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वार्षिक प्रतिवेदन
Annual Report

2020

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

In India, agriculture is hailed as one of the vital drivers of economic growth. However, nationwide lockdown imposed because of Covid-19 outbreak in India was a huge economic setback. The lockdown posed serious challenges to economic growth. Surprisingly, agriculture was the only sector to register a positive growth of 3.4% during Quarter-I (April-June, 2020). Just as India's food grain output witnessed a record surge (308.65 MT) despite challenges posed by Covid-19, the country's horticulture production too is likely to touch an all-time high of 329.86 million tonnes (MT) in 2020-21. The overall output of vegetables is estimated to be 196.27 million tonnes (growth of 4.42 per cent) as compared to 188.28 million tonnes in the previous year. Like all other crises, the present crisis too has a silver lining as it created opportunities in the food supply chain network, especially in vegetables.

The important institutional milestones which occurred in 2020 includes notification of five varieties and hybrids developed at this institute at National level by CVRC. To further strengthen the breeding programmes for development of trait-specific varieties, the germplasm holding of the Institute was enriched. Vegetable varieties resistant to major pests & diseases and for improved yield attributes in tomato, cherry tomato, chilli, pea, cowpea, Lu a, melons, okra, pumpkin and underutilized vegetables are being bred under Mega programme Integrated Gene Management. Under Biotechnological Interventions, work on in-planta transformation of okra in the cultivar Kashi Kranti was initiated for development of Transgenic okra. A mapping population of 114 RILs of brinjal was phenotyped for 33 traits related to leaf, flower, fruit and plant morphology. Besides varietal improvement, several input use-e cient technologies for production of vegetables both under field and protected environment has been standardized such as training systems in polyhouse vegetables, development of crop group specific micronutrient formulations, organic nutrient management, vegetable grafting for enhanced productivity, weed management etc. Under Mega Programme Integrated Plant Health Management, a gamut of organic, bioagents, chemical and integrated pest management modules were tested for keeping the pest populations below the economic threshold level and to provide choices to the growers. In addition, more than 19380.45 kg of quality seeds which includes 3283.0 kg of breeder seeds has been produced under the Mega Programme Seed Enhancement in Vegetables. The Entrepreneurship Development Programme of the Institute has ushered, especially, the young entrepreneurs to profitable ventures of vegetable production. The institute has also expanded its outreach activities under SCSP, TSP and in NEH region covering Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Sikkim, Meghalaya and Tripura states.

Our accomplishments in 2020 were possible because of the continuous encouragement, guidance and support of the senior o cials of ICAR. I place on record my deep sense of gratitude to Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR, Dr. A.K. Singh, DDG (Hort.), ICAR, and Dr. V. Pandey, 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 sta members of this Institute whose sincere e orts 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 Divisions, KVK's, Administration, Accounts & Other sta , especially, Dr. P. M. Singh, Head (I/C) Crop Improvement Division and Chairman, PME Cell, ICAR-IIVR and his team in shaping this publication, are gratefully acknowledged

Jagdish Singh
Director

Varanasi
March 31, 2021

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Executive Summary

In order to increase production, productivity and utilization of vegetables for livelihood and nutritional security of the country, ICAR-Indian Institute of Vegetable Research has made concerted efforts in field of basic, applied and strategic research for vegetables through six Mega-programmes.

Under mega programme on Integreted Gene Management, the Institute is maintaining more than 6500 germplasm accessions of 44 major and minor vegetable crops. In collaboration with ICAR-NBPGR, scientist of the institute made exploration trip to different parts of the country for augmenting new germplasm in its kitty. During the year 2020, 355 accessions in 11 vegetable crops were provided to 14 organizations through Material Transfer Agreement (MTA) for research purpose.

Under genetic improvement of tomato, test hybrid VRTH-1118 yielded 59 tonnes/ha, having medium firm fruits and average fruit weight of 90-100 g. Work on pyramiding of disease resistance genes (ToLCV, RKN and LB) in tomato was further progressed and one *ty5* gene liked CAPS marker ty5-1 (*Hinf1*) and one Ty3 gene based marker *Ty3* SCAR1 were validated. Results of wide hybridization for resistance against *Alternaria solani* between collar rot resistant yellow fruited wild species and susceptible cultivated tomato, Hawaii 3998 indicated that the resistance may be controlled by a single recessive gene. Advance lines VRTKB-17 exhibited high β-carotene content in fruit (7.90 mg/100 g fruit weight) with yield of 34.1 t/ha.

In brinjal, a total 258 germplasm including 23 accessions of five related wild species of brinjal were maintained and evaluated. Round fruited type, IVBHR-20 and long fruited type IVBHL-24 performed better over checks in field evaluation. Among 91 tested germplasm/varieties/hybrids, IVBR-20, IVBHL-23 and IVBL-28 were found resistant against *Phomopsis* fruit rot.

In chilli, an inbred line IIVRC-18057 was found promising for yield and disease tolerance and it was submitted for multi-location testing. A7 X F5-112 and K. Anmol X Japani Longi were identified as promising hybrids in two consecutive years of station trial. Significant variability for anthracnose resistance was recorded in 250 RIL progenies of Pusa Jwala X IIVRC-452 (F_7) ranging from immune response to highly susceptible genotypes. Grafting and alternate grafting on resistant and susceptible combination of stock and scion in selected F_7 lines of BS 35 x Kashi Sinduri along with screening with universal primer confirmed inherent resistance of the RIL progenies against ChiLCV disease.

Under programme on genetic improvement of pea, VRPE-60 and VRPE-66 were identified as promising lines for early maturity group (November sowing). AMMI analysis of eight genotypes over four seasons indicated that VRPM-901-5 had high yield potential (176.22 q/ha) along with its greater yield stability. After screening of 78 pea germplasm for high temperature tolerance and suitability for early sowing; VRPE-29, VRPE-30, VRPE-964, VRPE-17 and VRPE-18 found promising for late September sowing. Single flower pea genotype VRPSel-17, and multiflower pea genotype VRPSel-3 (pink flower) and VRPSel-26 (purple flower) were identified which may be used in inheritance related studies.

Five Genotypes of vegetable cowpea collected last year were evaluated for yield and horticultural traits. A total of 11 F_1 cross combinations were made based on yield, quality and resistance to cowpea golden mosaic disease resistance.

In French bean, several segrgants of various genertions *viz.* VRBSEM-75 in F_8 and VRBSEM-200, VRBSEM-202, VRBSEM-17, VRBSEM- 206 in F_{10} & F_{11} were found promising for yield and pod quality and free from DYMV incidence in field condition. Indian bean entries VRBSEM-3 and VRBSEM-9 were identified in AICRP (VC) annual meeting.

In seed propagated gourds, bitter gourd lines VRBG-32 in small segment, VRBTG-2-1 in medium segment and VRBTG-2-1-1 long segment and VRBTG-37-1 in white fruited segement were found promising. Among gynoecious based hybrids, VRBTG-5(G) x

VRBTG-47-2 was found most promising for yield (3.35 kg/ plant). Advance line of bottle gourd, VRBG-6 was found promising for yield while cross VRBG-4 x VRBG-59 was highest yielder among tested hybrids. Among tested ash gourd genotypes, maximum yield per plant was reported in VRAG-50-1 (22.75 kg/plant).

Under genetic improvement of Luffa, Kashi Shreya x VRSG-17-31 among hybrids & VRSG-17-2 among advanced lines, were found promising for various horticultural traits and tolerance against Sponge Gourd Mosaic Virus and Downy Mildew disease under field condition. Ridge gourd germplasm VRRG-35 and hybrid VRRG-5A X VRRG-75-2016 were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downy Mildew disease under field condition. In Satputia, germplasm VRS-28-1 and hybrid VRS-1 x VRS-74-10-4 were found most promising for yield and horticultural traits.

In cucumber, germplasm line VRCU-12-18, advance lines VRCU Sel.-9-03 and hybrid VRCUH-19-02 were found promising based on their yielding abilty. Among 19 parthenocarpic cucmber lines evaluated, VRCUP-20-05-17 was found most promising for yield and horticultural traits whereas under protected condition, the most promising line was VRCUP-20-02. High variability for β carotene (3.73-4.83 mg/100g) was recorded among pumkin lines. Summer squash line VRSS-20-161 was found most promising for yield.

In melons, three advance lines of watermelon, two of round melon and one of long melon, were documented with NBPGR, New Delhi. Four new germplasm were augmented from Mirzapur (U.P) and Jaipur (Rajasthan). Based on the total yield and TSS of the watermelon fruits, hybrid VRW-8 x VRW-11, line VRW-513 (Mini segment), VRW-14-1(Yellow flesh), VRW-58 (Orange), VRW-53 and VRW-53-1 (Ice-box segment) were found most promising. VRW-514-1 (mini segment) was proposed for varietal identification at Institute Level. In round melon, maximum yield per plant was found in VRM-11-1 (0.97 kg) whereas in long melon, VRLM-1 (1.11 kg/plant) was found most promising line. Improved monoecious muskmelon line VRMM-170 and green fleshed muskmelon genotype VRMM-41 were found most promising for yield and high TSS content.

Under genetic improvement of okra, 10 new germplasm belonging to 4 species were augmented from diffrent parts of the country. Best performing okra hybrids found superior over the check in all aspects were VRO-120 × VRO-124 (green segment) and VROR-161× Kashi Lalima (red segment). The cut leaf okra genotypes VRO-120 and VRO-125 performed consistently for yield and viral disease tolerance along with stable expression of cut leaf morphology across the six seasons of evaluation. Sufficient intra and inter-specific variation was reported for the Fe, Mn, Zn and Ca content in the genus *Abelmochus.* Genotype IC506134 was identified for its non-dehiscent fruit types where fruits do not split open and seeds remain concealed within it. Biochemical analysis of symptomatic and asymptomatic okra plants infected with ELCV revealed that catalase was always lower in the resistant plants as compared to the susceptible plants of the same genotype.

In cole crops, several CMS based cauliflower hybrids viz. VRCF-41×VRCF-75-1, VRCF-41×VRCF-50 *etc* expressed 10-22% heterosis for curds at different temperatures. Tropical cabbage genotypes VRCAB-112, VRCAB-116 and VRCAB-111 were found promising for yield and curd quality traits. The F_1 crosses between trichome and non-trichome tropical kale genotypes indicated that the presence of trichomes on petiole and leaf lamina is governed by monogenic recessive gene. Radish genotypes Kashi Mooli-40, (white root); Kashi Lohit (red root); and VRRAD-134 (purple exterior) were found most promising for yield and quality traits. The most promising carrot genotypes with higher root yield and better quality were VRCAR-86 (red root); Kashi Krishna (black root), VRCAR-142 (orange root), VRCAR-154 (yellow root), VRCAR-160 (cream root) and VRCAR-107-1 (rainbow-type root).

Under biotechnological interventions including transgenics for managing stresses in vegetables, *in-planta* transformation of okra in the cultivar Kashi Kranti was initiated for development of Transgenic okra. A mapping population of 114 RILs of brinjal was phenotyped for 33 traits related to leaf, flower, fruit and plant morphology. Phenotypic data and genotyping information of RILs was analyzed using Composite Interval Mapping technique and 17 QTLs classified as 'major', were identified to be affecting fruit and yield-related components.

In underexploited and future vegetables, among 40 newly augmented accessions of Winged bean, maximum pod yield was recorded in EC 178282. Genotype VRWBH- 27-18, was identified as most promising for green pod yield and related traits while

genotype VRWB-69 was adjudged as best line for tuber yield and associated traits. Molecular characterization of winged bean germplasm through SCoT and IISR markers was performed for studying genetic diversity and population structure. Glabrous phenotype in vegetable soybean was found to be controlled by a single dominant gene. Several vegetable soybean genotypes *viz.*, AGS-339, AGS-447 etc. were found superior for various horticultural traits. Genotype VRCB-48 and VRCB-95 of cluster bean outperformed checks for second consecutive year and were included in AICRP (VC) IET trials. In faba bean, Muradabad-103, EC-628941, EC- 628929 and Cherry emerged as superior genotypes for yield, varietal purity and disease tolerance in 2nd consecutive year of testing. Seven genotypes of faba bean were evaluated for L-dopamine content in dry seed through HPLC and genotype EC-628921 was found with highest L-DOPA content (1.425mg/g dry seed). Among the 12 water chestnut genotypes evaluated, VRWC-1 was noted as promising genotype for dry matter content and fruit yield. Four new germplasm lines of lotus were augmented from different part of the country and Genotype VRL-1 was found promising for different horticultural traits. Water spinach genotypes *viz.* VRWS-1, VRWS-2 etc. were found promising for different horticultural traits. Sweet corn hybrid SC 19 × SC 27 was found most promising for yield and high TSS content. Two genotypes of beet leaf (Palak) VRPLK-2 and VRPLK-7 were documented with NBPGR, New Delhi. Bathua genotype VRCHE-7 with greenish-purple leaves was found promising for luxuriant plant growth and biomass yield. Two promising amaranthus genotypes VRAM-44 (red) and VRAM-308 (green) were submitted for IET varietal evaluation trials of AICRP (VC). Laipatta genotypes VRLP-8, VRLP-18 and VRLP-33 were found best performing in terms of late flowering and green yield.

Under vegetatively propagated and perennial vegetable crops, pointed gourd clones *viz.* VRPG-101, VRPG-103, VRPG-133 *etc.* were found most promising for fruit yield per plant. Teasel gourd genotypes VRSTG-17 and VRSTG-10, spine gourd genotypes VRSEG-118 and VRSEG-114, ivy gourd genotypes VRIG-17 and VRIG-25 were found best for fruit yield per plant. Maximum yield per plant was recorded in Basella genotype VRB-3. Among 22 moringa genotypes evaluated, highest fruiting was observed in the genotype VRMO-13 (1450 fruits).

This year, a total of eight varieties and one hybrid developed at ICAR-IIVR, Varanasi were identified by AICRP (VC) during its annual meeting held in Sepetember, 2020. Apart from this, 4 varieties (1 each of brijal, tomato, French bean and radish) were notified by Central Varietal Release Committee in its meeting held in October, 2020 for cultivation in different agro-climatic zones of the country.

Under mega programme on seed enhancement in vegetables, 19380.45 kg of seeds including 3283.00 kg breeder seeds and 43.45 kg hybrid seed of different vegetables varieties/hybrids was produced for distribution amongst the seed indenters and farmers. At the Regional Research Station, Sargatia, a total of 53565.30 kg wheat, paddy and vegetable seed were produced. In priming, coating, ovule conversion and seed enhancement related studies, seeds of Okra cv. Kashi Kranti primed with 0.5% of humic acid recorded significantly high field emergence and number of fruits per plant whereas plant height, pod dimensions (length and width) and number of seeds per fruit was unaffected. In pollination studies for seed augmentation in vegetables including support of honey bees, different pollinators visiting okra cv. Kashi Chaman flowers during peak flowering period were recorded and ants were found to be the major flower visitors followed by lepidopteran insects mainly moths and butterflies. Increase in pollinator visits was observed after the spray of pollinator attractants (combination of 5% sugar+5% jaggery+50ppm boron) which also significantly enhanced the seed yield and seed quality parameters. In studies related to drying and storage of vegetable seeds, after 36 month of storage, seeds stored with zeolite beads recorded highest speed of germination and vigour indices in radish cv Kashi Hans.

In the Division of Vegetable Production, studies carried out on technologies for protected vegetable production, gynoecious cucumber hybrids were evaluated which revealed that parthenocarpic cucumber Y-225 followed by Defender were suitable under protected conditions. Further, studies on influence of different training systems in cucumber under naturally ventilated polyhouse indicated that the umbrella system followed by the drape system and pinch system recorded significantly higher values for yield per plant. Performance of polyhouse tomato on different training system was observed which revealed that among different training systems, plants trained to two-stem recorded highest numbers of clusters and yield per plant. In Capsicum plants grown in a vertical

culture, two-stem system produced the good size and blocky shaped fruits with comparatively higher yield than one stem system. Among four muskmelon varieties, Kashi Madhu registered the highest yield of 3.35 kg/plant under protected conditions whereas pruning studies revealed 4-lateral system give highest yield in muskmelon.

Under cropping system studies, highest total productivity was obtained with cowpea-tomato-okra cropping sequence followed by okra-tomato-cowpea. Cowpea-Tomato-Okra cropping system was found profitable with highest BC ratio of 3.71.

In agronomic bio-fortification studies in vegetable crops, it was found that the micronutrient formulations significantly improved the yield and yield attributing parameters of cabbage and cauliflower. Foliar application of the micronutrient formulations significantly influenced the number of pods/plant and pod yield of cowpea and okra over control.

Under organic farming of vegetables (rabi season crops), using weed mat mulch produced highest yield (23.39 t/ha) of broccoli which was 43.4 and 20 percent higher over no mulch and paddy straw mulch, respectively. For tomato crop, among the organic manure treatments, highest yield (35.13t/ha) was recorded with application of FYM @25t/ha. Similarly, the highest yield of vegetable pea was recorded under application of FYM @ 20t/ha. For summer season vegetable crops, results revealed that application of NADEP Compost @ 25t/ha recorded highest yield in bottle gourd grown after pea and broccoli, respectively, which was significantly higher over inorganic treatment. Evaluation of different cropping systems indicated highest productivity in terms of wheat equivalent yield in bottle gourd-Pea-bottle gourd sequence with B:C ratio of 1.87.

Studies related with improving water productivity of vegetable crops through drip irrigation system revealed that maximum number of tomato fruits and yield was obtained with drip irrigation at 2 days interval with 100% ET. There was 30.5% and 33% less water used, in cabbage and cauliflower, respectively under drip irrigation at 100% ET as compared to conventional furrow irrigation system.

Inter-specific grafting study was carried out in tomato under polyhouse and in open field contition which revealed that TSS content enhanced by 11-36% over ungrafted control. Grafting study in tomato in open field condition using three brinjal rootstocks with three improved cultivars of tomato (Kashi Aman, Kashi Adarsh and Kashi Chayan) revealed that maximum number of fruits per plant were observed when these cultivars were grafted over brinjal rootstock IC-111056. Grafting study was also carried out in cucumber, bitter gourd and muskmelon using different inter-specific cucurbitaceous rootstocks. Maximum yield in cucumber, bitter gourd and muskmelon was recorded with sponge gourd as rootstock. Experimental findings of grafted pomato revealed that potato production ranged between 505 to 745.67 g while tomato production was in the range of 826-3090 g from single pomato plant.

For weed management, black polythene mulch recorded highest weed control efficiency in French bean, cowpea and okra. Among herbicide treatments in French bean, maximum weed control index was noted in Pendimethalin @750 g a.i /ha as pre- emergence followed by Imazethapyr @ 100g a.i. / ha as post emergence at 25 DAS.

In studies on conservation agriculture under vegetable based cropping system, results indicated that among different tillage practices, pod yield of pea var. Kashi Nandini was maximum under conventional tillage with residue mulch. For Okra var Kashi Kranti and in sweet corn, the yield was higher under crop residue mulch as compared to no mulch system.

To know the influence of polyamines on postharvest senescence and quality of high value vegetables, experimental results indicated that SPM @ 1.5 mM + chitosan (1%) was best treatment for most of the fruit quality parameters of cucumber. In bottle gourd, use of postharvest physical treatments such as intermittent warming and hot water were found be an effective and low cost technology for lowering the chilling injury during low temperature storage of bottle gourd.

With the objective of empowering rural youth for vegetable-based entrepreneurship, 50 young vegetable growers from East Champaran district of Bihar were trained in 21 days Entrepreneurship development programmee (EDP) at ICAR-IIVR, Varanasi and they were exposed to different avenues of vegetable production technologies and motivated to become entrepreneur in their respective field. During Economic impact assessment of IIVR developed technologies, it was observed that IIVR's okra varieties fetched consumer preference and better price in the market than

the okra hybrids of private companies because of the optimum fruit size and colour.

Among the different pest management modules evaluated on bottle gourd (cv. Kashi Ganga), module 2 (M2) *i.e.,* spraying of Dichlorvos @ 0.75 ml/lit during 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var *Kurstaki* @ 2 g /lit at 40 DAS, Imidacloprid @ 0.4 ml/lit at 50 DAS, *Lecanicillium lecanii* @ 5 g/lit at 60 DAS and Azadirachtin 0.03% @ 10 ml/lit at 70 DAS was found superior for reducing red pumpkin beetle, whitefly, white plume moth and mirid bugs population. Based on studies for dose optimization, phytotoxicity of chlorantraniliprole 18.5% SC as well as economics of use for controlling the shoot and fruit borer of brinjal, chlorantraniliprole at 40 g a.i. ha^{-1} was recommended.

In toxicological investigations on the novel and botanical insecticides, spinetoram, spinosad, emamectin benzoate, indoxacarb and chlorantraniliprole were recommended to manage diamond back moth and cabbage butterfly on rotational basis in the cabbage ecosystem. Experiments conducted for dose standardization of chlorantraniliprole 18.5 SC and fipronil 5 SC for the management of red pumpkin beetle and pumpkin caterpillar, *Diaphania indica* of cucumber indicated that Fipronil, @ 2 ml/L was found to be most effective with 83.18% (0.63 beetles/plant) reduction in red pumpkin beetle population. Chlorantraniliprole 18.5 SC @ 0.25 and 0.5 ml/L was significantly effective against *D. indica* with 94.01 and 93.19% reduction in larval population. Residue persistence and safety evaluation of chlorantraniliprole (18.5% SC) in okra fruits revealed that dissipation of chlorantraniliprole application took less time to reach the EU-MRL (0.60 mg kg^{-1}), hence this chemical can be used safely in okra crop for the management of insect pests. Moreover, this chemical did not pose any problem to the health of man and environment.

While investigating biological control of major vegetable insect pests, total five larval parasitoids, one pupal parasitoid and one hyperparasitoid were identified from ICAR-IIVR experimental farm. Bio-efficacy of different entomopathogenic fungi (EPF) alone and their 1:1 combination with neem oil (0.5%) at half of their recommended doses were evaluated against brinjal jassids (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*) which indicated that *Lecanicillium lecanii* @ 5 g/l was found most promising against jassids and whiteflies with maximum per cent reduction over control (PROC) 40.40 and 26.94, respectively. Similarly in Okra, *Lecanicillium lecanii* @ 5 g/l was found most promising against jassids and whiteflies. Biology and bionomics of tortoise beetle, *Cassida circumdata* was studied under laboratory conditions which revealed that *C. circumdata* had life cycle of 38.5 – 70.25 days and adults survived for 15 to 33 days with an average of 23.20±7.69 days.

