	10 February, 2022
Mr. Yashoda Nand Gupta Representative of Ms. Holten King Company, Una, Himachal Pradesh	05 April, 2022
Dr. Rachna Sharma Government Women's College, B.L.W., Varanasi	05 September, 2022
Dr. Abhilaksh Likhi Additional Secretary, Ministry of Agriculture and Welfare, Government of India	22 September, 2022
Dr. Prabhat Kumar Commissioner Horticulture, Government of India	22 September, 2022
Shri. Tarannum Kadarbhai Liaison Officer Indo-Dutch COEs	22 September, 2022
Dr. A.K. Singh DDG (Horticulture Science), ICAR, New Delhi	28 September, 2022
Dr. Major Singh Member, A.S.R.B., New Delhi	28 September, 2022
Dr. Mathura Rai Former Director, ICAR-IIVR, Varanasi	28 September, 2022
Dr. P.S. Naik Former Director, ICAR-IIVR, Varanasi	28 September, 2022
Shri. Surya Pratap Shahi Hon'ble Minister for Agriculture, Agricultural Education and Research, Govt. of U.P.	07 November 2022
Shri. Dinesh Pratap Singh Hon'ble Minister of Horticulture, Agricultural Marketing, Agricultural Foreign Trade and Agricultural Export, Govt. of U.P	07 November 2022
Shri. Baldev Singh Aulakh Hon'ble Minister of State for Agriculture, Agricultural Education and Research, Govt. of U.P.	07 November 2022
Shri. Dharmpal Singh Hon'ble Minister of Animal Husbandry and Dairy Development, Govt. of U.P.	07 November 2022
Dr. Himanshu Pathak Secretary, DARE and DG, ICAR, New Delhi	07 November 2022
Shri. Manoj Kumar Singh Additional Secretary (Rural Development and Panchayati Raj) and Agriculture Production Commissioner, Govt. of U.P.	07 November 2022
Vice-Chancellors of various Agricultural Universities of Bihar, Jharkhand and Uttar Pradesh	07 November 2022

Shri. Surya Pratap Shahi Hon'ble Minister for Agriculture, Agricultural Education and Research, Govt. of U.P.	20 December, 2022
Dr. Panjab Singh, Ex-Secretary, DARE & DG (ICAR)	20 December, 2022
Dr. A.K. Singh, DDG (Horticulture), ICAR, New Delhi	20 December, 2022

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वाराणसी - २२१३०५

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