During evaluation of different modules for management of fungal diseases of tomato, significantly lowest late blight severity (65.97%) was recorded in integrated module comprising one spray of copper oxychloride @0.3% after 30 days of transplanting + one spray of mancozeb @0.2.5% at flowering to fruit setting stage + one spray of cymoxanil 8% + mancozeb 64% @0.2.5% on late blight appearance, however, the highest total yield as well as total marketable yield was recorded in biological module (T2). Artificial screening of tomato germplasm lines/ advanced lines against fusarium wilt indicated that few lines like VRT-02(PC), VRTH-H-5, VRTH-16-74 and 17-163 were resistant with PDI value between 4 to 10 % only. In another set of similar experiment using 24 days old seedlings of 20 tomato lines and hybrids, VRTH16-75 and Kashi Chayan were found moderately resistant. Among seven *Trichoderma* sp., three i.e. *Trichoderma asperllum*, TCV-2 and TTV-2 were found most potential under *in vitro* dual culture antagonism against *Sclerotium rolfsii*, *Phythium aphanidermatum*, *Fusarium oxysporum*, *Macrophomina phaseolina* and *Rhizoctonia solani.* Mass multiplication of talc-based *Trichoderma asperellum* was done and properties were studied for its potential use as bioagent. *Colletotrichum acutatum* was identified as causal agent for new emerging disease in chilli crop which is is seed borne and spreading in chilli growing area of this region.

In bio-prospecting of microbial agents, talc based formulation of bioagents having *Actinomyces* sp. (IIVR-N1.2), *Bacillus subtilis* (IIVR- CRB7) and *Trichoderma asperellum* (IIVR) as components, were found to be effective in controlling incidence of nursery diseases (damping off and bacterial blight) in nursery of tomato, chilli, cabbage and cauliflower. Several brinjal lines *viz.* VBVR-20-81-6, IVBR-21-B1-7, etc. were found free from *Sclerotinia rot* while screening and scoring the brinjal germplasm against Sclerotinia blight. Recording of incidence of late blight on organic tomato production revealed lowest incidence of late blight (63%) in comparison to control (90%) with treatment T1-Vermicompost in organic tomato production in block –II.

During evaluation of different management modules against major bacterial disease of tomato, lowest late blight (*Phytophthora infestans*) incidence, PDI (57.66) was recorded with chemical module in tomato (cv. Kashi Aman) however all treatments including control were found free from bacterial blight. Effectiveness of bacterial bio-agents, fungicides and bactericides against bacterial diseases on cabbage cv. CAB-111 was studied and highest cabbage yield (17.85 t/ha) was recorded with chemical module (I- copper oxychloride 50 WP @ 0.3%; II-spray streptocycline (9:1) @ 150 ppm, III-copper hydroxide 53.8 DF @ 0.2%, IV-azoxystrobin 23 SC @ 0.1% applied at 20 DAT and 4 subsequent sprays done after 20 days of interval from first spray). Evaluation of seed health and detection of seed borne pathogens in vegetable crop was performed and important seed borne fungal genera namely *Alternaria*, *Colletotrichum*, *Sclerotinia*, *Macrophomina*, *Phoma*, *Phomopsis* and bacterial genera *Pseudomonas*, *Xanthomonas* were identified. Newly isolated Trichoderma culture was screened against soil borne pathogenic fungi such as *Sclerotinia sclerotiorum*, *Sclerotium rolfsii* and *Macrophomina phaseolina* including *Fusarium* sp. by dual culture technique and *Trichoderma* species was found to be effective biocontrol agent against *F. oxysporum* only.

Under the studies on characterization of viruses infecting vegetable crops and their management, phylogenetic analysis of viruses infecting cucurbit crops revealed the presence of Cucumovirus, Potyvirus, Polerovirus Tobamovirus, Orthotospovirus and Begomovirus. Sequence analysis based on the nucleotide sequence of the 2a fragment reveled that CMV isolate infecting cucurbits had shared ancestry with the CMV reported on tomato, snake gourd, bottle gourd, pepper and banana from India. Complete coat protein gene of Watermelon bud necrosis virus (WBNV) and Cucurbit aphid-borne yellow virus isolates infecting round melon plants and watermelon respectively, were amplified and cloned into pTZ57r/T vector system and transformed into E.coli DH10β. Sequence analysis of total RNA from symptomatic plants of Satputia (*Luffa hermaphrodita*) exhibiting symptoms resembling virus infection, such as yellowing and mild downward rolling of leaves, revealed 99% identity with luffa aphid-borne yellow mosaic virus isolates reported earlier from different part of the world. It was first confirmed report for the infection of polerovirus in satputia from India.

For management of viral diseases in tomato, among five different modules tested, integrated module (T4): Seed treatment with thiomethoxam; seedling root dip in talc based CRB-7 @ 1% for 30 minutes after 21 days after sowing; black silver mulching; border cropping with bajra; soil drenching with humic acid@5ml/l at 25 DAT; installation of yellow sticky traps; foliar sprays of micronutrient @ 0.3% twice at 30 days interval; rotational foliar spray of *Beauveria bassiana*(5g/l), cyantriliprole(1.8ml/l), spiromesifen (1.25ml/l), salicylic acid (2mM), thiomethoxam (0.35g/l), neem oil(0.3%), thiomethoxam+lambdacyhalothrin (0.25ml/l) and chlorantraniliprole+thiomethoxam (0.3ml/l) at 10 days interval, was found effective in reducing tomato leaf curl disease incidence and improving yield of tomato (cv. Kashi Amrit).

Population dynamics of major insect pests of different cucurbitaceous vegetables showed that maximum incidence of red pumpkin beetle, *Diaphania indica* and melon weevil was observed on different cucurbit vegetable crops. The highest incidence of red pumpkin beetle was observed on bottle gourd during 46th SMW (55.53/plant/week) followed by pumpkin during 48th SMW (45.93/plant/week). During summer of 2020, maximum incidence of red pumpkin beetle, pumpkin caterpillar (*Diaphania indica*), melon weevil, thrips, whiteflies and fruit damage by cucurbit fruit fly was observed. The dynamics of brinjal shoot and fruit borer (BSFB), *L. orbonalis* in brinjal was recorded by installing sex pheromone and large fluctuation in the incidence of *L. orbonalis* population was observed with maximum moth catches noted from 9th SMW to 20th SMW. Similarly, population dynamics of S. *litura* majorly infesting tomato, cabbage and cauliflower was studied and considerable fluctuation in the moth catches in the pheromone trap was observed during the study period. Laboratory bioassay on three kale germplasms with different densities of trichomes conducted to study the feeding preference of 3rd instar larvae of diamond back moth, *Plutella xylostella* and *Spodoptera litura* indicated that DBM and *S. litura* larvae preferred to feed more on young leaves of F_1 hybrid with no/less /sparse trichome.

For mapping and characterization of phytoplasma infecting vegetable crops and their management, samples of symptomatic brinjal plants were collected from Rajasthan, Andhra Pradesh, Tamil Nadu, Punjab, Maharashtra and Uttar Pradesh and nested PCR amplification of 16S rDNA region of phytoplasma using

universal primer was performed to confirm the presence of phytoplasma.

For bio-management of postharvest diseases, isolation of postharvest pathogens were carried out from unhealthy brinjal fruit collected from the market and based on the colony morphology, the pathogen was identified to be *Rhizopus stolonifera*. The isolated fungal pathogen culture could produce disease symptoms in the healthy surface sterilized brinjal fruit. Postharvest fungal pathogen *Rhizopus* were tested against already available potential biocontrol agents in dual culture plate assay. Fungal biocontrol agents of the genus Trichoderma were found to be more effective against the fungal pathogen Rhizopus. Bioagent Tasp1 was most effective and could inhibit mycelial growth of *Rhizopus* by 98.50% followed by TCV2 (87.51%) and TTV2 (83.51%). While screening of Trichoderma against major plant pathogens (*Macrophomina*, *Pythium*, *Sclerotium rolfsii*, *Rhizoctonia solani* and *Fusarium*), among six Trichoderma isolates tested against five major pathogen of vegetable crops, isolate TCV2 was found to be the most effective against all the fungus pathogen.

Studies on residue dynamics, safety evaluation and decontamination of chlorantraniliprole was conducted and a simple method for the estimation of chlorantraniliprole by GC-µECD, 63Ni was evolved. Residue dissipation of chlorantraniliprole (18.50% SC) in brinjal fruits revealed that half-lives of chlorantraniliprole residue in brinjal fruits were 1.82 days, 1.40 days and 2.78 for RD half, RD and DD, respectively.

कार्यकारी सारांश

देश की आजीविका और पोषण सुरक्षा सुनिश्चित करने की दिशा में सब्जियों की उत्पादन, उत्पादकता और उपयोग को बढ़ाने के लिए, भाकृअनुप- भारतीय सब्जी अनुसंधान संस्थान ने छह वृहद् परियोजनाओं के माध्यम से सब्जियों के लिए बुनियादी, प्रायोगिक और रणनीतिक अनुसंधान के क्षेत्र में ठोस प्रयास किए हैं।

एकीकृत जीन प्रबंधन पर वृहद् कार्यक्रम के तहत, संस्थान 44 प्रमुख और अल्प-दोहित सब्जी फसलों के 6500 से अधिक जननद्रव्यों का अनुरक्षण कर रहा है। संस्थान के वैज्ञानिकों ने जननद्रव्य भण्डार में वृद्धि हेतु भाकृअनुप-राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो के सहयोग से देश के विभिन्न हिस्सों में अन्वेषण यात्राएं कीं। वर्ष 2020 के दौरान, सामग्री हस्तांतरण समझौते (एमटीए) के माध्यम से 14 संगठनों को अनुसंधान के लिए 11 सब्जी फसलों के 355 जननद्रव्य प्रदान किए गए।

टमाटर के आनुवंशिक सुधार के तहत, मध्यम कड़े फल और 90-100 ग्राम औसत फल वजन वाले परीक्षण संकर वीआरटीएच-1118 से 59 टन/हे. का फल उत्पादन प्राप्त हुआ। टमाटर में रोग प्रतिरोधक जीन (टीओएलसीवी, आरकेएन और एलबी) के पिरामिडिंग सम्बंधित कार्य को आगे बढ़ाया गया और एक ty5 जीन से सम्बंधित CAPS मार्कर ty5-1 (Hinf1) और एक Ty3 जीन आधारित मार्कर Ty3 SCAR1 की पुष्टि हुई। अल्टरनेरिया सोलानी के खिलाफ प्रतिरोध विकास हेतु कॉलर सड़न प्रतिरोधी पीले फल वाली जंगली प्रजातियों और खेती योग्य परन्तु अतिसंवेदनशील टमाटर की किस्म हवाई 3998 के बीच बाह्य-संकरण के परिणाम ने संकेत दिया कि प्रतिरोध एकल अप्रभावी जीन द्वारा नियंत्रित होता है। अग्रिम पंक्ति वीआरटीकेबी-17 के फलों में उच्च बीटा-कैरोटीन की मात्रा (7.90 मिलीग्राम/100 ग्राम फलों का वजन) तथा 34.1 टन/हे. की उपज प्राप्त हुई।

बैगन में, कुल 258 जननद्रव्यों, जिसमें बैगन की पांच संबंधित जंगली प्रजातियों के 23 प्रभेद शामिल हैं, का अनुरक्षण एवं मूल्यांकन किया गया। गोल फल वाले संकर किस्म आइवीबीएचआर-20 और लम्बे फल वाले आइवीबीएचएल-24 ने प्रक्षेत्र परीक्षण में नियंत्रण प्रजाति की तुलना में बेहतर प्रदर्शन किया। कुल 91 परीक्षित जननद्रव्यों /किस्मों/संकरों में आइवीबीआर -20, आइवीबीएल 23 और आइवीबीएल-28 फोमोसिस फल सड़न रोग के खिलाफ प्रतिरोधी पाए गए।

मिर्च में, एक अंतःप्रजात पंक्ति आईआइवीआरसी-18057 को उपज और रोग सहनशीलता के लिए आशाजनक पाया गया और इसे बहुस्थानिक परीक्षण के लिए चिन्हित किया गया। लगातार दो वर्षों के स्टेशन परीक्षण में ए7 X ऍफ़ ५-112 और काशी अनमोल X जापानी लोंगी को उत्कृष्ट संकरों के रूप में पहचाना गया। फल सड़न (एन्थ्रेक्नोज) प्रतिरोध के लिए पूसा ज्वाला X IIVRC-452 (F7) की 250 RIL संततियों में सार्थक विभिन्नता (पूर्ण प्रतिरोधी से लेकर अतिसंवेदनशील तक) दर्ज की गई। बीएस 35 x काशी सिंदूरी की चयनित ऍफ़ 7 पंक्तियों में मूलवृन्त और सांकुर के प्रतिरोधी और अतिसंवेदनशील संयोजन के उपयोग से ग्राफ्टिंग और वैकल्पिक ग्राफ्टिंग के साथ-साथ यूनिवर्सल प्राइमर के साथ स्क्रीनिंग (चयन) के द्वारा आरआईएल की संततियों में मिर्च के गुर्चा रोग के खिलाफ अंतर्निहित प्रतिरोध की पुष्टि हुई।

मटर के आनुवंशिक सुधार कार्यक्रम के तहत, वीआरपीई-60 और वीआरपीई-66 को शीघ्र परिपक्वता समूह (नवंबर बुवाई) के लिए आशाजनक पाया गया। चार मौसमों में आठ मटर के प्रभेदों के AMMI विश्लेषण ने संकेत दिया कि वीआरपीएम-901-5 में उच्च उपज क्षमता (176.22 क्विंटल / हेक्टेयर) के साथ-साथ इसकी उपज स्थिरता अधिक थी। उच्च तापमान सहनशीलता और जल्दी बुवाई की उपयुक्तता के लिए 78 मटर जननद्रव्यों की जांच के बाद; वीआरपीई-29, वीआरपीई -30, वीआरपीई -964, वीआरपीई -17 और वीआरपीई -18 सितंबर के अंत में बुवाई के लिए आशाजनक पाए गए। एकल पुष्प मटर जीनोटाइप वीआरपीसेल -17, और बहु-पुष्प मटर के प्रभेद वीआरपीसेल- 3 (गुलाबी फूल) और वीआरपीसेल-26 (बैंगनी फूल) की पहचान की गई, जिनका उपयोग वंशानुक्रम संबंधी अध्ययनों में किया जा सकता है।

पिछले वर्ष संग्रहित किए गए लोबिया के पांच जननद्रव्यों का उपज और बागवानी लक्षणों के लिए मूल्यांकन किया गया। उपज, गुणवत्ता और लोबिया गोल्डन मोज़ेक रोग प्रतिरोध के आधार पर कुल 11 ऍफ़-1 संकर संयोजन बनाए गए।

फ्रेंच बीन में, विभिन्न पीढ़ियों की कई पृथक्करण पंक्तियाँ जैसे कि ऍफ़-8 में वीआरबीएसईएम् -75 और ऍफ़-१० व् ऍफ़-११ में वीआरबीएसईएम् -200, वीआरबीएसईएम् -202, वीआरबीएसईएम् -17, वीआरबीएसईएम् -206 उपज और फली की गुणवत्ता के लिए आशाजनक और प्रक्षेत्र स्थिति में DYMV रोग से मुक्त पायी गयी। अ.भा.स.शो.प. (सब्जी फ़सल) की वार्षिक बैठक में सेम की वीआरबीएसईएम् -3 और वीआरबीएसईएम् -9 नामक प्रविष्टियों की पहचान की गई।

बीज प्रवर्धित गोर्ड्स फसलों के अंतर्गत, करेला में छोटे फल समूह में वीआरबीजी-32, मध्यम फल समूह में वीआरबीटीजी -2-1 और लंबे फल समूह में वीआरबीटीजी -2-1-1 और सफेद फल वाले सेगमेंट में वीआरबीटीजी -37-1 उत्कृष्ट पाए गए। गाइनोसियस आधारित संकरों में, वीआरबीटीजी-5(जी) x वीआरबीटीजी-47-2

उपज के लिए सबसे आशाजनक (3.35 किग्रा/पौधा) पाया गया। लौकी की उन्नत किस्म, वीआरबीजी-6 को उपज के लिए आशाजनक पाया गया, जबकि परीक्षित संकरों में वीआरबीजी-4 x वीआरबीजी-59 सबसे अधिक उपज देने वाला पाया गया। लौकी के परीक्षित जननद्रव्यों में वीआरएजी-50-1) में प्रति पौधा अधिकतम उपज (22.75 किग्रा/पौधे) दर्ज की गई।

लुफ्फा वर्गीय सब्जियों के आनुवंशिक सुधार के तहत, परीक्षित संकरों में काशी श्रेया x वीआरएसजी-17-31 और उन्नत लाइनों में वीआरएसजी-17-2, विभिन्न बागवानी लक्षणों और स्पंज गोर्ड मोज़ेक वायरस और मृदु रोमिल आसिता रोग के प्रति सहनशीलता के लिए आशाजनक पाए गए। नसदार तोरई के जननद्रव्य वीआरआरजी-35 और संकर वीआरआरजी -5A X वीआरआरजी -75-2016 को विभिन्न बागवानी लक्षणों के लिए आशाजनक पाया गया और प्रक्षेत्र स्थिति के तहत इसमें स्पंज गोर्ड मोज़ेक वायरस और मृदु रोमिल आसिता रोग के प्रति सहनशीलता पाई गई। सतपुतिया में, जननद्रव्य वीआरएस-28-1 और संकर वीआरएस-1 x वीआरएस-74-10-4 उपज और बागवानी लक्षणों के लिए उत्कृष्ट पाए गए।

खीरे की जननद्रव्य पंक्ति वीआरसीयू-12-18, उन्नत पंक्ति वीआरसीयू सेल.-9-03 और संकर वीआरसीयूएच-19-02 को उनकी उपज क्षमता के आधार पर आशाजनक पाया गया। मूल्यांकित की गई 1 9 पार्थेनोकार्पिक खीरे की लाइनों में, वीआरसीयूपी-20-05-17 को उपज और बागवानी लक्षणों के लिए सबसे उत्कृष्ट पाया गया, जबकि संरक्षित स्थिति के तहत वीआरसीयूपी-20-02 सबसे आशाजनक लाइन पाई गयी। कद्दू के विभिन्न प्रभेदों के बीच β कैरोटीन के लिए सार्थक विभिन्नता (3.73-4.83 मिलीग्राम/100 ग्राम) दर्ज की गई। चप्पन कद्दू की पंक्ति वीआरएसएस-20-161 को उपज के लिए सबसे अधिक आशाजनक पाया गया।

तरबूज की तीन अग्रिम पंक्तियाँ (दो गोल खरबूजे की और एक लंबी खरबूजे की) एनबीपीजीआर, नई दिल्ली में प्रलेखित की गई। मिर्जापुर (यूपी) और जयपुर (राजस्थान) जिलों से चार नए जननद्रव्य संवर्धित किए गए। फलों की कुल उपज और टीएसएस के आधार पर तरबूज के संकर वीआरडब्ल्यू -8 x वीआरडब्ल्यू -11, पंक्ति वीआरडब्ल्यू -513(मिनी सेगमेंट), वीआरडब्ल्यू -14-1 (पीला गूदा), वीआरडब्ल्यू -58 (नारंगी), वीआरडब्ल्यू -53 और वीआरडब्ल्यू -53-1 (आइस-बॉक्स सेगमेंट) सबसे आशाजनक पाए गए। संस्थान स्तर पर किस्मों की पहचान के लिए वीआरडब्ल्यू 514-1 (मिनी सेगमेंट) प्रस्तावित किया गया। टिंडे में प्रति पौधा अधिकतम उपज वीआरएम-11-1 (0.97 किग्रा) में पाई गई जबकि ककड़ी में वीआरएलएम-1 (1.11 किग्रा/पौधा) सबसे आशाजनक पंक्ति पाई गई। उन्नत मोनोएशियस खरबूजे की पंक्ति वीआरएमएम-170 और हरे गूदे वाली खरबूजे की जीनोटाइप वीआरएमएम -41 उच्च उपज और टीएसएस के लिए सबसे अधिक आशाजनक पाए गए।

भिंडी के आनुवंशिक सुधार के तहत देश के विभिन्न हिस्सों से 4 प्रजातियों के 10 नए जननद्रव्य संवर्धित किए गए। सर्वोत्कृष्ट प्रदर्शन करने वाले भिंडी के संकर वीआरओ-120 x वीआरओ-124 (हरा फल समूह) और वीआरओआर-161 × काशी लालिमा (लाल फल समूह) सभी पहलुओं में नियंत्रण प्रजाति से बेहतर पाए गए। कट लीफ समूह के भिन्डी के जननद्रव्य वीआरओ-120 और वीआरओ-125 छह ऋतुओं के मूल्यांकन में कट लीफ गुण की स्थिरता के साथ-साथ उपज और विषाणु जनित रोग सहिष्णुता के लिए लगातार उत्कृष्ट पाए गए। एबेलमोस्कस जीनस में Fe, Mn, Zn और Ca की मात्रा के लिए अन्तः एवं अंतर-प्रजाति स्तर पर सार्थक भिन्नता पाई गयी। आईसी 506134 जीनोटाइप की पहचान इसके अविघटित फलों के लिए की गई, जिसमें फल खुल कर नहीं फटते और बीज उसके भीतर छिपे रहते हैं।

गोभीवर्गीय फसलों में, कई कोशकीय नर बंध्य आधारित फूलगोभी के संकर जैसे वीआरसीएफ-41× वीआरसीएफ -75-1, वीआरसीएफ -41× वीआरसीएफ -50 आदि में विभिन्न तापमानों पर शीर्ष के लिए 10-22% संकर ओज़ प्राप्त हुआ। उष्णकटिबंधीय गोभी के प्रभेद वीआसीएबी-112, वीआसीएबी -116 और वीआसीएबी 111 उपज और शीर्ष गुणवत्ता लक्षणों के लिए आशाजनक पाए गए। ट्राइकोम युक्त और बिना ट्राईक़ोम वाले केल के प्रभेदों के बीच ऍफ़ 1 संकरण ने संकेत दिया कि डंठल और पत्ती पर ट्राइकोम की उपस्थिति एकल अप्रभावी जीन द्वारा नियंत्रित होती है। मूली के प्रभेद काशी मूली-40, (सफेद जड़); काशी लोहित (लाल जड़); और वीआरआरएडी-134 (बैंगनी बाहरी) उपज और गुणवत्ता के लक्षणों के लिए सबसे अधिक आशाजनक पाए गए। गाजर के प्रभेद वीआरसीएआर-86 (लाल जड़); काशी कृष्णा (काली जड़), वीआरसीएआर -142 (नारंगी जड़), वीआरसीएआर -154 (पीली जड़) उच्च जड़ उपज और बेहतर गुणवत्ता वाले सबसे आशाजनक पाए गए।

सब्जियों में तनाव के प्रबंधन के लिए ट्रांसजेनिक सहित जैव प्रौद्योगिकी तकनीक के तहत, ट्रांसजेनिक भिंडी के विकास के लिए काशी क्रांति किस्म में भिंडी के पौधे में रूपांतरण शुरू किया गया। बैंगन की 114 अन्तःप्रजात पंक्तियों (आरआईएल) का पत्ती, फूल, फल और पौधों की बाह्य-रूप से संबंधित 33 लक्षणों के मानचित्रण हेतु फेनोटाइप किया गया। आरआईएल के फेनोटाइपिक आंकड़ों और जीनोटाइपिंग जानकारी का कम्पोजिट इंटरवल मैपिंग तकनीक का उपयोग करके विश्लेषण किया गया और 17 क्यूटीएल को 'प्रमुख' श्रेणी में वर्गीकृत किया गया, जिन्हें फल और उपज से संबंधित घटकों को प्रभावित करने के लिए पहचाना गया था।

अल्प दोहित और भविष्य की सब्जियों के उन्नयन कार्यक्रम के तहत, पंखिया सेम के 40 नए संवर्धित जननद्रव्यों में, अधिकतम फली उपज ईसी 178282 जननद्रव्य में दर्ज की गई। जननद्रव्य वीआरडब्ल्यूबीएच -27-18 को हरी फली उपज और संबंधित लक्षणों के लिए सबसे उत्कृष्ट पाया गया, जबकि वीआरडब्ल्यूबी-69 को कंद उपज और संबंधित लक्षणों के लिए सर्वोत्तम पंक्ति के रूप में चयनित किया गया। आनुवंशिक विभिन्नता एवं जनसंख्या संरचना का अध्ययन करने के लिए SCoT और ISSR चिन्हकों के माध्यम से

पंखिया सेम के जननद्रव्यों का आणविक लक्षण किया गया। सब्जी सोयाबीन में ग्लैब्रस फेनोटाइप एक प्रमुख जीन द्वारा नियंत्रित पाया गया। कई सब्जी सोयाबीन के प्रभेद जैसे, एजीएस-339, एजीएस-447 आदि विभिन्न बागवानी लक्षणों के लिए बेहतर पाए गए। ग्वार के प्रभेद वीआरसीबी-48 और वीआरसीबी -95 ने लगातार दूसरे वर्ष उपज हेतु बेहतर प्रदर्शन किया और अ.भा.स.शो.प. (सब्जी फ़सल) परीक्षणों में शामिल किया गया। बाकला में, मुरादाबाद-103, ईसी-628941, ईसी- 628929 और चेरी लगातार दूसरे वर्ष परीक्षण के दौरान उपज, किस्मों की शुद्धता और रोग सहनशीलता के लिए बेहतर पाये गये। बाकला के सात प्रभेदों का एचपीएलसी के माध्यम से सूखे बीज में एल-डोपामिन की मात्रा ज्ञात करने के लिए मूल्यांकन किया गया और ईसी-628921 नामक प्रभेद में उच्चतम एल-डोपामिन की मात्रा (1.425 मिलीग्राम / ग्राम सूखे बीज) पाई गयी। मूल्यांकित किए गए सिंघाड़े के 12 प्रभेदों में, वीआरडब्ल्यूसी-1 को शुष्क पदार्थ की मात्रा और फल उपज के लिए उत्कृष्ट पाया गया। देश के विभिन्न हिस्सों से कमल की चार नई जर्मप्लाज्म लाइनों को संवर्धित किया गया और वीआरएल -1 को विभिन्न बागवानी लक्षणों के लिए आशाजनक पाया गया। करेमु साग में वीआरडब्ल्यूएस- 1 , वीआरडब्ल्यूएस-2 इत्यादि प्रभेद विभिन्न बागवानी लक्षणों के लिए आशाजनक पाए गए। स्वीट कॉर्न के संकर एससी 19 × एससी 27 को उपज और टीएसएस की मात्रा के लिए सबसे अधिक आशाजनक पाया गया। पालक के दो प्रभेदों वीआरपीएलके- 2 और वीआरपीएलके -7 को भाकृअनुप-राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो , नई दिल्ली में प्रलेखित किया गया। हरे-बैंगनी पत्तों वाला बथुआ का प्रभेद वीआरसीएचई-7 पौधों की प्रभावी वृद्धि और बायोमास के लिए आशाजनक पाया गया। अ.भा.स.शो.प. (सब्जी फ़सल) के आईईटी किस्म मूल्यांकन परीक्षणों के लिए बथुआ के दो आशाजनक प्रभेद वीआरएएम-44 (लाल) और वीआरएएम-308 (हरा) प्रदान किए गए। लाईपत्ता के प्रभेद वीआरएलपी-8, वीआरएलपी -18 और वीआरएलपी -33 देर से फूलने और हरी उपज जैसे गुणों हेतु सबसे उत्कृष्ट पाए गए।

परवल के कृन्तक वीआरपीजी-101, वीआरपीजी-103, वीआरपीजी-133 आदि प्रति पौधे फल उपज के लिए सबसे अधिक आशाजनक पाए गये। ककरोल के प्रभेद वीआरएसटीजी-17 और वीआरएसटीजी -10, करतोली के प्रभेद वीआरएसईजी-118 और वीआरएसईजी -114, कुंदरू के प्रभेद वीआरआईजी-17 और वीआरआईजी -25 प्रति पौध फल उपज के लिए सर्वश्रेष्ठ पाए गए। बासेला के प्रभेद वीआरबी-3 में प्रति पौधा अधिकतम उपज दर्ज की गई। मूल्यांकित किए गए सहजन के 22 प्रभेदों में, वीआरएम्ओ-13 में उच्चतम फलन (1450 फलिया) दर्ज किया गया।

इस वर्ष, सितंबर, 2020 में आयोजित वार्षिक बैठक के दौरान आईसीएआर-आईआईवीआर, वाराणसी में विकसित कुल आठ किस्मों और एक संकर की पहचान द्वारा की गई थी। इसके अलावा, अक्टूबर, 2020 में आयोजित बैठक में बैंगन, टमाटर, फरास बीन तथा मूली (प्रत्येक की एक) की 4 किस्मों को केंद्रीय किस्म विमोचन समिति द्वारा देश के विभिन्न कृषि-जलवायु क्षेत्रों में खेती के लिए अधिसूचित किया गया।

सब्जियों में बीज संवर्धन पर वृहद् कार्यक्रम के अंतर्गत, बीज मांगकर्ताओं और किसानों के बीच वितरण के लिए 19380.45 किलोग्राम बीज (जिसमें 3283.00 किलोग्राम ब्रीडर बीज और विभिन्न सब्जियों की किस्मों/संकरों के 43.45 किलोग्राम संकर बीज सम्मिलित है) का उत्पादन किया गया। क्षेत्रीय अनुसंधान केंद्र सरगटिया में कुल 53565.30 किलो गेहूं, धान और सब्जी बीज का उत्पादन किया गया। प्राइमिंग, कोटिंग, बीजांड रूपांतरण और बीज वृद्धि संबंधी अध्ययनों में, भिंडी के काशी क्रांति किस्म के बीज में 0.5% ह्यूमिक एसिड के उपचार से खेत में अंकुरण और प्रति पौधे फलों की संख्या में वृद्धि दर्ज की गई, जबकि पौधे की ऊंचाई, फली आयाम (लंबाई और चौड़ाई) और प्रति फल बीज की संख्या जैसे गुण अप्रभावित रहे। सब्जियों में मधुमक्खियों की सहायता से बीज संवर्धन के लिए परागण सम्बंधित अध्ययन में भिन्डी के काशी चमन किस्म के फूलों पर आने वाले वाले विभिन्न परागणकर्ता की गणना अधिकतम फूल की अवस्था के दौरान दर्ज किया गया था और चींटियों को प्रमुख फूल आगंतुकों के रूप में पाया गया था, जिसके बाद लेपिडोप्टेरान समूह के कीड़े मुख्य रूप से पतंगे और तितलियों का स्थान था। सब्जियों के बीजों के सुखाने और भंडारण से संबंधित अध्ययनों में, 36 महीने के भंडारण के बाद, जिओलाइट मोतियों के साथ संग्रहीत मूली की काशी हंस किस्म के बीजों में अंकुरण और शक्ति सूचकांकों की उच्चतम गति दर्ज की गयी।

सब्जी उत्पादन विभाग में, संरक्षित सब्जी उत्पादन हेतु प्रौद्योगिकियों पर किए गए अध्ययन के अंतर्गत गाइनोसियस संकर ककड़ी का मूल्यांकन किया गया, जिससे पता चला कि पार्थेनोकार्पिक ककड़ी वाई-225 और उसके बाद डिफेंडर प्रजाति संरक्षित परिस्थितियों में खेती हेतु उपयुक्त है। इसके अलावा, प्राकृतिक रूप से हवादार पॉलीहाउस के तहत ककड़ी में विभिन्न छंटाई प्रणालियों के प्रभाव पर अध्ययन से संकेत मिलता है कि अम्ब्रेला सिस्टम के बाद ड्रेप सिस्टम और पिंच सिस्टम से प्रति पौधे उपज में काफी सार्थक वृद्धि दर्ज हुई। विभिन्न छंटाई प्रणालियों पर पॉलीहाउस में टमाटर का प्रदर्शन देखा गया जिससे पता चला कि विभिन्न छंटाई प्रणालियों में, दो-तने वाले पौधों ने सबसे अधिक संख्या में क्लस्टर और प्रति पौधे उपज दर्ज की। शिमला मिर्च के पौधों को एक ऊर्ध्वाधर प्रणाली में उगाया गया तथा दो-तने वाले सिस्टम ने एक स्टेम सिस्टम की तुलना में तुलनात्मक रूप से अधिक उपज वाले अच्छे और चौकोर आकार के फल पैदा किए। खरबूजे की चार किस्मों में, काशी मधु ने संरक्षित परिस्थितियों में सबसे अधिक 3.35 किग्रा/पौधे की उपज दर्ज की, जबकि छंटाई अध्ययनों से पता चला कि 4-पार्श्व प्रणाली से खरबूजे में उच्चतम उपज प्राप्त होती है।

फसल प्रणाली अध्ययन के तहत, लोबिया-टमाटर-भिंडी फसल अनुक्रम के बाद भिंडी-टमाटर-लोबिया अनुक्रम में उच्चतम कुल उत्पादकता प्राप्त की गई। लोबिया-टमाटर-भिंडी फसल प्रणाली 3.71 के उच्चतम लाभ: लागत (बी:सी) अनुपात के साथ लाभदायक पाई गई।

सब्जी फसलों में कृषि संबंधी जैव-फोर्टिफिकेशन अध्ययनों में यह पाया गया कि सूक्ष्म पोषक तत्वों के सम्मिश्रणों के उपयोग से गोभी और फूलगोभी उपज में काफी सुधार हुआ। सूक्ष्म पोषक तत्वों के सम्मिश्रण का पत्ते पर छिड़काव करने से लोबिया और भिंडी की फली/पौधे और फली उपज की संख्या पर भी सार्थक प्रभाव पड़ा।

रबी मौसम की सब्जियों की जैविक खेती के तहत, वीड मैट मल्च का उपयोग करके ब्रोकली की उच्चतम उपज (23.39 टन / हेक्टेयर) का उत्पादन किया गया जो कि बिना पलवार और धान की पुआल की पलवार से क्रमशः 43.4 और 20 प्रतिशत अधिक थी। टमाटर की फसल के लिए, जैविक खाद उपचारों में, सबसे अधिक उपज (35.13 टन / हेक्टेयर) एफवाईएम @ 25 टन प्रति हेक्टेयर के उपचार के साथ दर्ज की गई। इसी प्रकार, मटर की उच्चतम उपज 20 टन/हेक्टेयर की दर से एफवाईएम के प्रयोग के तहत दर्ज की गई। ग्रीष्म ऋतु की सब्जी फसलों के लिए किये गए शोध परिणामों से पता चला है कि क्रमशः मटर और ब्रोकली के बाद उगाई जाने वाली लौकी में 25 टन/हेक्टेयर की दर से नाडेप कम्पोस्ट के प्रयोग ने उच्चतम उपज दर्ज की, जो कि अकार्बनिक उपचार से काफी अधिक थी। विभिन्न फसल प्रणालियों के मूल्यांकन के पश्चात 1.87 के बी: सी अनुपात के साथ लौकी-मटर-लौकी अनुक्रम में गेहूं के बराबर उपज के मामले में उच्चतम उत्पादकता का संकेत मिला।

ड्रिप सिंचाई प्रणाली के माध्यम से सब्जी फसलों की जल उत्पादकता में सुधार से संबंधित अध्ययनों से पता चला कि टमाटर की अधिकतम फल उपज 2 दिनों के अंतराल पर 100% ET के साथ ड्रिप सिंचाई से प्राप्त की गई थी। परंपरागत नाली सिंचाई प्रणाली की तुलना में पत्तागोभी और फूलगोभी में टपक सिंचाई के द्वारा 100% ET पर क्रमशः 30.5% और 33% कम पानी का उपयोग हुआ।

टमाटर में पॉलीहाउस के अन्दर और खुले मैदान में अंतर-जातीय ग्राफ्टिंग अध्ययन किया गया, जिसमें पता चला कि नियंत्रण (बिना ग्राफ्टिंग) की तुलना में ग्राफ्टिंग में टीएसएस की मात्रा में 11-36% की वृद्धि हुई। टमाटर की तीन उन्नत किस्मों (काशी अमन, काशी आदर्श और काशी चयन) के साथ तीन बैंगन रूटस्टॉक्स का उपयोग करके खुले प्रक्षेत्र की स्थिति में टमाटर में ग्राफ्टिंग अध्ययन से पता चला कि प्रति पौधे अधिकतम फल तब देखे गए जब इन किस्मों को बैंगन रूटस्टॉक IC-111056 पर ग्राफ्ट किया गया था। खीरा, करेला और खरबूजे में विभिन्न अंतर-जातीय कद्दुवर्गीय सब्जियों के रूटस्टॉक्स का उपयोग करके ग्राफ्टिंग अध्ययन भी किया गया । ककड़ी, करेला और खरबूजे में अधिकतम उपज नेनुआ के साथ रूटस्टॉक में दर्ज की गई थी। ग्राफ्टेड पोमैटो के प्रायोगिक निष्कर्षों से पता चला कि आलू का उत्पादन 505 से 745 ग्राम प्रति पौध के बीच था।

खरपतवार प्रबंधन के लिए, ब्लैक पॉलीथिन मल्च से फ्रेंच बीन, लोबिया और भिंडी में उच्चतम खरपतवार नियंत्रण दक्षता दर्ज हुई। फ्रेंच बीन में पूर्व-उद्भव के रूप में शाकनाशी उपचारों में, अधिकतम खरपतवार नियंत्रण सूचकांक पेंडीमेथालिन @ 750 ग्राम एआई / हेक्टेयर में नोट किया गया, इसके बाद नियंत्रण इमाजेथापायर @ 100 ग्राम एआई / हेक्टेयर 25 डीएएस (अंकुरण के बाद) में दर्ज किया गया।

सब्जी आधारित फसल प्रणाली के तहत संरक्षण कृषि पर अध्ययन में परिणामों ने संकेत दिया कि विभिन्न जुताई प्रथाओं में, मटर (काशी नंदिनी) की फली उपज पारंपरिक जुताई के तहत अवशेष मल्च के साथ अधिकतम रही। भिंडी की काशी क्रांति किस्म और स्वीट कॉर्न में बिना मल्च प्रणाली की तुलना में फसल अवशेष मल्च के तहत उपज अधिक पाई गयी।

कटाई के बाद उच्च मूल्य वाली सब्जियों की गुणवत्ता पर पॉलीमाइन के प्रभाव को जानने के लिए किये गए प्रयोगात्मक परिणामों ने संकेत दिया कि एसपीएम @ 1.5 एमएम + काईटोसैन (1%) खीरे के अधिकांश फल गुणवत्ता मानकों के लिए सबसे अच्छा उपचार था। लौकी में कटाई के बाद कम तापमान के भंडारण के दौरान शीतजनित हानि को कम करने के लिए रुक-रुक कर गर्म पानी का उपचार और गर्मी देने जैसे भौतिक उपचारों का उपयोग एक प्रभावी और कम लागत वाली तकनीक पाया गया।

सब्जी आधारित उद्यमिता के लिए ग्रामीण युवाओं को सशक्त बनाने के उद्देश्य से, बिहार के पूर्वी चंपारण जिले के 50 युवा सब्जी उत्पादकों को भाकृअनुप- भारतीय सब्जी अनुसंधान संस्थान, वाराणसी में 21 दिनों के उद्यमिता विकास कार्यक्रम (ईडीपी) में प्रशिक्षित किया गया और उन्हें सब्जी उत्पादन के विभिन्न प्रौद्योगिकियों/ तरीकों से अवगत कराया गया और अपने संबंधित क्षेत्र में उद्यमी बनने के लिए प्रेरित किया गया। भाकृअनुप-भारतीय सब्जी अनुसंधान संस्थान द्वारा विकसित प्रौद्योगिकियों के आर्थिक प्रभाव के मूल्यांकन के दौरान यह देखा गया कि भाकृअनुप-भारतीय सब्जी अनुसंधान संस्थान की भिंडी की किस्मों को उपभोक्ताओं ज्यादा पसंद करते है और बाजार में निजी कंपनियों के भिंडी संकरों की तुलना में इसे बेहतर कीमत मिलती है क्योंकि फल आकार और रंग आकर्षक होता है।

लौकी की काशी गंगा प्रजाति में विभिन्न कीट प्रबंधन मॉड्यूलों में मॉड्यूल-2 (डाईक्लोरोवास @ 0.75 मिली/लीटर बुवाई के 20 और 30 दिनों के दौरान, बैसिलस थुरिंजिएन्सिस कुर्स्ताकी @ 2 ग्रा /40 डीएएस पर, इमिडाक्लोप्रिड @ 0.4 मिली/लीटर 50 डीएएस पर, लेकेनिसिलियम लेकेनी @ 5 ग्राम / लीटर 60 डीएएस पर और अज़ादिरिक्टिन 0.03 % @ 10 मिली / लीटर 70 डीएएस पर) रेड पम्पकिन बीटल, व्हाइटफ्लाई, सफेद प्लम मोथ और मिरिड बग्स की आबादी को कम करने के लिए बेहतर उपचार पाया गया। मात्रा अनुकूलन तथा क्लोरेंट्रानिलिप्रोल 18.5% एससी की पादप-विषाक्तता के अध्ययन में उपयोग के अर्थशास्त्र के आधार पर बैंगन के तना और फल छेदक कीट को नियंत्रित करने के लिए, क्लोरेंट्रानिलिप्रोल की 40 ग्राम एआई प्रति हेक्टेयर की सिफारिश की गई।

नवीन और वानस्पतिक कीटनाशकों पर अविषालुता संबंधी अध्ययन में, गोभी पारिस्थितिकी तंत्र में हीरक पृष्ठ शलभ (डीबीएम) और कैबेज बटरफ्लाई के प्रबंधन हेतु स्पिनटोरम, स्पिनोसैड,

एमेमेक्टिन बेंजोएट, इंडोक्साकार्ब और क्लोरेंट्रानिलिप्रोल की चक्रीय आधार पर छिडकाव हेतु सिफारिश की गई। रेड पम्पकिन बीटल, कद्दू कैटरपिलर और खीरे के डायफेनिया इंडिका के प्रबंधन के लिए क्लोरेंट्रानिलिप्रोल 18.5 एससी और फाइप्रोनिल 5 एससी के खुराक मानकीकरण के लिए किए गए प्रयोग ने संकेत दिया कि फिप्रोनिल @ 2 मिली / लीटर 83.18% (0.63 बीटल / एल) बीटल आबादी में कमी के लिए सबसे प्रभावी पाया गया। । क्लोरेंट्रानिलिप्रोल 18.5 एससी @ 0.25 और 0.5 मिली/ली डायफेनिया इंडिका के खिलाफ काफी प्रभावी था, जिससे लार्वा की आबादी में क्रमशः 94.01 और 93.19% की कमी आई। भिंडी के फलों में क्लोरेंट्रानिलिप्रोल के अवशेष दृढ़ता और सुरक्षा मूल्यांकन (18.5% एससी) से पता चला कि क्लोरेंट्रानिलिप्रोल अवशेष अपव्यय को ईयू-एमआरएल (0.60 मिलीग्राम किग्रा) तक पहुंचने में कम समय लगता है, इसलिए इस रसायन का उपयोग भिंडी की फसल में कीटों के प्रबंधन के लिए सुरक्षित रूप से किया जा सकता है। इसके अलावा इस रसायन से मनुष्य और पर्यावरण के स्वास्थ्य के लिए कोई समस्या पैदा नहीं होती है।

प्रमुख सब्जी कीट पीड़कों के जैविक नियंत्रण की जांच के दौरान, भाकृअनुप-भारतीय सब्जी अनुसंधान संस्थान, वाराणसी के प्रायोगिक फार्म से कुल पांच लार्वा परजीवी, एक प्यूपल परजीवी और एक हाइपरपैरासिटोइड की पहचान की गई। विभिन्न एंटोमोपैथोजेनिक कवक (ईपीएफ) की अकेले एवं नीम के तेल (0.5%) के साथ 1:1 के संयोजन में बैंगन में जैसिड्स और व्हाइटफ्लाई के खिलाफ जैव-प्रभावकारिता और उनकी अनुशंसित खुराक की आधी मात्रा का मूल्यांकन किया गया, जिसने संकेत मिला कि लेकेनिसिलियम लेकेनी @ 5 ग्राम/ ली जैसिड्स और व्हाइटफ्लाइज़ के खिलाफ सबसे अधिक प्रभावी रहा, जिसमें नियंत्रण की तुलना में अधिकतम क्रमशः 40.40 और 26.94 प्रतिशत कमी (पीआरओसी) पाई गयी। इसी प्रकार भिंडी में, लेकेनिसिलियम लेकेनी @ 5 ग्राम/लीटर को जैसिड्स और सफ़ेद मक्खी के खिलाफ सबसे अधिक आशाजनक पाया गया। टोरटॉइज बीटल (कैसिडा सर्कमडाटा) के जीव विज्ञान और बायोनॉमिक्स का प्रयोगशाला परिस्थितियों में अध्ययन किया गया जिससे पता चला कि इसका जीवन काल 38.5 दिन से लेकर 70.25 दिन तक का होता है।

टमाटर में कवक रोगों के प्रबंधन के लिए विभिन्न मॉड्यूल के मूल्यांकन के दौरान, एकीकृत मॉड्यूल (ट्रांसप्लांट के 30 दिनों के बाद कॉपर ऑक्सीक्लोराइड का एक स्प्रे @ 0.3% + फूल आने के समय से फल बनने की अवस्था में मैनकोज़ेब @ 0.25 % का एक स्प्रे + साइमोक्सैनिल का एक स्प्रे 8% + मैनकोजेब 64% @0.25% लेट ब्लाइट दिखने पर) में काफी कम लेट ब्लाइट की समस्या (65.97%) दर्ज की गई, हालांकि, उच्चतम कुल उपज और साथ ही कुल बिक्री योग्य उपज जैविक मॉड्यूल (T2) में दर्ज की गई। फ्यूसेरियम विल्ट के खिलाफ टमाटर जर्मप्लाज्म लाइनों/उन्नत लाइनों की कृत्रिम जांच ने संकेत दिया कि वीआरटी-02 (पीसी), वीआरटीएच-एच-5, वीआरटीएच-16-74 और 17-163 जैसी कुछ लाइनें केवल 4 से 10% के बीच पीडीआई मूल्य के साथ प्रतिरोधी थीं। इसी तरह के 20 टमाटर लाइनों और संकरों के 24 दिन पुराने अंकुरों का उपयोग करते हुए प्रयोग करते हुए एक अन्य अध्ययन में, वीआरटीएच 16-75 और काशी चयन मध्यम प्रतिरोधी पाए गए। सात ट्राइकोडर्मा किस्मों में, तीन यानी ट्राइकोडर्मा एस्परलम, टीसीवी-2 और टीटीवी-2 इन विट्रो डुअल कल्चर विधि में स्क्लेरोटियम रॉल्फिस, फाइटियम एपेनडर्मेटम, फुसैरियम ऑक्सीस्पोरम, मैक्रोफोमिना फेजोलिना और राइजोक्टोनिया सोलानी के खिलाफ सबसे अधिक संभावित पाए गए। पाउडर-आधारित ट्राइकोडर्मा एस्परेलम का बड़े पैमाने पर गुणन किया गया और बायोएजेंट के रूप में इसके संभावित उपयोग के लिए गुणों का अध्ययन किया गया। कोलेटोट्रिचम एक्यूटैटम की पहचान मिर्च की फसल में नई उभरती हुई बीमारी के लिए कारक एजेंट के रूप में की गई थी, जिससे मिर्च उगाने वाले क्षेत्र में बीज जनित रोग फैल रहा है।

माइक्रोबियल एजेंटों के जैव-पूर्वेक्षण में, बायोएजेंट के पावडर आधारित फॉर्मूलेशन जिसमें एक्टिनोमाइसेस (IIVR-N1.2), बैसिलस सबटिलिस (IIVR-CRB7) और ट्राइकोडर्मा एस्परेलम (IIVR) घटकों के रूप मौजूद था , टमाटर, मिर्च, गोभी और फूलगोभी की नर्सरी में नर्सरी रोगों (डैम्पिंग ऑफ और बैक्टीरियल ब्लाइट) को नियंत्रित करने में प्रभावी पाए गए। स्क्लेरोटिनिया ब्लाइट के खिलाफ बैंगन जननद्रव्य की जांच और स्कोरिंग की गई तथा कई बैंगन की लाइनें जैसे वीबीवीआर-20-81-6, आईबीवीआर -21-B1-7, आदि स्क्लेरोटिनिया रॉट से मुक्त पाए गए। जैविक टमाटर उत्पादन में लेट ब्लाइट की घटनाओं के दर्ज आंकड़ों से पता चला कि ब्लॉक-II में टी 1-वर्मीकम्पोस्ट उपचार से जैविक टमाटर उत्पादन में नियंत्रण (90%) की तुलना में लेट ब्लाइट (63%) की सबसे कम घटनाएं सामने आईं।

टमाटर के प्रमुख जीवाणु रोग के खिलाफ विभिन्न प्रबंधन मॉड्यूल के मूल्यांकन के दौरान, टमाटर (प्रजाति काशी अमन) में सबसे कम लेट ब्लाइट (फाइटोफ्थोरा इन्फेस्टैन्स) , पीडीआई (57.66) रासायनिक मॉड्यूल के साथ दर्ज किया गया था, हालांकि नियंत्रण सहित सभी उपचार बैक्टीरियल ब्लाइट से मुक्त पाए गए। गोभी (सीएबी-111 प्रजाति) पर जीवाणु रोगों के खिलाफ जीवाणु जैव एजेंटों, कवकनाशी और जीवाणुनाशकों की प्रभावशीलता का अध्ययन किया गया था और उच्चतम गोभी उपज (17.85 टन/हेक्टेयर) रासायनिक मॉड्यूल (I-कॉपर ऑक्सीक्लोराइड 50 डब्ल्यूपी @ 0.3%; II- स्ट्रेप्टोसाइक्लिन का स्प्रे (9:1) @ 150 पीपीएम, III-कॉपर हाइड्रॉक्साइड 53.8 डीएफ @ 0.2%, IV-अजाक्सीत्रोबिन 23 एससी @ 0.1% 20 DAT पर और पहले स्प्रे से 20 दिनों के अंतराल के बाद 4 स्प्रे किए जाते हैं) के साथ दर्ज की गई थी। । बीज स्वास्थ्य का मूल्यांकन और सब्जी की फसल में बीज जनित रोगजनकों का पता लगाया गया और महत्वपूर्ण बीज जनित कवक जैसे अल्टरनेरिया, कोलेटोट्राईकम, स्क्लेरोटिनिया, मैक्रोफोमिना, फोमा, फोमोप्सिस और बैक्टीरियल जेनेरा स्यूडोमोनास, ज़ैंथोमोनास इत्यादि की पहचान की गई। नए पृथक ट्राइकोडर्मा कल्चर की मिट्टी से पैदा होने वाले रोगजनक कवक जैसे स्क्लेरोटिनिया स्क्लेरोटियोरम, स्क्लेरोटियम रॉल्फिस और मैक्रोफोमिना फेजोलिना,

फ्यूजैरियम के खिलाफ दोहरी संवर्धन तकनीक द्वारा जांच की गई और ट्राइकोडर्मा प्रजातियों को केवल फ्यूजैरियम ऑक्सीस्पोरम के खिलाफ प्रभावी जैव नियंत्रण एजेंट पाया गया।

सब्जी फसलों को संक्रमित करने वाले विषाणुओं के लक्षण वर्णन और उनके प्रबंधन के अध्ययन के तहत, कद्दुवर्गीय फसलों को संक्रमित करने वाले विषाणुओं के फ़ाइलोजेनेटिक विश्लेषण से कुकुमोवायरस, पोटीवायरस, पोलेरोवायरस टोबामोवायरस, ऑर्थोटोस्पोवायरस और बेगोमोवायरस की उपस्थिति का पता चला। 2ए खंड के न्यूक्लियोटाइड अनुक्रम पर आधारित अनुक्रम विश्लेषण से पता चला है कि कद्दुवर्गीय सब्जियों को संक्रमित करने वाले सीएमवी की भारत से टमाटर, स्नेक गोर्ड, लौकी, काली मिर्च और केले पर रिपोर्ट किए गए सीएमवी के साथ वंशावली मिलती है। वाटरमेलोन बड नेक्रोसिस वायरस (WBNV) के पूर्ण कोट प्रोटीन जीन और कुकुरबिट एफिड-बोर्न येलो वायरस को, जो क्रमशः टिंडे के पौधों और तरबूज को संक्रमित करते हैं, प्रवर्धित किए गया और pTZ57r / T वेक्टर सिस्टम में क्लोन किए गया और E.coli. DH10 β में रूपांतरित किया गया।सतपुतिया के रोगसूचक पौधों जिनमे वायरस के संक्रमण जैसे लक्षण प्रदर्शित होते हैं, जैसे कि पत्तियों का पीलापन और हल्का नीचे की ओर लुढ़कना,से कुल आरएनए के अनुक्रम विश्लेषण से लफ्फा एफिड-बोर्न येलो मोज़ेक वायरस आइसोलेट्स के साथ 99% समानता का पता चला है जो पहले विश्व के विभिन्न भागों में दर्ज किया गया था। भारत से सतपुतिया में पोलेरोवायरस के संक्रमण के लिए यह पहली बार पुष्टि की गई रिपोर्ट थी।

टमाटर में विषाणु जनित रोगों के प्रबंधन के लिए, परीक्षण किए गए पांच अलग-अलग मॉड्यूल में, एकीकृत मॉड्यूल (थायोमेथोक्सम के साथ बीज उपचार; बुवाई के 21 दिनों के बाद 30 मिनट के लिए पाउडर आधारित सीआरबी -7 @ 1% में अंकुर जड़ को डुबाना; ब्लैक सिल्वर मल्चिंग; बाजरा के साथ सीमा फसल; 25 डीएटी पर ह्यूमिक एसिड @ 5 मि.ली. /लीटर के साथ मिट्टी को भिगोना ; पीले चिपचिपे ट्रैप की स्थापना; सूक्ष्म पोषक तत्वों का 0.3% की दर से 30 दिनों के अंतराल पर दो बार पर्ण छिड़काव; ब्यूवेरिया बेसियाना (5 ग्राम/ली), सायंट्रिलिप्रोल (1.8 मिली/ली), स्पिरोमेसिफेन (1.25 मिली/ली), सैलिसिलिक एसिड (2 मिमी), थायोमेथोक्सम (0.35 ग्राम/ली), नीम का तेल (0.3%), थायोमेथोक्सम का पत्तियों पर चक्रीय छिडकाव + लैम्ब्डासाइलोथ्रिन (0 . 2 5 मिली/ ली) और क्लोरेंट्रानिलिप्रोल + थायोमेथोक्सम (0.3ml/l) को 10 दिनों के अंतराल पर) को टमाटर की पत्ती कर्ल रोग को कम करने और टमाटर (काशी अमृत) की उपज में सुधार करने में प्रभावी पाया गया।

विभिन्न कद्दुवर्गीय सब्जियों के प्रमुख कीट पीड़कों की जनसंख्या गतिकी से पता चलता है कि विभिन्न सब्जियों की फसलों पर रेड पम्पकिन बीटल, डायफेनिया इंडिका और खरबूजे की वीविल की अधिकतम संख्या देखी गई। लौकी में सबसे अधिक रेड पम्पकिन बीटल 46वें SMW (55.53/पौधे/सप्ताह) के दौरान देखा गया, इसके बाद कद्दू में 48वें SMW (45.93/पौधे/सप्ताह) के दौरान देखा गया। 2020 की गर्मियों के दौरान, रेड पम्पकिन बीटल, कैटरपिलर (डायफेनिया इंडिका), खरबूजे की घुन, थ्रिप्स, सफ़ेद मक्खी और ककड़ी फल मक्खी द्वारा अधिकतम फलों की क्षति पाई गई। बैगन तना एवं फल बेधक (बीएसएफबी) की गतिशीलता को बैंगन में सेक्स फेरोमोन लगा कर दर्ज किया गया और इसकी आबादी में बड़े उतार-चढ़ाव के साथ 9 वें एसएमडब्ल्यू से 20 वें एसएमडब्ल्यू तक अधिकतम मोथ कैच की संख्या दर्ज की गयी। इसी तरह, मुख्य रूप से टमाटर, गोभी और फूलगोभी को प्रभावित करने वाले एस लिटुरा की जनसंख्या गतिशीलता का अध्ययन किया गया था और अध्ययन अवधि के दौरान फेरोमोन ट्रैप में पकडे गए कीट संख्या में काफी उतार-चढ़ाव देखा गया। डायमंड बैक मोथ, प्लूटेला जाइलोस्टेला और स्पोडोप्टेरा लिटुरा के तीसरे इंस्टार लार्वा की फीडिंग वरीयता का अध्ययन करने के लिए ट्राइकोम के विभिन्न घनत्व वाले तीन केल के जननद्रव्यों पर प्रयोगशाला बायोएसे से संकेत मिला कि डीबीएम और एस लिटुरा के लार्वा संकर प्रजाति के अनुपस्थित/कम/विरल ट्राइकोम युक्त नए पत्तों को खाना अधिक पसंद करते हैं।

सब्जी फसलों को संक्रमित करने वाले फाइटोप्लाज्मा के मानचित्रण, लक्षण वर्णन और उनके प्रबंधन के लिए, राजस्थान, आंध्र प्रदेश, तमिलनाडु, पंजाब, महाराष्ट्र और उत्तर प्रदेश से रोगयुक्त बैंगन के पौधों के नमूने एकत्र किए गए और यूनिवर्सल प्राइमर का उपयोग करके फाइटोप्लाज्मा की उपस्थिति की पुष्टि करने के लिए इसके 16S rDNA क्षेत्र के नेस्टेड पीसीआर प्रवर्धन का कार्य किया गया। ।

कटाई के बाद की बीमारियों के जैव प्रबंधन के लिए, बाजार से एकत्र किए गए रोगयुक्त बैगन के फलों से कटाई के बाद के उत्पन्न होने वाले रोगजनकों को अलग किया गया और कॉलोनी बाह्यरूप के आधार पर, राइज़ोपस स्टोलोनिफेरा की रोगज़नक़ के रूप में पहचान की गई। इससे पृथक कवक स्वस्थ्य बैंगन के फल में रोग के लक्षण पैदा करने में सक्षम पाया गया। कटाई उपरांत रोगज़नक़ राइज़ोपस का ड्यूल कल्चर प्लेट विधि द्वारा उपलब्ध संभावित बायोकंट्रोल एजेंटों के खिलाफ परीक्षण किया गया। ट्राइकोडर्मा जीनस के फंगल बायोकंट्रोल एजेंट रोगज़नक़ राइज़ोपस के खिलाफ अधिक प्रभावी पाए गए। इनमें बायोकंट्रोल एजेंट Tasp1 सबसे प्रभावी था और यह राइज़ोपस की वृद्धि को 98.50% तक रोक सकता है, इसके बाद TCV2 (87.51%) और TTV2 (83.51%) को प्रभावी पाया गया।

क्लोरेंट्रानिलिप्रोल के अवशेषों की गतिशीलता, सुरक्षा मूल्यांकन और परिशोधन पर अध्ययन किया गया और GC-μECD, 63Ni द्वारा क्लोरेंट्रानिलिप्रोल के आकलन के लिए एक सरल विधि विकसित की गई। बैगन के फलों में क्लोरेंट्रानिलिप्रोल (18.50% एससी) के अवशेष अपव्यय से ज्ञात हुआ कि बैगन फलों में क्लोरेंट्रानिलिप्रोल अवशेषों का अर्ध आयु आरडी आधा, आरडी और डीडी के लिए क्रमशः 1.82 दिन, 1.40 दिन और 2.78 था।

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

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ICAR-Indian Institute of Vegetable Research

Division of Vegetable Improvement

MEGA PROGRAMME 1: INTEGRATED GENE MANAGEMENT

Programme Leader: Dr. P. M. Singh

Project 1.1: Genetic Improvement of Tomato

Germplasm Maintenance: Four tomato genotypes (AVTO1219, AVTO1314, AVTO1315 and AVTO1424) were introduced from World Vegetable Centre, Taiwan and their seed were multiplied. Twenty-three wild accessions and 335 cultivated tomato accessions were maintained.

Characterization of germplasm lines

Evaluation against ToLCV: Fifteen advanced tomato breeding lines including four Ty_3 containing lines (VRT12-1-3-2, VRT2-2-3-1, VRT12-1-4-11 and H-88-78-2), six Ty_3 and Ty_2 pyramided lines (VRT-18-1, VRT-6-1-4, VRT4-55-20, VRT4-20-8, VRT4-20-18 and VRT12-1-3), one Ty_2 containing line and five tomato line (H-88-78-1, H-88-78-2, H-88-78-3, H-88-78-4 and H-88-78-5) along with two susceptible lines (Kashi Amrit and Punjab Chhuhara) were evaluated against ToLCV under natural epiphytotic conditions (Mid-September, transplanting; Table 1, Fig. 1).

Table 1: Disease severity index of ToLCV tomato lines under natural epiphytotic conditions

S.No	Genotype	Mean Disease severity index*
1	VRT-18-1	0.133^{f}
2	VRT4-20-18	0.205^{ef}
3	VRT12-1-3	0.225^{ef}
4	VRT-6-1-4	0.297^{ef}
5	VRT4-20-8	0.307^{ef}
6	H-88-78-2	0.337^{ef}
7	VRT4-55-20	0.351^{ef}
8	VRT2-2-3-1	0.356^{ef}
9	VRT12-1-4-11	0.358^{ef}
10	VRT12-1-3-2	0.563^{def}
11	H-88-78-4 (VRT-78-4)	1.525^{cdef}
12	H-88-78-1	1.54^{cde}
13	VRT-8-6-1	1.774^{bcd}
14	H-88-78-3	1.896^{bcd}
15	H-88-78-5	2.318^{abc}
16	Kashi Amrit	2.967^{ab}
17	Punjab Chhuhara	3.547^{a}
	LSD	1.397

*Means with different letters indicate statistically significant difference at $P<0.05$ based on Tukey's HSD test

Fig. 1: Fruits of advanced breeding lines of tomato

Evaluation against *Alternaria solani:* Genotypes WIR-3928, LA-2157, LA-2325 and H-88-78-1 gave immune reaction to collar rot symptom when inoculated with *Alternaria solani* (4632) at 45 days after sowing while susceptible genotypes Punjab Chhuhara and Hawaii-3998 died due to collar and early blight (Fig. 2).

Fig. 2: Reaction of tomato genotypes against *A solani* inoculation after 45 days after sowing

Development and evaluation of hybrids:

A total of 48 hybrids having minimum *Ty*-2 or *Ty*-3 from any of the parents were evaluated in main tomato growing season (planted in October). The field trial also included ten hybrids of commercial companies and Arka Rakshak (public sector hybrid) as commercial checks. Yieldwise, test hybrids viz. VRTH810, VRTH813, VRTH818, VRTH812, VRTH1216, VRTH1013, VRTH1118, VRTH110 and VRTH1018 performed well. The test hybrid VRTH1118 yielded 59 tonnes/ha. The fruits of VRTH1118 hybrid showed medium firmness with a pericarp thickness of 0.5-0.6 cm and recorded average fruit weight of 90-100 g. The test hybrid was free from the ToLCV disease in the last two year trials. The hybrid was submitted for multilocation testing under AICRP-VC as Kashi Tomato Hybrid-2.

Pyramiding of genes for multiple disease resistance in tomato (ToLCV, LB and RKN): Based on marker assays, number of fruits and other visible horticultural characters 17 F_4 plants with *Ty2, Ty3, Ph2* and *Ph3* in different combinations and twelve F_6 families with *Ty3* or *Ty3+Ph2* or *Ty3+Ph3* were advanced to next generation. All the lines were evaluated under natural epiphytotic conditions for ToLCV (with September transplanting in 2020) along with susceptible check Punjab Chhuhara. Total twenty families were found free from the disease (VRT 20-2, VRT 20-4, VRT 20-5, VRT 20-8, VRT 20-9, VRT 20-10, VRT 20-13, VRT 20-14, VRT 20-17, VRT 20-21 to VRT 20-29, VRT 20-32 and VRT 20-32) and will be forwarded to next generation. Based on marker assays 103 F_3 plants with *Ty2, Mi1, Ph2* and *Ph3* in different combinations were advanced to next generation. Thirty F_4 families supposed to be having *Ty3* gene were advanced.

Pyramiding of *Ty* genes in Kashi Vishesh and Kashi Aman backgrounds: Pyramiding involved two backcross programs for two di erent recurrent parents *viz.* Kashi Vishesh and Kashi Aman under DBT sponsored project-Introgression of Begomovirus Resistance Genes in Tomato (*Solanum lycopersicum* L.) through MAS and Genomic Approaches. As the project ended in December 2019, the remaining work has been taken up under the institute project. This year, seeds from BC_3F_2 plants with targeted genes in di erent combinations were collected and BC_3F_3 families were grown and genotyping for the targeted genes is in progress. In the process, one *ty5* gene liked CAPS marker ty5-1 (*Hinf1*) and one *Ty3* gene based marker Ty3 SCAR1 were validated (Fig. 3).

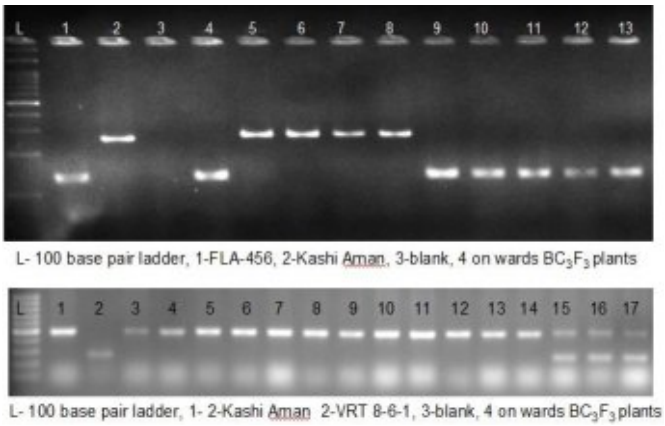


Fig. 3: Marker assays with ty5-1(*Hinf1*) and Ty3 SCAR1 in BC_3F_3 plants

Identification of QTL regions for ToLCV resistance using QTL-Seq approach: This work was also carry forward from the earlier DBT sponsored project. Polymorphic survey was done between susceptible Kashi Vishesh (H-86) and VRT-78-4 with twenty CAPS markers in combination with 16 enzymes around 40 Mb region of 11 chromosome of VRT-78-4. Five markers (TGS1476+ Xba, TGS2478+ MseI, TGS1449+ HinfI, C2At3g44890+ HinfI and C2At5g 51700+ DdeI) were found polymorphic.

Wide hybridization for heat stable root knot nematode resistance: Fifty F_3 plants from seven F_3 of Kashi Amrit × LA 2157 (*Solanum arcanum*) cross along with parents were screened against root knot nematode *Meloidogyne incognita* under pot condition by inoculating 2000 second stage infective juveniles per plant during April-May, 2019. Ten F_3 plants, each of two separate F_3 families had shown resistance and no segregation was observed. Seeds were collected from all the resistant plants. High temperatures during fruiting, resulted in very poor germination in F_4 generation. Only one F_4 plant reached flowering stage which was used in back cross programme. Seeds were collected from selfed fruits of the F_4 plant (Fig. 4).

Fig. 4: Reaction of Kashi Amrit and F_4 plant on artificial inoculation of *M. incognita*

Wide hybridization for resistance against *Alternaria solani*: In total, 147 F_2 seedlings of cross between collar rot resistant yellow fruited wild species and susceptible cultivated tomato, Hawaii 3998 along with parents were challenged with aggressive culture of A. *solani* and were scored for collar rot symptoms. Results indicated that the resistance may be controlled by a single recessive gene. In addition, around 175 back cross populations of VF36, Kashi Amrit and *Solanum chilense* (LA1972) were maintained.

Development of tomato varieties / hybrids for rainy season cultivation: Ninety genotypes comprising of advance lines (Developed at IIVR Varanasi), released varieties (From different parts of country) and elite lines (Received from NBPGR, N. Delhi) were evaluated in rainy season (Transplanting: first week of August) and winter season (Transplanting second week of October) both. The advance lines VRT-51 (53.3 t/ha), VRT-50 (52.9 t/ha) and VRT-34 (51.1 t/ha) were high yielder in rainy season and these advance lines were also the highest yielder with -2.10 %, 8.31 % and 13.7 % increase in yield as compared to yield of winter season grown crop, respectively (Table 2, Fig. 5).

Table 2: Performance of selected advance lines/ varieties for rainy season cultivation

Varieties	7th August transplanting		14th October transplanting		Increase/ decrease in yield (%)
	Yield (t/ha)	ToLCV incidence (in %)	Yield (t/ha)	TLCV incidence (in %)	
VRT-34	51.1	7.5	59.2	5	13.70
ToLCV-32	46.2	0	46.7	0	1.07
VRT-50	52.9	0	57.7	0	8.31
VRT-51	53.3	0	52.2	0	-2.10
VRT-01	46.2	0	29.6	0	6.85
VRT-30	44.4	0	35.7	0	2.48
ToLCV-16-1	41.8	0	33.6		-8.29
Sel.-7	30.6	40	24.3	65	-25.92
Kashi Aman	38.3	20	56.5	10	32.32
PB-1	42.5	0	52.3	0	18.73

VRT-30 VRT-34 VRT-16-1 VRT-51

Fig. 5: Advance lines of tomato for rainy season cultivation

Development of cherry tomato

Twenty-five advance lines (F_8) of cherry tomato comprising of 14 red fruited and 11 yellow fruited, were planted in open field condition at a spacing of 60 x 45 cm in second week of October. Out of 25 advance lines, the yellow fruited advance line VRCYT-3 (F_8) gave 23.5 t/ha yield whereas the red fruited advance line VRCRT-14 (F8) gave 20 t/ha yield (Table 3, Fig. 6). These lines were free from ToLCV incidence in field condition. Other advance lines showed high incidence of ToLCV ranging from 40-100%.

Table 3: Features of cherry tomato advance lines

Traits	VRCYT-(F8)	VRCRT-4(F8)
ToLCV incidence	5%	10%
Fruit shape	Oblong	Round
Fruit colour	Yellow	Red
Fruit weight (g)	7.6	5.82
Number of fruits / clusters	13.8	11.6
Yield (t/ha)	23.5	20.0
Pericarp thickness(cm)	0.30	0.24
TSS	5.81	7.14

Fig. 6: Promising advance lines of cherry tomato

Development of β-carotene rich tomato lines: Sixteen β-carotene lines were transplanted in second week of October at a spacing of 60x45cm for evaluation. Out of 16 advance lines, the advance lines VRTKB-17 (7.90 mg/100 g fruit weight) and VRTKB-14 (6.75 mg/100 g fruit weight) were exhibited high β-carotene with yield of 34.1 t/ha. These lines were also free from ToLCV incidence in field condition (Table 4, Fig. 7).

Table 4: Features of beta carotene rich tomato advance lines

Traits	VRTKB-14	VRTKB-4	VRTKB-2	VRTKB-17	VRTKB-11
ToLCV incidence	Free	20%	Free	Free	15%
Average fruit weight (g)	48.89	49.09	38.10	53.08	41.00
Yield (t/ha)	34.2	32.3	29.1	34.1	23.1
Pericarp thickness(cm)	0.51	0.52	0.54	0.49	0.48
TSS	4.31	5.6	4.86	4.21	4.10
Lycopene(mg/100)	1.04	0.14	0.140	0.405	0.73
Beta carotene	6.75	3.52	3.95	7.90	3.72

VRTKB-14 (F9) VRTKB-2(F9) VRTKB-17(F9)

Fig. 7: Promising advance lines of beta carotene rich tomato

Generation advancement: A total of 252 single plant selections were advanced. These comprised of F_2 (39), F_3 (37), F_4 (30) and F_6 (61) for developing variety for rainy season (tropical tomato) cultivation; F_8 (25) for cherry tomato; F_9 (13) for β-carotene rich tomato; F_2 (48) F_3 (14) and F_4 (23) for high temperature tolerance and F_3 (23) for moisture deficit tolerance.

Maintenance breeding: Nucleus seed of released varieties *viz.,* Kashi Amul, Kashi Adarsh, Kashi Aman, Kashi Anupam, Kashi Sharad, Kashi Hemant, Kashi Amrit, Kashi Vishesh and Kashi Chayan, and nucleus seed of parental lines of Kashi Abhiman were produced.

Project 1.2: Genetic Improvement of Brinjal

Maintenance and evaluation of germplasm: A total 258 germplasm including 23 accessions of five related wild species of brinjal were maintained and evaluated for further use in crop improvement program.

Evaluation of hybrids: 56 F_1 hybrids (22 round fruited and 34 long fruited types) targeting various market segments were evaluated for fruit quality and yield parameters along with standard checks. Among round fruited types, IVBHR-20 and IVBHR-21 performed better over checks, while among long fruited types IVBHL-24 performed best (Table 5 & 6; Fig. 8).

IVBHR-20 IVBHR-21 IVBHL-24

Fig. 8: Promising hybrids of brinjal

Evaluation of advance lines: Among advance lines, BCB 3-1 X BR-14 (IVBR-21) in round fruited type and Punjab Barasati X IVBL-9 (IVBL-29) in long fruited type were evaluated for two years and identified as promising for multi-location testing through AICRP (VC) trials (Fig. 9).

Table 5: Evaluation of hybrids: Round fruited (22)

Code for hybrids	Days to 50% Flowering (DAT)	Fruit Length (cm)	Fruit Width (cm)	Average Fruit Weight (g)	No. of Fruit/ Plant	Yield/ Plant (kg)	Projected Yield (q/ha)
BHR-B2-40 (IVBHR-20)	**58.0**	**10.2**	**8.9**	**340.2**	**23.8**	**8.1**	**860.3**
BHR-B2-41 (IVBHR-21)	**52.0**	**10.7**	**10.2**	**249.2**	**27.2**	**6.8**	**720.2**
BHR-B2-42	58.0	9.1	8.7	279.8	24.4	6.8	723.9
BHR--B2-36 (IVBHR-19)	58.0	10.9	9.2	385.0	18.3	7.0	748.6
BHR-B3-54	52.0	9.1	8.3	424.4	16.2	6.9	730.5
Pusa Hybrid-6 ©	**55.0**	**11.1**	**9.7**	**310.5**	**19.2**	**6.0**	**633.4**
Kashi Sandesh ©	**54.0**	**10.6**	**8.8**	**323.6**	**22.1**	**7.2**	**759.9**

Table 6: Evaluation of hybrids: Long fruited (34)

Code for hybrids	Days to 50% Flowering (DAT)	Fruit Length (cm)	Fruit Width (cm)	Average Fruit Weight (g)	No. of Fruit/ Plant	Yield/ Plant (kg)	Projected Yield (q/ha)
BHL-B4-81	52.0	19.8	3.5	83.2	72.2	6.0	638.2
BHL-B4-86 (IVBHL-24)	**54.0**	**25.7**	**3.6**	**110.4**	**71.1**	**7.8**	**834.1**
BHL-B4-87	56.0	21.2	3.1	128.6	54.5	7.0	744.7
IVBHL-21-B1-18	52.0	19.3	3.4	122.6	52.2	6.4	680.0
IVBHL-23-B2-20	58.0	14.3	3.8	116.2	58.8	6.8	726.0
Navina ©	52.0	15.3	3.2	111.8	32.2	3.6	382.5

Table 7: Evaluation of round fruited promising lines

Code for advance lines	Days to 50% Flowering (DAT)	Fruit Length (cm)	Fruit Width (cm)	Average Fruit Weight (g)	No. of Fruit/Plant	Yield/Plant (kg)	Projected Yield (q/ha)
IVBR-22	52.0	8.3	6.9	25.8	230.6	5.9	632.1
IVBR-23	54.0	8.4	7.2	23.2	255.8	5.9	630.5
IVBR-24	55.0	8.9	7.4	20.2	258.6	5.2	555.0
IVBR-21	**53.0**	**10.4**	**8.6**	**22.9**	**291.8**	**6.7**	**710.5**
IVBR-20	52.0	10.6	9.2	22.7	285.5	6.5	688.6
KS-224 ©	57.0	9.0	7.4	21.8	236.4	5.2	547.6
SWARNA MANI ©	56.0	10.3	8.3	26.9	221.5	6.0	633.1

Table 8: Evaluation of long fruited promising lines

Code for advance lines	Days to 50% Flowering (DAT)	Fruit Length (cm)	Fruit Width (cm)	Average Fruit Weight (g)	No. of Fruit/ Plant	Yield/ Plant (kg)	Projected Yield (q/ha)
IVBL-29-1	47	16.2	3.7	59.3	106.4	6.30952	670.4
IVBL-29	**48**	**17.9**	**3.8**	**65.4**	**112.8**	**7.37712**	**783.9**
IVBL-30	46	17.4	3.9	67.2	108.6	7.29792	775.4
IVBL-28	48	16.8	2.5	63.2	112.3	7.09736	754.1
IVBL-31	56	14.4	4.2	64.6	112.8	7.28688	774.2
Kashi Taru/ IVBL-9 ©	52	22.7	4.3	54.8	128.7	7.05276	749.3
Punjab Sadabahar-©	54	21.3	4.4	62.5	110.2	6.8875	731.8

New crosses attempted and Generation Advancement: 56 new crosses (22 in round and 34 in long fruit shapes) were attempted in the season, which shall be evaluated for fruit quality and yield parameters in the next season. 488 segregating populations (56:F1 to F2; 69: F2 to F3; 52: F3 to F4; 69: F4 to F5; 111: F5 to F6; 51:F6 to F7; 33: F7 to F8; 36: F8 to F9; 11: F9 to F10) were advanced to next higher generations. Ten promising lines were identified and seeds have been harvested from single plant for evaluation of promising lines in the next season.

IVBR-21

IVBL-29

Fig. 9: Promising advance lines of brinjal

Screening of brinjal germplasm against *Phomopsis* blight (PB): 91 germplasm (varieties, advanced breeding line, hybrids) and 28 Multinational Seed Companies based varieties/hybrids of brinjal were screened and scored against phomopsis fruit rot/blight. *Phomopsis vexans* fruit blight incidence recorded up to 37.66% on brinjal germplasm/varieties however, its highest incidence (56.33%) recorded on varieties obtained from Multinational Seed Companies. Pathogenicity test of isolates of *P. vexans* were performed followed by detached fruit method. Among tested germplasm/varieties IVBR-20, IVBHL-23 and IVBL-28 were found resistant against *Phomopsis* fruit rot (Table 7 & 8;).

Screening of brinjal germplasm against *Sclerotinia* blight (SB): 119 germplasm (varieties/advanced breeding line) including varieties of Multinational Companies of brinjal were screened against *Sclerotinia* rot caused by *Sclerotinia sclerotiorum*. *Sclerotinia* rot incidence upto 4.66% were recorded on brinjal germplasm/varieties. Out of which germplasm/variety viz. VBVR-20-81-6, IVBR-21-B1-7, IVBL-29-B1-16, IVBHL-20-B1-17, IVBHL-21-B1-18, IVBL-23-B2-22, IVBL-25-B2-23, IVBL-27-B2-25, IVBL-28-B2-26, IVBHR-B3-44,47,48,49,51,52, IVBHL-B3-59,62,6365,67, IVBHR-B2-36, IVBHL-B4, 81,84,86 and 87 were found free from *Sclerotinia* rot .

Entries for multi-location testing through AICRP (VC): Based on the performance in last two years, hybrids IVBHR-20, IVBHR-21 and IVBHL-24 were identified promising and were submitted for MLT. Among advance lines, BCB 3-1 X BR-14 (IVBR-21) in round fruited type and Punjab Barasati X IVBL-9

(IVBL-29) in long fruited type were identified as promising and were submitted for MLT.

Maintenance Breeding: Seeds of Kashi Sandesh (200 g), Kashi Taru (250 g), Kashi Komal (300 g), Kashi Prakash (250 g), Kashi Himani (350 g) and Kashi Uttam (500 g) have been multiplied for distribution and multi-location demonstration. Parental lines of hybrids were also multiplied.

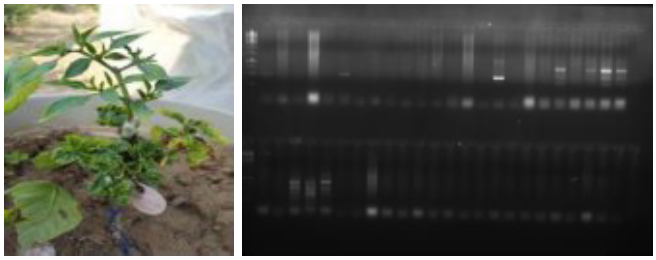
Project 1.3: Genetic Improvement of Chilli

Collection and maintenance of germplasm: Four hundred accessions of chillies and sweet pepper were planted and maintained which consisted of cultivated chillies (292), sweet pepper (30), stu pickle type chillies (35), paprika lines (10), wild accessions (22) and two genetic and nine sets of cytoplasmic-genetic male sterile lines. Chilli germplasm from North-Eastern part of the country were collected and evaluated. The significant chilli collections included Naga collection 18-1,18-4 and 18-5. Nucleus seeds of Kashi Anmol, Kashi Gaurav, Kashi Sinduri, Kashi Abha and Pusa Jwala and su cient amount of elite parental lines were also produced. Besides, 10 accessions of pickle type and ornamental chilli were also collected from the local area.

Confirmation of ChiLCV resistance in screen house: A RIL population was developed using resistant line BS-35, a natural interspecific derivative of *C. frutescens* and *C. chinense* and paprika variety Kashi Sinduri. During 2018-19, twenty virus free plants were isolated. These plants were symptom-less for leaf curl disease under heavy infestation in field condition. Their resistance was also confirmed through molecular screening with both universal primer for begomovirus as well as beta satellite particles. Out of 20, five lines along with susceptible check Pusa Jwala were grown in pots in glass house during May (o season). None of the plants had developed leaf curl symptoms which were also confirmed through molecular screening and seed was harvested.

Grafting experiment for confirmation of resistant against ChiLCV

Grafting and alternate grafting on resistant and susceptible combination of stock and scion in selected F_7 lines of BS 35 x Kashi Sinduri successfully done. Molecular screening with universal primer was performed for robust screening. Disease was found not found on resistant scions when grafted on susceptible stocks and vice-versa which confirmed inherent resistance of the plants against ChiLCV (Fig. 10).



Alernate grafting | Molcular screening for presence of viral particles

Fig. 10: Grafting experiment for screening chilli against ChiLCV disease

Study on unique mutants: During the year 2018-19, two unique chilli mutant plants were obtained namely 'leafy rosette' forming mutant and 'undi erentiated inflorescence'. The rosette forming mutant has now became stable for this trait as all the progenies are similar to parental line. F_1 cross of this line with tall chilli accession Kalyanpur Chanchal and Perennial have been successfully developed. F_2 and backcross generations involving both parents, were advanced for its potential utilization in genetic studies of many traits like plant height, fruit morphology, disease resistance etc. In case of 'undi erentiated inflorescence', the line was still segregating for this unique trait. Fruits setting was observed on grafted scion of normal sister plants which is researchable issue (Fig. 11). This mutant needs to be characterized through molecular studies for confirmation of genes involved in the process on un-di erentiation.

'undifferentiated inflorescence' | Grafting of normal scion yielded fruit

Fig. 11: Unique mutants of chilli

Evaluation and development of hybrids: A total of 40 F_1 hybrids including commercial hybrids from the

private seed sectors were evaluated for various characters. Significant variability was observed for di erent traits like plant height (40.8-88.6), fruit length (6.40 – 15.98 cm), fruit width (0.80 – 1.66 cm), fruits per plant (11.0-89.8) and ten fruit weight (25– 100 g). A total of 80 new hybrid combinations utilizing elite lines (including wild/weedy relatives) as pollen parent were also developed on the cytoplasmic male sterile and other potential combiners. A7 X F5-112 and K. Anmol X Japani Longi were identified as promising hybrids in two consecutive years of station trial and their seed will be multiplied in bulk for further testing in multi-location trials (Table 9).

Table 9: Variability among tested chilli hybrids for horticultural traits

Traits	F_1 hybrids
Fruit length (cm)	Sahyadri (17.3 cm) to GMS-3 × VR-339 (4.8 cm)
Fruit number/plant	A7 × EC 519636 (100) to Sahyadri (25)
Fruit width	GMS-3 × VR 339 (1.7 cm) to Rajlaxmi (0.8 cm)
10 fruit weight	Sahyadri (125 g) to Rajlaxmi (24 g)

Transfer of CMS in the elite chilli lines: This programme was started for the development of stable CMS/GMS lines with good combining ability. Crosses were made between selected CMS lines and elite male parents. 20 progenies of di erent combination are in di erent stages of CMS/GMS transfer involving elite parents *viz.* VR 339, Kalyanpur Chanchal, F5-112 and EC-519636. New CMS transfer programme involving 4 CMS lines has been started by making crosses with 10 elite parents.

Line development: Advanced population developed utilizing selected chilli lines, wild species and natural interspecific derivatives are being maintained in di erent generations for various traits. 14 F_2 populations (interspecific) have been advanced to next generation (Fig. 12). Lines in F_9 generation and onwards have been coded as IIVRC-19001 onwards. Several lines in F_6 to F_8 generations derived from diverse cross combinations have been advanced (Fig. 13). Apart from this four RIL populations *viz*. Kashi Sinduri x AKC 89/38 (F_{11}), Pusa Jwala X IIVRC-452 (F_8), Kashi Anmol x Japani Longi (F_7), PT-12-3 x Bhut Jolokia (F_{11}) and Kashi Sinduri X BS-35 (F_8) have been advanced to next generation and these RILs will be utilized for mapping of important quantitative traits such as resistance to thrips, mites, viral diseases and pungency (Table 10). Apart from this, various promising RIL progenies which have shown stable performance for consecutive two or more years have been identified and characterized. Their seeds have been multiplied for their submission to NBPGR for getting IC registration number.

Taiwan-2 x NG-4 VR 338 x EC 790571

Fig. 12: Promising F_2 population generated through inter-specific hybridization

RILs and Advance lines for IC registration: Advanced RILs from K. Sinduri x AKC89/38 [23 nos.] and PT-12-3 x Bhoot Jolokia [4 nos.]. In addition, the IC numbers to be obtained for 37 promising advance lines of chilli with stable performance.

Kashi Anmol x Japani Longi, F_6 R Line x Kalyanpur Chanchal, F_6

Fig. 13: Promising advanced lines of chilli

Table 10: RILs of chilli under evaluation for various agronomic traits

RIL	Generation	No of families	Trait
Kashi Sinduri × AKC 89/38	F_{11}	142	Morphological traits
Pusa Jwala × IIVRC-452	F_8	250	Anthracnose
Kashi Anmol × Japani Longi	F_7	380	Thrips, mites tolerance and pungency
PT-12-3 × Bhut Jolokia	F_{11}	78	Leaf curl virus, morphology and pungency
Kashi Sinduri × BS-35	F_8	109	Leaf curl virus, anthracnose and pungency

AICRP Trials 2019-20

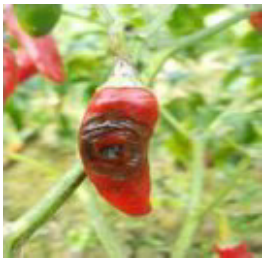
Seven chilli/capsicum trials of AICRP (VC) which comprised of one germplasm trial, 3 hybrid trials, 2

varietal trials and one capsicum trial were allotted and conducted. All the trials were reported and data submitted to AICRP (VC). In addition to this, many entries were contributed by ICAR-IIVR for di erent trials and they are at various stages of testing viz. IIVRC-18057 (varietal IET), IIVRC-18132 (varietal AVT-I), VRC-14 and VRC-16 (varietal AVT-II), CCH-10 (hybrid AVT-II). AVT-II trials of CCH-11 were completed and data was compiled.

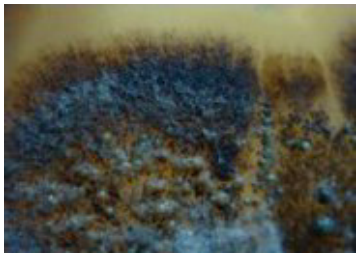
Screening for Anthracnose [*Colletotrichum capsici* L.] resistance in chilli: 250 RIL progenies Pusa Jwala X IIVRC-452 (F_7) were advanced for the identification and development of anthracnose resistant genotypes with better yield attributes. Upon field investigation, significant variability was observed among RIL progenies for severity of disease ranging from immune response to highly susceptible genotypes (Table 11). *In vitro* screening of the RILs indicated significant variation for resistance against pathogen (Fig. 14). Resistance genotypes would be further utilized in breeding programme for development of anthracnose resistant chilli lines.

Table 11: Number of F_7 individuals in different disease category under field screening

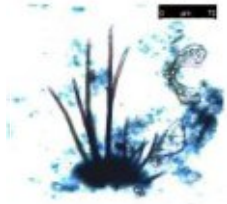
S.N.	Disease Reaction	No. of F_7 individuals
1	Resistant (R)	20
2	Moderately Resistant (MR)	34
3	Susceptible (S)	104
4	Moderately Susceptible (MS)	97
5	Highly Susceptible (HS)	10



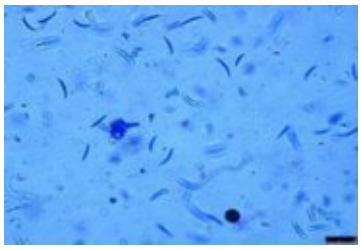
Rotten red ripe fruit



Fungal colony



Fruiting body of fungus



Fungal spores

Fig. 14: Screening chilli germplasm against anthracnose disease

White blistering in chilli fruits- Thrips mediated emerging problem: A large number of chilli fruits having small to medium sized white to light green blister spots were observed at the experimental field of ICAR-IIVR, Varanasi. Such white blisters later turned to brownish out growth (Fig. 15). Lowest fruit damage (3.48%) was recorded in the genotype IIVRC-KSAK-365 whereas highest (25%) fruit damage was observed in PJ x T-2-150. Microscopic investigation of the fruits revealed thrips population inside the blisters. Observations are being taken for further investigation of this emerging problem.

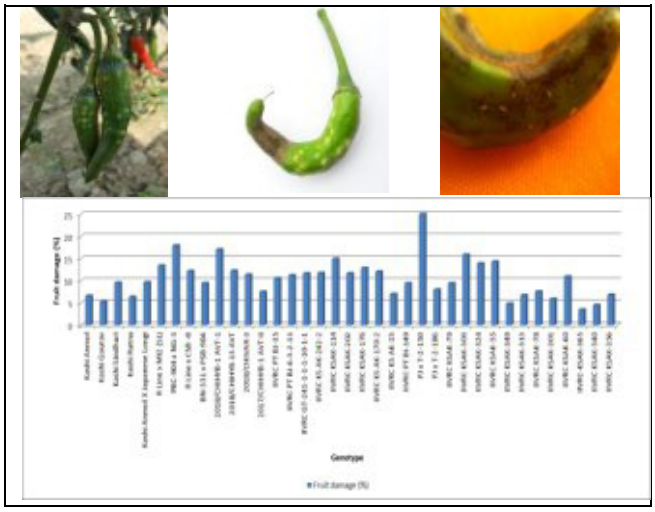


Fig. 15: White blisters on chilli fruits and per cent fruit damage chilli germplasm

Project 1.4: Genetic Improvement of Pea

Germplasm Maintenance: In addition to advanced breeding material, a total of 185 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.

Germplasm Registration: The genotype 'VRPM-905-1' bearing 3-5 pods has been registered as unique germplasm for multi-flowering by NBPGR, New Delhi. (INGR19077).

Germplasm Documentation: A total of 04 lines were allotted with IC Numbers from NBPGR, New Delhi *viz*., VRPD-2 (IC632629), VRPD-3 (IC 632630), VRPM-901(IC632631) and VRPM-901-5 (IC630592).

Generation advancement of breeding material: Among total 289 advanced lines grown, 164 lines were advanced to F_2 population, 43 lines to F_3, 23 lines to F_4,

32 lines to F_5, 8 to F8 and 19 to F_9 with targeted traits of earliness, high yield, resistant to powdery mildew and rust.

Introgression of genes for earliness, higher pod yield, resistance to powdery mildew, rust and for edible podded types through hybridization: A total of 65 F_1 crosses were attempted to create the genetic variation for earliness, higher pod yield, resistant to powdery mildew, rust and for edible podded type by utilizing the parents *viz*., Kashi Ageti, Kashi Nandini, Kashi Udai, HUDP-15, EC865944, EC865975, Arka Sampoorna, Mithi Phali, VRPD-2, VRPD-3 *etc*. A total of160 F_1s made during the 2018-19 were also advanced to its F_2 population.

Identification of promising lines for early maturity group

Among the early maturity group (Nov. sowing), eight advance breeding lines *viz*. VRPE-109 (79.0g), VRPE-101 (66.7g), VRPE-18 (75.0g), VRPE-56 (82.7g), VRPE-29 (66.7g), VRPE-66 (85.3g), VRPE-60 (84.0g) and VRPE-111 (80.0g) were found at par with the standard check Kashi Ageti (75.0g) for pod yield/plant. The genotype VRPE-60 was found superior for days taken to 50% flowering and days to first picking over the standard check Kashi Ageti. The lines *viz*., VRPE-60 and VRPE-66 were found bearing long pods having length of 9.43 and 9.2 cm, respectively and found significantly superior over the standard check Kashi Ageti. The genotype VRPE-66 was also found superior for high pod yield (85.3 g).

Identification of promising lines in mid maturity group: Among the mid-maturity group, the advance breeding lines *viz*.VRP-7×PC-531 (45.7 days), PMPM-1×VRPMR 11 (47.7 days) and PC-531 ×VRPMR-11 (47.0 days) were found superior for days taken to flowering and picking when compared with standard check PC-531, 63.3 days. Similarly, three lines *viz*., VRP-7×PC-531 (152.9g), PMPM-1×VRPMR-11 (130.7g) and PALAMP-1 (140.7g) found superior for pod yield/plant over the standard check Kashi Shakti (93.7g).

Stability Analysis of Multi-Flowering Pea Genotype: To study Genotype × Environmental interactions, and yield stability of multi-flowering peas lines, a total of 08 genotypes were grown over four environments. The AMMI analysis of variance for pod yield (q/ha) indicated significant (p = .0001) environment, genotypes and G×E interaction. The high PC1 and PC2 scores of the genotypes VRPM-901-5 (G8) showed its high yield potential with overall mean of 176.22 q/ha along with its high yield stability which is three time to single podded cultivar NO-17, and almost one and half times to double podded cultivars PC-531 (G2) and VL-8 (G3) (Fig. 16).

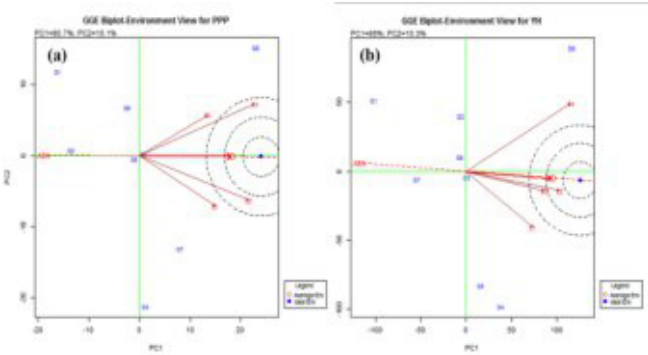


Fig. 16: GGE-Environment biplot for (a) pods per plant (PoPP) and (b) pod yield per hectare (YPH). **Where, G1: VRPSel–17; G2: PC-531; G3:VL–8; G4: VRP–500; G5: VRPM–501; G6: VRPM–502; G7: VRPSel–1; G8: VRPM–901–5; E1:2015-16; E2:2016-17; E3:2017-18 and E4:2018-19.**

Identification of unique pea genotypes

1. Single-Flower Pea Genotype: VRPSel-17 has been identified as a versatile vegetable pea genotype for multiple genetic studies**.** It is a mid-season genotype of vegetable Pea, unique in the fact that it bears only one flower (white) on all its flowering nodes, and not a ected by external growing conditions including the environment. The genotype is showing consistent flowering behaviour of single FPP on all the reproductive nodes over the years and seasons. The genotype is kept as unique selection from the germplasm, maintained at ICAR-IIVR, Varanasi since last few years and presently in use for various genetic studies. The genotype is also characterized by its indeterminate shoot growth habit (average plant height 160cm) with longer internodal and peduncle length that reflects as a dominate trait in its o -springs. Pods are 6-7cm long, green in colour having 20-25 pods per plant with four to five seeds per pod. Seeds are smooth, yellowish cream (GYG161C) in colour having 100-Green seed weight of 37-40g. The genotype is also resistant to major pea diseases powdery mildew and rust. Although this genotype is having low pod yield (60-70gm/plant) than the commercial cultivars, due to its distinct morphological appearance, this genotype can be used in multiple genetic studies such as inheritance of flower numbers, flowering times, peduncle traits, seed and pod characters, diseases studies *etc* (Fig. 17).

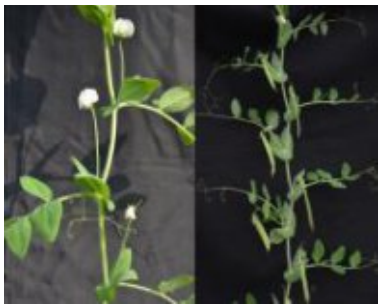


Fig. 17: VRPSel-17 at flowering and pod formation stage with single flower on each reproductive node

2. Multi-Flower Pea Genotypes: ICAR-IIVR, Varanasi has developed various multi-podded pea lines earlier which were from white flower background. Two new pea genotypes *VRPSel-3* (pink flower) and *VRPSel-26* (purple flower) have been identified having 3 flowers on most of its peduncle. Both these genotypes were of *afila* types. The lines were developed from single plant selection approach (selection for multi-flowers & pods) that bred true for multi-flowers trait, from the pea germplasm maintained at IIVR (Fig. 18).

Fig. 18: The newly identified multi-flowered lines in peas (a): VRPSel-26 and (b): VRPSel-3

Advancement of the RIL population in Peas: Two RIL population of garden peas belonging to multi-flowering genotypes were advanced to F_4 generation. The DNA was also isolated for 217 and 142 plants (from the stored samples of F_2) for the BSA.

Screening of germplasm for Powdery Mildew: A total of 69 germplasm lines were screened for powdery mildew resistance by adopting the scale of Warkentin *et al*. (1996). Scoring was done under normal field conditions and score ranged between 0–1 was classified as resistant whereas, scale ranged between 5–9 was classified as susceptible. Lines EC 865944 and EC 865975 were found as immune against powdery mildew. Out of 69 lines screened, fifteen lines were also found resistant viz., VRPE-29, VRPE-49, VRPE-60, VRPE-66, VRPE-952, VRPE-960, VRPM-9 × VRPM-11, HUDP-15 × PMR-11, VRPMR-11 × VRPMR-9, VRPMR-9 × VRPMR-11, VRPSel-17, EC865944, EC865975, EC866031 and EC865951 (Fig. 19).

Fig. 19: Phenotypic appearance of the resistant genotypes grown during *Rabi* 2019-20

Screening of germplasm for pea rust: A total of 58 germplasm lines were screened for pea rust resistance by adopting the scale of Singh et al. (2015). Scoring was done under normal field conditions and score ranged between 0–5. Out of 58 lines screened, twenty two lines were also found resistant viz., VRPE-25, VRPE-22, VRPE-16×VRPE-22,VRPE-59,VRPE-32, VRPE-28, VRPE-56,VRPE-2,VRPE-60, VRPE-55, VRPE-36, VRPE-918, VRPE-960, VRPM-9 × VRPM-11, VRPM-11 × VRP-7, VRPMR-9 × VRP-7, HUDP-15 × PMR-11, AP-3 × VRP-500, VRP-22 × VRP-500, VRPMR-11 × VRPMR-9, VRPMR-9 × VRPMR-11, VRPSel-17 and HUDP-15.

Screening of germplasm for high temperature tolerance, suitable for early sowing (*Rabi* 2020-21)

A total of 80 genotypes were evaluated for tolerance to high temperature, suitable for early sowing during October. Two sowing dates *viz*., 28th September and 15 October during were selected to screen the genotypes for high temperature tolerance at vegetative stage. The experiment was laid in Augmented Block Design with row length of 4m each.

In the first sowing, out of 78 genotypes, only 54 genotypes were germinated that showed the e ect of high temperature on seed germination on the remaining lines. Eight genotypes *viz*., Kashi Uday, VRPE -17, VRPE -24, VRPE -39, VRPE-36 and VRPE-29, VRPE-30 and VRPE-60 took minimum days for 50 % flowering (27-30 days). However, for days to first picking, the genotypes *viz*., VRPE-111, VRPE-30, VRPE-29, VRPE-32, VRPE-917, VRPE-960 and VRPE-919 were found earliest with first picking ready in 47 to 50 days. The average numbers of flowers in these genotypes vary

from 2.3 to 8, while the pods from 2.3 to 7.0. Pod length in these genotypes was found to vary from 6.9 (VRPE-55) to 8.48 cm (VRPE-960), while pod width from 1.3 (VRPE-36) to 1.7 cm (VRPE-952). Similarly, a variation of 4.0 to 7.0 for seeds/pod and 4.2-8.4 g for average pod weight was recorded. Based upon earliness, yield and other pod quality parameters, the genotypes *viz*., VRPE-29, VRPE-30, VRPE-964, VRPE-17 and VRPE-18 found promising for September sowing.

Further, for the second sowing, all the genotypes showed normal germination. The genotypes VRPE-29, VRPE-30 were earliest in flowering and days to picking, that were ready for first harvest in 50 days compared to standard check kashi Nandini and kashi Uday that took 60-65 days (Fig. 20 & 21).

Fig. 20: Promising genotypes of table peas identified for September sowing along with the standard check

Fig. 21: Promising genotypes of table peas for Oct. sowing along with the standard check Kashi Uday

AICRP trials: A total of five new entries were submitted for AICRP (VC) varietal trial *viz*., VRPE-111 and VRPE-101-5 for Early IET; VRPMS-919 and VRP-500 for Mid IET and VRP-343 for IET (Powdery mildew resistance) during the year 2019-20. A total of 08 trial of peas were conducted during 2019-20 *viz*., Pea Early IET (2019), Pea Early AVT-1 (2018), Pea Early AVT-II (2017), Pea Mid IET-1 (2019), Pea Mid AVT-1 (2018), Pea Mid AVT-II (2017), Pea Edible Podded AVT-1 (2018) and Pea (mid-season) Powdery Mildew IET, 2019.

Project 1.5: Genetic Improvement of Cowpea

Germplasm evaluation: Five Genotypes of vegetable cowpea collected last year were evaluated in *Kharif,* 2020 and the data has been presented in Table 12.

During the year 2020, a total of 10BC_1F_1, 4BC_1F_2, 16 F_2, 10 F_3, 10 F_4, 16F_5, 11 F_7 were advanced to next filial generation by single plant selection. During *Kharif,* 2020 a total of 11 F_1 cross combinations were done based on yield, quality and resistance to cowpea golden mosaic disease resistance. Two elite lines of cowpea VRCP-68-2 and VRCP-71-1 were in AVT-I stage of AICRP (VC) trials. Maintenance breeding of IIVR released varieties Kashi Kanchan, Kashi Nidhi, Kashi Gauri, Kashi Unnati, Kashi Shymal along with recently identified variety Kashi Vishan (VRCP-12) were maintained true to type.

Project 1.6: Genetic Improvement of Indian bean and French bean

Indian bean (Dolichos bean)

Generation Advancement: Bush type 177 SPS (Single Plant Selection) comprised of F_4 (82), F_6 (15) F_7 (12), F_8 (17) and F_{10} & F_{11} (24) were advanced to next generation. More than 100 superior segregants were selected from di erent generations viz. F_4 (30), F_6 (24), F_7 (12), F_8 (17) and F_{10} & F_{11} (24). The segregants VRBSEM-123-SPS (2) in F_6, VRBSEM-104, VRBSEM-100, VRBSEM-106 SPS-1 and VRBSEM-109 in F_7, VRBSEM-75 in F_8 and VRBSEM-200, VRBSEM-202, VRBSEM-17 VRBSEM- 206 in F_{10} & F_{11} were superior in yield as

Table 12: Characterization of collected genotypes of vegetable cowpea

Genotype	Plant height (cm)	Pod length (cm)	Pod number	10 pod weight (g)	No. of seeds per pod	Growth habit
SBC/DRB-227	351.33	28.50	31.33	131.00	12.67	Pole type
SBC/DRB-150	315.00	21.00	6.00	75.00	7.33	Pole type
SBC/DRB-220	403.00	29.67	18.67	118.00	11.17	Pole type
SBC/DRB-141	323.00	27.67	41.33	93.00	12.17	Pole type
SBC/DRB-155	41.00	27.33	15.50	72.00	13.20	Bush type
SBC/DRB-129	325.33	28.33	32.33	83.00	14.00	Pole type

well as pod quality and free from DYMV incidence in field condition.

Germplasm Maintenance: 101 germplasm comprising of 85 pole type and 16 bush types were maintained.

Seed Production: Seeds of entries VRBSEM-3 (8 kg), VRBSEM-9 (8 kg), VRBSEM- (5 kg), VRBSEM-14 (7 kg), VRBSEM-207 (10 kg), VRBSEM-18(9kg), VRBSEM-200 (9 kg), Kashi Haritima (5 kg), Kashi Khushaal (5 kg) and Kashi Sheetal (5 kg) were produced for supply to the testing centres under AICRP(VC).

Entries under AICRP (VC) testing: A total of five advance lines namely VRSEM-1 of pole type and, VRBSEM-14, VRBSEM-18, VRBSEM-8 and VRBSEM- 207 of bush type are under AICRP (VC) testing.

Entries identified through AICRP (VC): VRBSEM-3 and VRBSEM-9 have been identified in 38th AICRP (VC)) group meeting

French bean

Maintenance Breeding: 37 bush type and 30 pole type genotypes of frenchbean were grown and maintained. Kashi Sampan, Kashi Rajhans and VRFBB-91 varieties of bush type French bean were grown and maintained true to type. Pole type French bean variety Kashi Baingani was also grown and maintained true to type with su cient seed quantity.

Advancement of filial generations: 4F1, 5F2, 6F4, 5F4, 3 F5 combinations were advanced to next filial generation. 7 F4 combinations of pole type were advanced to next filial generation.

Entries identified through AICRP (VC): The variety VRFBB-91 of bush type french bean was released in XXXVIII AICRP (VC) group meeting group meeting held through virtual mode during 25-27th September, 2020. This French bean variety was recommended for zone I comprising of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. It gives a yield of 148-195 quintals/hectare.

Project: 1.7: Genetic Improvement of seed propagated gourds

Bitter Gourd

Evaluation of augmented germplasm: During the year 5 new germplasm (VRBG-62, VRBG-63, VRBG-64, VRBG-65 and VRBG-66) were collected from Mirzapur (U.P.) and evaluated for di erent agro-morphological traits. Newly collected genetic stocks were grouped under small (VRBG-64 and VRBG-63), medium (VRBG-65) and long (VRBG-62 and VRBG-66) category. Maximum yield per plant was found in VRBTG-62 (1.52 kg/plant) followed by VRBTG-65 (1.48 kg/plant) and VRBG-66(1.20 kg/plant).

Thirty-three germplasm were received from ICAR-NBPGR, New Delhi (exploration based germplasm) but out of these only 10 accessions had germinated. All the germplasm were characterized, selfed and multiplied for seed enhancement (Table 13).

Evaluation of advance lines: Nine advanced lines in di erent segments (small, medium and long) were evaluated for desirable horticultural traits. Maximum yield per plant was found in VRBTG-2-1-1 (2.70 kg) followed by VRBTG-39 (2.40 kg) in the long category. Number of fruits per plant was found maximum in VRBTG-2-1-1 (37.33) followed by VRBTG-39 (31.33). As per the individual fruit weight, maximum value recorded in VRBTG-32 (91.67 g) followed by VRBTG-2-1-1 (88.33 g) at edible stage. On the basis of overall performance VRBTG-28-1, VRBTG-4-1, VRBTG-32, VRBTG-43 in small segment, VRBTG-2-1, DVBTG-4 and DVBTG-3 in medium segment, VRBTG-2-1-1 and VRBTG-39 in long segment were found promising (Fig. 22).

VRBTG-2-1 VRBTG-4-1 VRBTG-28-1

Fig. 22: Some advance lines of bitter gourd

Table 13: Performance of newly augmented germplasm

Germplasm	Germination (days)	50% flowering (days)	Node of 1st female flower	No. of fruits /Plant	Fruit length (cm)	Fruit Width (cm)	Fruit weight (g)	Yield/ plant (kg)
VRBG-62	10	40	11.66	23.33	16.53	4.06	65.00	1.52
VRBG-63	11	41	13.33	19.33	12.63	3.77	41.66	0.81
VRBG-64	9	37	10.33	31.67	5.06	2.02	16.33	0.53
VRBG-65	10	42	12.00	28.67	14.26	4.13	51.66	1.48
VRBG-66	10	40	16.66	15.33	25.93	3.66	78.33	1.20

Evaluation of white fruited germplasm: Four white fruited germplasm VRBTG-37-1, VRBTG-37, VRBTG-23-1 and IC-391819 were evaluated for di erent morphological traits (Fig. 23). Maximum yield per plant was noted in VRBTG-37-1(1.45 kg) followed by IC-391819 (1.15 kg) and VRBTG-23-1 (0.98 kg).

VRBTG-37-1 (White) VRBTG-23-1 (White)

Fig. 23: White fruited germplasm of bitter gourd

Development and Evaluation of Hybrids: During the year twenty-six hybrids were developed in summer season and evaluated in rainy season (Fig. 24). Developed hybrids were grouped under di erent segments (long=16, medium=7 and small=3) as per the length of fruits. The hybrid combination IC-212504 x VRBTG-10 (3.14 kg/ plant) was highest yielder followed by DVBTG-4 x VRBTG-47-2 (2.46 kg / plant) and BT-1-1(B) x BT-1 A (2.34 kg / plant).

DVBTG-4 x VRBTG-47-2 | BT-1-1(B) x BT-1(A) | IC-212504 x VRBTG-10

Fig. 24: Promising experimental hybrids of bitter gourd

Development and evaluation of gynoecious based hybrids: -Seven gynoecious base hybrids were developed by using two female parents (gynoecious) and four diverse male parents (monoecious) during summer season (Fig. 25). These hybrids were evaluated along with parents in *kharif* season 2020. The combination VRBTG-5(G)x VRBTG-47-2 (3.35 kg/ plant) was higher yielder followed by VRBTG-34(G) x VRBTG-10 (3.14 kg/plant) and VRBTG-34(G) x VRBTG-5 (2.68 kg/plant).

Fig. 25: Gynoecious based bitter gourd hybrid VRBTG-5(G) x VRBTG-47-2

Field screening of bitter gourd against powdery mildew: A total of 76 germplasm were screened against powdery mildew in the open field condition. Five germplasm DVBTG-3, DVBTG-4, DVBTG-5, VRBTG-5-2 and VRBTG-47-2 were found resistant.

Advancement of generation: A total of 37 F_2, 18 F_3, 11 F_4 and 7 F_5 cross combinations were advanced to next generation.

Seed enhancement: Released varieties and promising lines of IIVR viz. Kashi Mayuri, VRBTG-10, VRBTG-47 and VRBTG-2-1 were maintained and multiplied for multi-location trial/demonstration.

Entries in AICRP (VC) trial for multi-location testing: One F_1 hybrid VRBTGH-3 (VRBTG- 10 x VRBTG-2-1) was included in IET of AICRP (VC) trial.

Bottle gourd: Thirty-five germplasm were received from ICAR-NBPGR, New Delhi (exploration based germplasm) but out of these only 23 germinated. Germplasm were characterized, selfed and multiplied for seed enhancement. Max. yield/plant (6.01kg) was noted in SBC/DRB-199 followed by in SBC/DRB-213 (5.64kg/plant) while the minimum (2.14kg/plant) was recorded in SBC/DRB-206.

Evaluation of advanced line: -Seven advanced lines were evaluated for di erent horticultural traits in summer and kharif season 2020 (Fig. 26). Maximum yield per plant was reported in VRBG-6 (9.91 kg) followed by VRBG-12 (8.94 kg) and VRBG-27 (7.93 kg). Maximum no. of fruits observed in VRBG-6 (11.67 fruits/plant) followed by VRBG-12 (11.00 fruits /plant) and VRBG-8 (10.33 fruits /plant).

VRBG-6 (Long) | VRBG-15-1 (Long) | VRBG-12 (Oblong) | VRBG-47 (Oblong)

Fig. 26: Promising advance lines of bottle gourd in various segments

Evaluation of variegated germplasm: During the year, 8 accessions (white and green spots) were evaluated for di erent horticultural traits (Fig. 27). The accession "VRBG-18 (oblong) gave maximum yield of 8.74 kg/plant followed by 7.87 kg/plant in VRBG-14 (medium long).

SBC/DRB-161-1 | SBC/DRB-12 | SBC/DRB-161 | SBC/DRB-1

Fig. 27: Variegated germplasm of bottle gourd

Evaluation of hybrids for yield attributes: During the year, ten hybrids were evaluated in di erent segments (long=5, medium long=2 and round=3) during summer and rainy season-2020. Five hybrids viz. VRBG-4 x VRBG-59 (10.52 kg/plant), VRBG-44 x VRBG-50 (8.58 kg/plant), VRBG-5 x VRBG-15-1 (6.96 kg/plant), Pusa Sandesh xVRBG-11 (6.30 kg/plant) and VRBG-14 x VRBG-61-2(5.82 kg/plant) out yielded against the check variety Kashi Bahar (6.05 kg/plant) and Pusa Samridhi (6.24 kg/plant). As per the individual fruit weight, maximum weight was recorded in VRBG-4 x VRBG-59 (991.67 g) followed by VRBG-44 x VRBG-50 (758.33 g) and Pusa Sandesh x VRBG-11 (725.00 g).

Field screening of bottle gourd against powdery mildew: Forty-two genotypes were screened for powdery mildew under natural condition. Six genotypes VRBG-61, VRBG-47, VRBG- 9-1-1, VRBG-67, SBC/DRB-151, SBC/DRB-12 were found partially resistant.

Ash gourd

Maintenance of germplasm lines: A total of 65 lines including identified/released varieties from di erent universities and ICAR institute were maintained as active collections. Fifteen new lines were developed in wax less segment and added in germplasm pool.

Evaluation of advance lines: Five advance breeding lines have been evaluated for important horticultural traits. Maximum yield per plant was reported in VRAG-50-1 (22.75 kg/plant) followed by VRAG-71(18.40 kg/plant) and VRAG-205 (18.20 kg/plant). Whereas, maximum number of fruits/plant was observed in VRAG-223 (2.50) followed by VRAG-54-1 (2.44) and VRAG-50-1 (2.30). On the basis of overall performance VRAG-223 and VRAG- 50-1 were found promising.

Multiplication and maintenance of seeds of released varieties of ash gourd: Two 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 Evaluation: A total of 80 germplasm of sponge were evaluated and twelve i.e. VRSG-171, VRSG-9, VRSG-195, VRSG-136, VRSG-57, VRSG-142-1, VRSG-2-12, VRSG-18, VRSG-13, VRSG-214 and VRSG-28 including one aromatic line i.e. VRSG-7-17 were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downey Mildew Disease under field conditions (Fig. 28).

VRSG-28 | VRSG-57 | VRSG-171 | VRSG-9

Fig. 28: Promising germplasm of sponge gourd

Advance Breeding Lines

Among the 82 advanced breeding lines of sponge gourd, VRSG-17-2, VRSG-17-3, VRSG-17-5, VRSG-17-10, VRSG-17-33, VRSG-18-2, VRSG-18-6, VRSG-18-10, VRSG-19-1, VRSG-19-2, VRSG-19-5 and VRSG-20-1 were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and downy mildew disease under field conditions (Fig. 29).

VRSG-17-5 | VRSG-17-31 | VRSG-19-1 | VRSG-20-1

Fig. 29: Promising advance breeding lines of sponge gourd

Development and evaluation of F_1 genotypes: A total of 64 F_1 cross combinations were developed by using the 16 Lines × 4 Testers. Among the 64 F1(s) of sponge

gourd 13 i.e. Kashi Shreya x VRSG-17-31, VRSG-17-5 × Kashi Shreya, VRSG-195 x Kashi Shreya, VRSG-17-14 x Pusa Supriya, VRSG-17-10 × VRSG-195, VRSG-136 x Pusa Supriya, VRSG-57× Kashi Shreya, VRSG-17-5 × VRSG-195, VRSG-17-31 x VRSG-195, VRSG-17-11 x VRSG -7-17, VRSG-171 × Kashi Shreya, VRSG-195 × Pusa Sneha, and VRSG-195 x Pusa Supriya were found promising for various horticultural traits over the checks i.e. Utsav (Clause Seeds), VNR Alok (VNR Seeds), Kashi Rakshita and Kashi Saumya showed tolerance against downy mildew and virus disease under field conditions (Fig. 30).

Kashi Shreya × VRSG-17-31 | VRSG-17-5× Kashi Shreya | VRSG-195× Kashi Shreya | VRSG-17-14 × Pusa Supriya | VRSG-17-10 × VRSG-195

Fig. 30: Promising F_1 hybrids of sponge gourd

Generation advancement: Under the generation advancement program, 22 populations were advanced from F_5 to F_6 were advanced from F_3 to F_4.

RILs program: One RILs population of Kashi Shreya x VRSG-7-17 (Aromatic line) advanced from F_3 to F_4 (250 plants).

Inheritance study of aroma trait in sponge gourd: The genotype VRSG 7-17 was found to produce a sharp aroma which resembles with the typical aroma of 'Basmati rice' in its various plant parts viz., leaves, flowers, fruits, blossom end of fruits, plant vine and peel due to the presence of high concentration of Hexenal and 3 Octanone which are either absent or found in very low concentration in the control sample 'Kashi Shreya' (VRSG-194). In order to study the inheritance of this trait in fruits, reciprocal crosses were made between the aromatic (VRSG7-17) and non-aromatic (Kashi Shreya) parental lines. Tender fruits from these F1s were rated for aroma to determine whether the respective aromas were dominant or recessive. All the F1 progenies were tested to be non-aromatic. Segregation data of F2s based on aroma rating of tender fruits from individual F2 plants were carried out. The data from 250 F2 progenies for aroma showed that the aroma is governed by single recessive gene

Promising genotypes/hybrids under multi-location testing of AICRP (VC) trials (2020): A total of 6 OP improved genotypes i.e. VRSG-17-5, VRSG-19-1 in IET and VRSG-17-10, VRSG-17-1 in AVT-I, VRSG-17-3 and VRSG-57 in AVT-II and 4 F_1 hybrids *viz.* VRSGH-7 in IET, VRSGH-6 in AVT-I, VRSGH-4 and VRSGH-5 in AVT-II are under multi-location testing of AICRP (VC) trials.

Maintenance breeding: Two varieties i.e. Kashi Shreya and Kashi Jyoti are being maintained by producing nucleus seed (2 kg each) and parental lines of two hybrids i.e. Kashi Rakshita and Kashi Saumya (250 (F) each and 500 (M)).

Ridge gourd

Germplasm Collection and Evaluation: Out of 139 gemplasm of ridge gourd 11 i.e. VRRG-6A, VRRG-5A, VRRG-35, VRRG-26, VRRG-110, VRRG-7-2016, VRRG-1-16, VRRG-8-17, VRRG-12-10, VRRG-42-2016 and VRRG-46-2016 were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downy Mildew disease under field conditions. Among the new collection i.e. 74, 10 germplasm line could not germinated and 29 germplasm lines did not produced fruits due sponge gourd mosaic disease incidence with severity of > 90% (Fig. 31).

VRRG-35 | VRRG-110 | VRRG-8-17 | VRRG-12-10 | VRRG-46-2016

Fig. 31: Promising germplasm lines of ridge gourd

Development and evaluation of F_1 genotypes: A total of 15 F_1 cross combinations were developed by using the 6 lines in HDMD. Among the 15 F1(s) of ridge gourd 7 i.e. VRRG-5A x VRRG-75-2016, VRRG-75-2016 x VRRG-5A, Kashi Shivani (VRRG-27) x VRRG-75-2016, VRRG-75-2016 x VRRG-26, VRRG-26 x VRRG-75-2016, VRRG- 6A×VRRG-5A and VRRG-75-2016 × VRRG-6A were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downy Mildew disease under field conditions (Fig. 32).

VRRG-5A x VRRG-75-2016 | Kashi Shivani x VRRG-75-2016 | VRRG-75-2016 x VRRG-26

Fig. 32: Promising F_1 hybrids of ridge gourd

Generation advancement of Ridge gourd (2020): Under the generation advancement program, 15 populations of ridge gourd were advanced from F_4 to F_5.

Promising genotypes/hybrids under multi-location testing of AICRP (VC) trials: Two OP improved genotypes i.e. VRRG-35 & VRRG-5A in AVT-I, and four F_1 hybrids namely, VRRGH-3 & VRRGH-4 in AVT-I and VRRGH-1 & VRRGH-2 in AVT-II are under multi-location testing of AICRP (VC) trials. However, 2 OP improved genotypes namely, VRRG-20-1 and VRRGH-5 were submitted to PC Cell for multi-location testing under AICRP (VC) during 2019-20, but trial could not be formed.

Varietal screening of sponge and ridge gourd genotypes against its major insect pests: Twelve germplasm of ridge gourd and 96 genotypes of sponge gourd were screened against melon weevil (*Acythopeus curvirostris citrulli,* whitefly (*Bemisia tabaci*) and), leaf miner (*Liriomyza trifolii*). The ridge gourd genotype VRRG-75 had shown the lowest infestation by melon weevil, whitefly and leaf miner followed by VRRG-6A. Amongst the sponge gourd, the genotype VRSG-17-31, VRSG-17-13, VRSG-17-18, VRSG-17-20, VRSG-17-22, VRSG-17-4, VRSG-17-23, VRSG-17-7, VRSG-17-30, VRSG-17-29, VRSG-17-8, and VRSG-18-1 had suffered lowest incidence against the three above major insect pests (melon weevil, leaf miner and whitefly) under Varanasi, Uttar Pradesh condition.

Maintenance breeding: One variety i.e. Kashi Shivani is being maintained by producing nucleus seed (2.5 kg).

Satputia

Out of 52 germplasms (35 old + 17 new collection) of Satputia VRS-28-1, VRS-24-1, VRS-25, VRS-3-17, VRS-20 and VRS-11 were found promising for horticultural traits. Among the new collection i.e. 17, nine germplasm lines did not produce fruits due sponge gourd mosaic disease incidence with severity of > 90% (Fig. 33a).

VRS-24-1 | VRS-11 | VRS-3-17

Fig. 33a: Promising germplasm lines of Satputia

Development and evaluation of F_1 genotypes: A total of 15 F_1 cross combinations were developed using 6 lines in Half Diallel Mating Design. Among the 15 F_1(s) of satputia, five *viz.* VRS-1 x VRS-74-10-4, VRS-11 x VRS-17-10, VRS-24-1 x VRS-28-1, VRS-11 x VRS-74-10-4 and VRS-11 x VRS-28-1 were found promising for various horticultural traits and showed tolerance against Sponge Gourd Mosaic and Downy Mildew disease under field conditions (Fig. 33b).

VRS-1 x VRS-74-10-4 | VRS-11 x VRS-17-10 | VRS-24-1 x VRS-28-1 | VRS-11 X VRS-74-10-4

Fig. 33b: Promising F_1 hybrids of Satputia

Multiplication and maintenance of seeds of satputia: Two kg seeds of Kashi Khushi were produced and 125 SPS were selected for maintenance of this variety.

AICRP-VC Trials Conducted during 2020: A total of 12 trials of sponge gourd and ridge gourd were conducted during summer 2020 as per technical programme of AICRP (VC). These were : Sponge gourd - Varietal IET, AVT-I and AVT- II; Sponge gourd - Hybrid IET and AVT-I; Sponge gourd Germplasm

Collection and Evaluation; Ridge gourd- Varietal IET and AVT- II; Ridge gourd- Hybrid IET, AVT-I and AVT- II and Ridge gourd Germplasm Collection and Evaluation.

Project 1.9: Genetic Improvement of Pumpkin and Cucumber

Cucumber

Germplasm evaluation and maintenance: A total of 58 germplasm/genotypes of cucumber were evaluated for yield and contributing traits in summer and 45 during rainy season. The number of fruits per plant ranged from 3.0 (VRCU-13-5) to 10.0 (VRCU-Sel-27), while average fruit weight ranged from 235 g (VRCU Sel-12-02) to 165 (VRCU-13-5). Yield per plant ranged from 554.72 (VRCU-7) to 1415.32 (VRCU-12-18) with a general mean value of 724.56 g.

Advancement of segregating generation: Selected individuals/crosses were advanced to subsequent generation from the segregating lines, i.e. 25 combinations in F_2 generation, 28 in F_3, 9 in F_4, 5 in F_5, 3 in F_6 and 4 families in F_7 generations were advanced.

Evaluation of advance lines: A total of 10 advance lines along with check PCUC-09 were evaluated for yield and its contributing traits in mottle green and long segment for validation of previous year results. The best performing lines based on the fruit colour, appearance and yield were VRCU Sel.-9-03 (Fruit length-20.32cm; Dia.-4.12cm; Av.wt.-212g; Fruits/plant-9.5 and Yield/plant-1.73kg) followed by VRCU-Sel-12-03 (Fruit length-18.63cm; Dia.-4.36cm; Av.wt.-225g; Fruits/plant-8.25 and Yield/plant-1.673kg). Fruits of these lines were non-bitter in taste.

Evaluation of hybrids: A total of 12 hybrids were evaluated for yield and its contributing traits in mottle green and long segment. Out of 12 hybrids, 2 were found promising based on the fruit colour, appearance and yield. These hybrids were non-bitter in taste. The yield and contributing traits of promising hybrids are given below (Table 14).

Development of parthehocarpic inbred lines

Nineteen parthenocarpic F_4 population derived from commercial hybrids were evaluated for yield and yield related parameters. The observations were recorded on number of fruits per plant, average fruit weight, fruit length and diameter. Among the evaluated lines, VRCUP-20-05-17 was found most promising (Fruit length-17.85cm; Dia.-3.50cm; Colour-light green; Av.wt.-212.2g; No. of fruits/plant-39 and Yield/vine-8.38kg with resistance to virus). A total of 15 F_5 populations were selected for further evaluation.

Evaluation of advance parthenocarpic cucumber lines under protected condition: Four advance parthenocarpic lines in dark green and light green segment were evaluated under insect proof net house. The observations were recorded on number of fruits per

Table 14: Performance of selected cucumber hybrids in mottle green segments

Hybrids	No. of fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Yield/ plant (g)	Fruit colour (at edible maturity)
VRCUH-19-02	8.75	21.75	4.25	215.00	1575.50	Green
VRCUH-19-03	7.25	21.25	4.12	198.25	1150.25	Green
VRCUH-19-04	7.25	19.55	4.25	185.25	1285.25	Green
VRCUH-19-09	7.80	18.80	4.00	168.25	11.82.25	Light green
VRCUH-19-11	8.25	21.25	4.15	190.50	1385.25	Light green
PCUCH-3	6.10	20.85	4.65	198.50	1050.25	Green
Malini	7.50	17.50	4.30	185.50	1175.50	Light green

Table 15: Performance of parthenocarpic lines

Parthenocarpic line	No. of fruits/plant	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Yield/vine (kg)	Fruit colour (at edible maturity)
VRCUP-20-01	36.00	16.95	4.00	200.00	7.20	Dark green
VRCUH-20-02	41.25	17.84	4.12	219.00	9.04	Dark green
VRCUH-20-03	31.20	15.84	3.84	207.00	6.46	Light green
VRCUH-20-04	28.35	16.66	4.20	209.00	5.93	Light green

plant, average fruit weight, fruit length and diameter. The most promising line was VRCUP-20-02 with yield of 9.04 kg/plant. The yield and contributing traits are given below (Table 15 & Fig. 34).

Fig. 34: Parthenocarpic line VRCUP 20-02

Maintenance of parthenocarpic lines: The plants were treated with the 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 5 selfed fruit. Recovery of seeds in selfed fruit was very poor due to formation of more cha y seeds.

Pumpkin

Enhancement, maintenance and evaluation of germplasm lines: Fifty two new germplasm collected from di erent places of country were received and evaluated for yield and its contributing traits during rainy season, 2020. Out of 52 germplasm, 7 accessions not germinated and remaining 45 accessions were highly infected by viruses at early stage. These accessions had only male flowers, therefore failed to maintain all these accessions. Beside these, 102 germplasm were maintained through selfing.

Hybridization and advancement of segregating generation

Hybridization: A total of 15 F_1 combinations were developed by utilizing divergent inbred lines.

Evaluation of F_1 hybrids: The selected 09 F_1 have been evaluated. Out of these, hybrid VRPKH-20-02, VRPKH-20-05 and VRPKH-20-05 were considered best on the basis number of fruits, yield, shape and colour.

Advancement of breeding material: Selected individuals/crosses were advanced to subsequent generation from the segregating lines, i.e. 05 combinations in F_2 generation developed using butternut squash, 03 in F_3 and 5 in F_4 families were advanced.

Evaluation of advance lines: Twelve advance breeding lines have been evaluated for important horticultural traits. Maximum yield per plant was reported in VRPK-63 (12.05 kg/plant) followed by VRPK-310 (6.25 kg/plant) and VRPK-11-06-05 (9.13 kg/plant). Whereas, maximum number of fruits/plant was observed in VRPK-63 (4.95) followed by VRPK-11-06-05 (3.50) and VRPK-09-01 (2.67). On the basis of overall performance and phenotypic acceptability VRPK-63, were found promising and selected for multilocation testing.

Development of high carotene inbred lines: Twelve lines were evaluated for quality and yield related traits. Good amount of variation (3.73-4.83 mg/100g) was observed in β carotene and flesh thickness (17.75 - 2.35mm). Deep orange and orange flesh colour was recorded in the accessions. The number of fruits per plant ranged from 2.0 to 7.0, while average fruit weight ranged from 0.652 kg to 1.57. Fruit length ranged from 12.47 cm to 22.33 cm and diameter ranged from 8.25 cm to 13.50 cm. The fruit shape was cylindrical, rectangular with bottle and crooked neck in the population (Fig. 35).

Fig. 35: Pumpkin line rich in β carotene

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

Summer squash (*Cucurbita pepo*)

Maintenance of germplasm: A total of 120 germplasm/genotypes of summer squash were evaluated for yield and contributing traits. The number of fruits

per plant ranged from 3.0 (VRSS-20-193) to 8.0 (VRSS-20-119), while average fruit weight ranged from 0.45 kg (VRSS-20-98) to 1.65 kg (VRSS-20-76). The fruit length ranged from 7.1 cm to 37.0 cm and diameter 7.2 to 14.5 cm (Fig. 36). Yield per plant ranged from 1.8 kg (VRSS-20-207) to 5.7 kg (VRSS-20-161).

Fig. 36: Evaluation of germplasm lines of summer squash

A total of 21 advance lines have been evaluated for yield and its contributing traits in di erent segment. The best performing lines based on the fruit colour, appearance and yield were VRSS-20-161 followed VRSS-20-160 (Table 16 & Fig.37).

Table 16: Yield and contributing traits of advance lines of summer squash

Hybrids	Fruit length (cm)	Fruit diameter (cm)	No. of fruit/ plant	Average fruit weight (g)	Yield/ plant (g)
VRSS-20-357	16.20	10.20	7.00	750	3.73
VRSS-20-161	30.10	6.90	7.50	1100	6.50
VRSS-20-160	28.20	9.80	6.50	850	5.10
VRSS-20-336	28.30	9.70	5.50	700	3.50
VRSS-20-321	22.50	7.70	6.50	750	3.73

VRSS-20-357 **VRSS-65**

Fig. 37: Promising advance lines of summer squash

Project 1.10: Genetic Improvement of Melons

Watermelon

Germplasm maintenance and augmentation

Seventy-six germplasm accessions including wild (*C. lanatus* var. *citroides*), small/medium/large-fruited, di erent flesh colour/skin colour, are being maintained in the field. Four watermelon germplasm (VRW-920 to VRW-924) were collected from Mirzapur District (U.P) and Jaipur District (Rajasthan) and their seeds are being multiplied. Three advance lines of watermelon, two of round melon and one of long melon have been documented with NBPGR, New Delhi whose IC numbers are IC-0636929 (VRW-10), IC-0636930 (VRW-8), IC-0636931 (VRW-11), IC-0636932 (VRM-11-1), IC-0636933 (VRM-1) and 0636934 (VRLM-1), respectively. In another exploration program of cucurbits at Bihar (2018), a total of 45 germplasm of various cucurbits were documented in NBPGR, New Delhi (IC-0637203 to IC-0637247).

Hybrid development and generation advancement: A total of 21 F_1 hybrids were evaluated during the spring-summer season of 2020. Based on the total yield and TSS of the hybrid fruits, VRW-8 x VRW-11 was found promising and selected for validation. This hybrid has medium pericarp thickness (1.1 cm), dark green in colour, round shape and has a yield potential of 500-550 q/ha. The segregating generations are being advanced to the next higher generation and promising advanced lines shall be identified for station trials before submitting for multi-location testing.

Maintenance and evaluation of advance lines for various economic traits: In the summer season, 30 promising line/germplasm having various flesh colour (red, scarlet red, canary yellow, Salomon yellow, orange and white) and sizes were evaluated for several economic traits. Among these, following lines, were found potential yielder with high TSS such as VRW-513, VRW-514-1, VRW-514-2, VRW-515 (lemon yellow) and VRW-511 {Mini segment <3.5 kg, scarlet red flesh/pink}; VRW-14-1(Yellow flesh), VRW-9-1, VRW-12-3-1, VRW-927, VRW-55 VRW-58 (Orange), VRW-82 (Orange), VRW-53 and VRW-53-1 (Ice-box segment 3-5.5 kg). Maximum yield per plant along with high TSS was observed in VRW-514-1 (10 kg/plant) followed by VRW-513 (9.70 kg/ plant). Seeds of two potential unique inbred lines VRW-10 (an andromonoecious line with orange-fleshed fruits) and VRW-14-1 (a unique inbred line having a yellow vein leaf, yellow skin and yellow flesh) has been multiplied for registration at ICAR-NBPGR, gene bank, New Delhi. Two promising advance lines, VRW-514-1 and VRW-32 were submitted for multi-location testing in IET trails of AICRP(VC)

after station trials and VRW-514-1 was proposed to the ITIC for varietal identification at Institute Level (Fig. 38).

Fig. 38: Colour segments in watermelon VRW-14-1(yellow), VRW-514(Red) and VRW-10(orange)

Round melon

Twenty lines were evaluated in augmented design during summer 2020 for yield and horticultural traits. All genotypes were characterized for traits like early horticultural maturity, high yield, fruit quality and resistance/tolerance to disease. Maximum yield per plant was found in VRM-11-1 (0.97 kg) followed by VRM-12-6 (0.85 kg/plant) and VRM-20-1(0.75 kg/plant). The number of fruits per plant was found maximum in VRM-11-1 (11.57) followed by VRM-20-1 (9.27). As per the individual fruit weight, the maximum value recorded in VRM-12-6 (95.28 g) followed by VRM-1-2 (88.66 g) and VRM-8 (78.55g) (Dark green skin) at the edible stage. All these lines are moderately resistance to susceptible for viruses under field conditions. Some promising genotypes were VRM-5, VRM-5-2, VRM-1, VRM-20-1, VRM-11-1 and VRM-12-6 for yield, varietal purity, and disease tolerance (Fig. 39).

A promising advance line, VRM-11-1 selected for high yield and better fruit quality in both *Zaid* and *Kharif* seasons submitted for multi-location testing in IET trails of AICRP(VC) after station trials and proposed to the ITIC for varietal identification at Institute Level.

VRM-20-1 VRM-11-1 VRM-1-2 VRM-8

Fig. 39: Promising genotypes of Round melon

Long melon

Forty-five germplasm accessions were maintained including segregation population with snap melon. Thirty lines were evaluated in augmented design during *summer* and *kharif* 2020 for yield and horticultural traits. All genotypes were characterized traits like early harvest, high yield, fruit quality and resistant/tolerant to disease. Maximum yield per plant was found in VRLM-1 (1.11 kg/plant) followed by VRLM-13-1 (0.71 kg/plant) in the long categories. Number of fruits per plant was found maximum in VRLM-1 (10.50) followed by VRLM-7 (9.08). As per the individual fruit weight, maximum value recorded in VRLM-01 (106.04 g) followed by VRLM-13-1 (99.37 g) at edible stage. On the basis of overall performance VRLM-1, VRLM-13-1 (Dark green), VRLM-17, VRLM-24-1 (Dark green) and VRLM-40 in medium to long segment and VRLM-11-1 and VRLM-7 small segment were to be superior for yield and quality attributes. A promising advance line, VRLM-01 selected for high yield and better fruit quality in both *Zaid* and *Kharif* seasons proposed to IVRC committee for varietal identification at Institute Level.

Screening of Long melon and Round melon germplasm for *kharif* season production: In 2019 and 2020, thirty-five genotypes of long melon and fifteen genotypes of round melon including the released cultivars were evaluated for yield and various yield contributing traits in *kharif* season. The sowing was done in mid-august under training system. In general, in all the accessions, yield of long melon and round melon decreased as compared to that in spring summer crop. But the results indicated that the expression of femaleness to seasonal change is also depends on germplasm. There are few lines in both long melon and round melon, having stable sex expression and exhibited no significant di erence in yield. These lines have more prolonged flowering and fruiting period than summers and based on yield and other quality parameters, improved lines viz. VRLM-1, VRLM-24-1 VRLM-13 and VRLM-40 in long melon and VRM-1, VRM-11-1, VRM-20-1 and VRM-5-2 in round melon were found promising and yielded at par with summers (Fig. 40). Therefore, these lines are recommended for both summer and kharif seasons with better opportunity of higher market price in kharif.

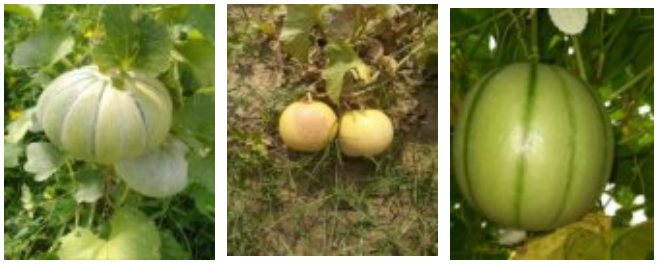
VRLM-24-1 DG VRLM-40 (LG) VRLM-11-1(LG) VRLM-1(LG)

Fig. 40: Promising genotypes of Long melon

Muskmelon

Status of germplasm: A total of 185 accessions of muskmelon which included genotypes of various fruit shapes *i.e.*, round, flaty round, oval and oblong and flesh colour i.e., yellow, white, orange and green flesh and 60 accessions of *C. melo* var *agrestris* and *C. callosus* were maintained at IIVR. In 2020, 10 accessions of muskmelon were augmented.

Performance of improved monoecious lines: Four improved monoecious lines (VRMM-170, VRMM-186, VRMM-301 and VRMM-302) of muskmelon, identified as most promising genotypes during 2019, were evaluated to validate their performance. These genotypes produced round to oval round fruit and exhibited earliness as compared to hermaphrodite lines. Fruit yield/vine, average fruit weight and TSS of VRMM-170; VRMM-186; VRMM301 and VRMM-302 were 4.5kg, 0.75-0.90kg and 10.00-11.00°Brix; 4.00kg, 0.68-0.80kg and 9.00-10.00°Brix; 3.6kg, 0.80-0.90 kg and 10° Brix; and 3.25kg, 0.75-0.85kg and 11° Brix, respectively (Fig. 41).



VRMM-301 **VRMM-170** **VRMM-302**

Fig. 41: Improved monoecious lines of muskmelon

Evaluation of green fleshed genotypes: Ten green fleshed genotypes of muskmelon VRMM-41, VRMM-42, VRMM-45, VRMM-47, VRMM-48, VRMM-49, VRMM-51, VRMM-52, VRMM-53 and VRMM-57 were evaluated for yield and fruit quality. Average fruit weight, number of fruits/plant, yield/plant and TSS in these genotypes varied from 300-850g, 3-7, 1.65-3.70kg and 11-13°Brix, respectively. VRMM-41, VRMM-42 and VRMM-47 were found as most promising genotypes in this segment (Fig. 42).

VRMM-41 **VRMM-42** **VRMM-47**

Fig. 42: Green fleshed genotypes of muskmelon

Evaluation of F_1 hybrids: A total of 15 F_1 hybrids which consist of 10 monoecious × andromonoecious, 2 andromonoecious × andromonoecious and 3 monoecious × monoecious were evaluated for various horticultural traits and fruit quality. These hybrids were either monoecious or andromonoeccious depending upon their parental combination. Among the monoecious × andromonoecious hybrids VRMM-301 × Kashi Madhu (Yield: 4.00kg/plant, TSS:10.5°Brix), VRMM-170 × Kashi Madhu (Yield: 3.82kg/plant, TSS:10°Brix), VRMM-301 × VRMM-35 (Yield: 3.55kg/plant, TSS: 10.20°Brix); in monoecious × monoecious the cross VRMM-170× VRMM-301(Yield: 3.25 kg/plant, TSS:9.0°Brix) and in andromonoecious × andromonoecious the hybrid Kashi Madhu × VRMM-35 (Yield:3.65 kg, TSS: 11°Brix) found to be most promising (Fig. 43).

VRMM-301×K.Madhu **VRMM-301×VRMM-35** **VRMM-170×VRMM 301** **VRMM-170×K. Madhu**

Fig. 43: Promising hybrids of muskmelon

Project 1.11: Genetic Improvement of Okra

Status of germplasm: A total of 710 accessions of diverse germplasm of cultivated okra maintained at ICAR-IIVR, which represent the significant diversity in the primary gene pool for various morphological, horticultural and biotic stress tolerance traits such as bush type, plant with short internodal length, thin fruited, ridge less, five to nine ridged, red fruited, cut leaf, YVMV and ELCV tolerance. Besides, 154 accessions of wild relatives including *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* also maintained at our institute. During 2020 10 new germplasm viz., 4 accession of cultivated okra, 3 accessions of *A. tetraphyllus*, 1 accessions of *A. tuberculatus* and 2 accessions of *A. moschatus* augmented.

Development and evaluation of F_1 hybrids in green fruited and red fruited segment: During spring

Table 17: Performance of promising F1 hybrids for yield and viral disease tolarance

Hybrids	Days to 50% flowering	Yield/ plant (g)	No. of fruits/plant	YVMV PDI	ELCV PDI
VRO-120× VRO-124	45.00	570.00	43.11	0.00	0.00
VRO-110×VRO-124	46.00	566.00	42.26	0.00	0.00
VRO-124× VRO-125	43.00	562.00	41.00	0.00	0.00
VRO-145 × 416-10-1	44.00	558.00	39.00	1.00	0.00
VRO-124× VRO-120	46.00	549.00	38.30	0.00	0.00
VRO-120× VRO-110	45.00	540.00	36.00	0.00	0.00
VRO 120× VRO-125	42.00	536.00	35.00	0.00	0.00
VRO-124 × VRO-109	45.00	530.00	33.00	3.00	0.00
VRO-125× VRO-145	47.00	525.00	32.25	2.00	0.00
VRO-145× VRO-124	44.00	510.00	32.00	1.00	0.00
VRO-145× VRO-120	47.00	500.00	31.00	0.00	0.00
VRO-145× VRO-125	46.00	490.00	29.00	0.00	0.00
Public sector hybrids (C)	49.00	420.00	24.80	10.50	11.05
Private sector hybrid (C)	51.00	535.00	36.00	00.00	1.55
Susceptible check (C)	45.55	205.88	11.36	90.00	76.00

summer season of 2020 a total of 26 F_1hybrids in the green fruited segment were developed using VRO-124, VRO-120, VRO-125, VRO-119, VRO-109, VRO-110, VRO-111, VRO-112, VRO-113, VRO-114, VROT-117,416-10-1, VROB-178 and VRO-145. These hybrids were evaluated during Kharif season using Kashi Bhairav, Kashi Shristi (Public sector hybrids) and Radhika (Private sector hybrid) as check. Out of these 26 experimental hybrids, 12 showed promising performance for fruit yield, quality, earliness and viral disease tolerance. Among these 12, the best performing hybrids found superior over the check in all respect were VRO-120 × VRO-124, VRO-110×VRO-124, VRO-124× VRO-125, VRO-145 × 416-10-1 and VRO-124× VRO-120 (Table 17).

In red fruited segment, 10 F_1 hybrids were developed utilizing Kashi Lalima, VROR-156, VROR-160, VROR-161, VROR-162 and VROR-158 and evaluated for plant architectural traits, redish purple fruit colur, fruit quality and tolerance to viral diseases. Among the evaluated red fruited hybrids VROR-161× Kashi Lalima (fruit yield: 347g/plant), VROR-160×VROR-161(fruit yield:325g/plant) and VROR-161×VROR-162 (fruit yield:300g/plant) were found most promising. Additionally, these three hybrids also exhibit high degree of tolerance to YVMV (PDI: 00%) and ELCV (PDI :< 2%).

Evaluation of advance lines in green fruited segment: A total of 51 advance lines were evaluated during kharif season for yield, fruit quality (uniform dark green fruit, devoid of seed bulging, spine), easy to harvest and tolerance to YVMV and ELCV diseases. Advance lines VRO-126, VRO-112-1, VRO-112, VRO-120, VRO-125, VRO-124, VRO-145, VRO-128 identified as most promising genotypes for fruit yield, fruit quality and disease tolerance during field evaluation. Among these promising lines, VRO-112 reported short fruit length of only 7-9 cm which fulfills the export specification of okra.

Multi-seasons performance of cut leaf okra lines: The cut leaf okra genotypes VRO-120 and VRO-125 were continuously evaluated in both summer and rainy season of 2018, 2019 and 2020 to find out their consistency in the expression of the morpho-horticultural traits, yield performance, tolerance to YVMV and ELCV diseases and vector loads. These two unique cut leaf genotypes performed consistently for yield and viral disease tolerance along with stable expression of cut leaf morphology across the six seasons of evaluation.

Evaluation of red fruited okra genotypes: A total of twenty five red fruited okra genotypes which included VROR-150, VROR-151, VROR-152, VROR-153, VROR-154, VROR-155, VROR-156, VROR-158, VROR-159, VROR-160, VROR-161, VROR-162, VROR-163, VROR164, VROR-165, VROR-166, VROR-170 etc. were evaluated along with Kashi Lalima for growth habit, branching pattern, uniform red fruit colour, fruit quality, yield and tolerance to viral diseases. In the evaluated genotypes, fruit colour ranged from reddish purple to dark purple, fruit length ranged from 12-16 cm, fruit diameter varied from 1.40-2.62 cm, number of fruits per plant ranged from 15-24 fruits and

Table 18: Nutritional content of red okra genotypes

Genotype	Environment	Anthocyanin Content (mg/100g FW)	Total carotenoids Content (mg /100g FW)	Total phenolics Content (mg catechol equivalent /100g FW)	Total Chlorophyll Content (mg /100g FW)
Kashi Lalima	2020-summer	3.75	0.61	40.15	0.61
	2020-rainy	3.66	0.58	38.50	0.59
	2020-poly house	3.51	0.65	41.25	0.49
	Mean	**3.80**	**0.61**	**39.96**	**0.56**
VROR-156	2020-summer	4.05	0.39	42.10	0.48
	2020-rainy	3.85	0.44	44.00	0.56
	2020-poly house	3.77	0.50	40.05	0.60
	Mean	**3.89**	**0.44**	**42.05**	**0.54**
VROR-158	2020-summer	3.40	0.50	35.64	0.41
	2020-rainy	3.35	0.56	36.00	0.34
	2020-poly house	3.65	0.51	34.50	0.36
	Mean	**3.47**	**0.52**	**35.38**	**0.37**
VROR-160	2020-summer	4.46	0.69	51.13	0.49
	2020-rainy	4.52	0.60	50.09	0.45
	2020-poly house	4.61	0.57	48.27	0.53
	Mean	**4.53**	**0.62**	**49.83**	**0.49**
Kashi Chaman	2020-summer	Nontraceable	0.87	34.97	1.61
	2020-rainy	Nontraceable	0.79	36.21	1.52
	2020-poly house	Nontraceable	0.81	38.00	1.58
	Mean	**-**	**0.82**	**32.06**	**1.57**

yield per plant varies from 210g-294g. Among the evaluated red fruited genotypes VROR-156(fruit yield: 250g/plant), VROR-160 (fruit yield: 294g/plant), VROR-161(fruit yield: 266g/plant) and VRO-165(fruit yield: 254g/plant) were identified as most promising red fruited genotypes with respect to yield, quality and disease resistance.

Evaluation of nutritional quality of red okra genotypes: Di erent nutritional parameters like total anthocyanin content, total carotenoids, total phenolics, and total chlorophyll content of 4 red okra genotypes Kashi Lalima, VROR-156, VROR-158, VROR-160 were analysed along with one green fruited genotype Kashi Chaman under three di erent environments i.e., summer season crop, rainy season crop and poly house grown okra during 2020 (Table 18).

Highest anthocyanin content and total phenolics content reported in VROR-160, followed by VROR-156 and Kashi Lalima.

Transfer of Genetic Male sterility (GMS) in desirable background: BC_2F_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 2020 and plants were selfed and BC_2F_2 seeds were harvested in the respective background. BC_2F_2 seeds were sown during the rainy season and all the plants were segregated for male sterility and were again back crossed with the respective recurrent parent and seeds harvested as BC_3F_1 which will be grown during summer season of 2021.

Generation advancement and characterization of $F_{2:8}$ RILs of VROR-156 × VRO-5: During the rainy season of 2020 seeds of 235 $F_{2:8}$ which consist of both red and green fruited recombinant inbred lines were grown and F_9 seeds were harvested from 200 RILS. They were also characterized for various morphological and horticultural traits. Fruit colour was either red or green, growth habit erect or bushy and plants were either tall or semi dwarf. Considerable variation was observed for all traits under consideration. Days to 50% flowering, plant height, number of branches per plant, fruit length, fruit diameter and fruit yield/plant varied from 42-53 days,102-180 cm, 2-5, 12-15 cm, 1.40-2.10 cm and 175-300g.

Intra and inter-specific variation of micronutrient content in the genus *Abelmochus:* Micronutrients (Fe, Mn, Zn and Ca) content of 42 germplasm in seven

Table 19: intra and inter-specific variation of micronutrients content in okra

Species	Micronutrients	Range (PPM)	Mean (PPM)	Deviation
Abelmoschus esculentus	Fe	30.00-87.00	57.00	2.90
	Mn	22.1-59.7	33.00	2.70
	Zn	23.3-53.8	34.24	2.31
	Ca	455-1855.25	1244.00	4.08
Abelmoschus caillei	Fe	36.00-85.00	53.91	2.36
	Mn	13.60-45.80	28.41	3.37
	Zn	18.20-38.30	27.41	2.10
	Ca	488.00-932.00	734.5	1.91
A. manihot	Fe	47.20-74.70	60.95	1.58
	Mn	12.20-33.90	24.40	2.78
	Zn	16.90-25.30	21.10	1.50
	Ca	605.00-818.00	712.60	1.35
A. tetraphyllus	Fe	38.00-60.50	42.16	1.59
	Mn	15.50-26.20	17.83	1.69
	Zn	16.90-32.60	24.17	1.93
	Ca	715.50-1072.10	782.32	1.50
A. tuberculatus	Fe	50.70-63.20	56.15	1.25
	Mn	15.20-26.50	20.85	1.74
	Zn	31.20-43.60	30.70	1.40
	Ca	719.10-941.22	703.74	1.31
A. ficulneus	Fe	49.60-68.10	58.85	1.37
	Mn	13.40-24.00	18.6	1.79
	Zn	27.11-34.00	26.61	1.25
	Ca	694.64-876.39	664.25	1.26
A. moschatus	Fe	30.00-76.00	53.21	2.53
	Mn	12.60-29.70	21.15	2.36
	Zn	19.90-35.10	31.00	1.76
	Ca	811.00-1705.00	1136.20	2.10

di erent species of okra *viz*., *Abelmoschus esculentus* (15), *Abelmoschus caillei* (6), *A. manihot* (4), *A. tetraphyllus* (7), *A. tuberculatus* (3), *A. ficulneus* (3) and *A. moschatus* (4) was estimated. Su cient intra and inter-specific variation was reported for the Fe, Mn, Zn and Ca content (Table 19).

Evaluation of scarlet red flowered ornamental type interspecific hybrid: The interspecific hybrid *A. moschatus* × *A. moschatus* subsp. *tuberosus* which developed by crossing in 2017 and subsequently evaluated for three years (2018, 2019 and 2020) for its showy scarlet flowers which bloom throughout the year even during winter month also. The flowers just resembled to China rose flowers. Single plant was capable to producing about 80-100 flowers every day. Besides, it can be also propagated through stem cutting. This hybrid showed immune reaction to YVMV and ELCV diseases (Fig. 44 & 45) and can be utilized for introgression of resistant gene into cultivated okra.

Identification of non-splitting fruit type in okra: Okra fruit is botanically a capsule which is simple dry fruit and dehiscent in nature and upon ripening it splits open and

Fig. 44: Red flowered fertile interspecific hybrid

Fig. 45: Dehiscent fruit of Kashi Pragati and non-dehiscent fruit of IC506134

exposes the seeds. Unexpected rainfall at the time fruit ripening a ects the seed quality as the seeds are exposed to excessive moisture directly. During the evaluation of germplasm, one genotype IC506134 was identified for its non-dehiscent fruit types where fruits do not split open and seeds remain concealed within it. This genotype can be used as a source for developing non-dehiscent fruit splitting tolerant genotypes in okra for improving seed quality.

Evaluation advance lines of okra for red spider mite tolerance: A set of 20 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 and VRO-146) along with three varieties Kashi Pragati, Kashi Kranti and Kashi Chaman were evaluated for reaction to red spider mite infestation based on the damage grading index. Based on damage grading index, among these 23 genotypes VRO-121-1 and VRO-145 were found to be highly tolerant; VRO-120 and VRO-125 moderately tolerant, while other genotypes were found to be susceptible to red spider mite (Fig. 46).

VRO-112-1 (tolerant) | VRO-145 (tolerant) | VRO-119 (susceptible)

Fig. 46: Red spider mite tolerant/susceptible lines of okra

Biochemical analysis of symptomatic and asymptomatic plants infected with ELCV: Biochemical analysis of symptomatic and asymptomatic plants infected with okra enation leaf curl virus was carried out during the *Kharif* season of 2020. Estimation of catalase (CAT), phenyl alanine ammonia lyase (PAL), peroxidase (PO), polyphenol oxidase (PPO) and super oxide dismutase (SOD) was done in the five genotypes namely, Kashi Kranti, Okyvres-10, VRO-102, VRO-115 and VROT-102. Both susceptible and resistant genotypes of these genotypes were used for the analysis of these defence related enzymes. Significant genotypic variation was found among the genotypes for these defence related enzymes. The catalase was always lower in the resistant plants as compared to the susceptible plants of the same genotype (Fig. 47). Similarly, PA, PO and PPO were found to be in higher concentration in the susceptible plants of the respective genotypes. However, the resistant plants had higher SOD concentration as compared to the susceptible plants of these genotypes.

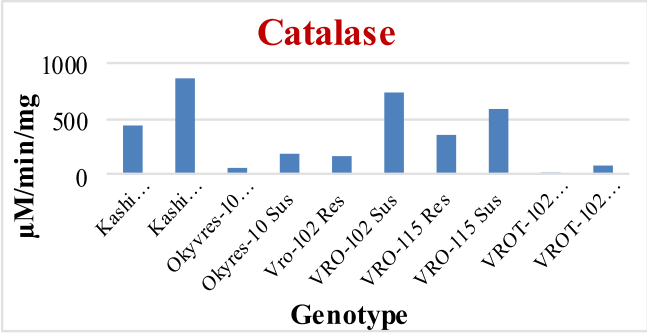


Fig. 47: Genotypic variation for catalase content in the susceptible and resistant plants of okra

Generation advancement of breeding material: Numbers of progeny families of di erent stages or generations of inbred lines development were grown. Single plant selections was performed to identify plants with uniform dark green fruit colour, faster fruit growth, easy to pick, free from fruit spine, desirable fruit size and resistance/tolerance to biotic stress like YVMV, OELCV and fruit borer. Selected plants were self-pollinated and seeds were collected for the further advancement to subsequent generation. Summary of the generation advancement work is: F_2-60 lines, F_3-33 lines (95 SPS), F_4-14 lines (72 SPS), F_5-9 lines (61 SPS), F_6-8 lines (70 SPS), F_7-8 lines (90 SPS), F_8-7 lines (75 SPS), F_9-6 lines (65 SPS) and F_{10}-5 lines (70 SPS).

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 (2 kg each). Parental lines of the hybrid Kashi Bhairo and Kashi Shristi were also maintained by self-pollination.

Project 1.12: Genetic Improvement of Cole Crops and Root Crops

Cole Crops

CMS lines and F_1 hybrids in tropical cauliflower: Back-cross breeding was followed to advance 20 BC populations (BC_1F_1-BC_6F_1) relating to Ogura-CMS system into various backgrounds i.e. plant type (Semi-spreading/Semi-erect), curd maturity (Early/Mid/Mid-late), curd colour (White/Orange) and flower colour (Yellow/White). Among these, five Ogura-CMS lines were found to be stable, robust and uniform (Fig. 48) at di erent curding temperatures such as VRCF-41 (28-30

˚C), VRCF-131 & VRCF-132 (24-28 ˚C), VRCF-110 (22-25 ˚C) and VRCF-212 (20-23 ˚C). The hybrids were developed by crossing with 8 pollen parents for further evaluation. The pollen grains of cole crops are round in shape and their diameter varies from 24-26 µm. Among 40 hybrids evaluated, eight best promising CMS-based F_1 hybrids expressing 10-22% heterosis for curds at di erent temperatures are VRCF-41×VRCF-75-1, VRCF-41×VRCF-50 and VRCF-131×VRCF-75-1 (28-30 °C); VRCF-131×VRCF-86, VRCF-110×VRCF-50 and VRCF-131×VRCF-75-1 (24-28 °C); and VRCF-212×VRCF-77 and VRCF-222×VRCF-77 (20-25 °C). The parental lines of CMS-based F_1 hybrids are ready for commercial use.

Fig. 48: Robust flower of CMS line (VRCF-131A) and its maintainer (VRCF-131B)

Evaluation of cauliflower: A sum of thirty-nine genotypes (varieties, advance lines, germplasm) of various maturity groups were evaluated and characterized for traits of economic importance. For curd yield and quality, the following genotypes were found to be promising namely VRCF-75-1 during 1st fortnight of October (28-32 °C); VRCF-75-1, VRCF-35 and VRCF-118 during 2nd fortnight of October (28-30 °C); Kashi Gobhi-25, VRCF-120, VRCF-112 and VRCF-32 during 1st fortnight of November (24-28 °C); and VRCF-104 and VRCF-77 during 1st fortnight of December (20-23 °C). The 4 promising genotypes (VRCF-104, VRCF-202, Kashi Gobhi-25 & VRCF-77) and 6 hybrids (VRCF-41×VRCF-75-1, VRCF-41×VRCF-50, VRCF-110×VRCF-50, VRCF-131×VRCF-75-1, VRCF-131×VRCF-86 & VRCF-222×VRCF-77) are in multi-location testing for early- and mid-season maturity under varietal/hybrid trials of AICRP-VC. Maintenance breeding of a variety Kashi Gobhi-25, and 5 CMS lines & their maintainers are being done by producing nucleus seed (50-1000 g of each) in flexible nylon-net cage.

Orange and green cauliflower: β-carotene rich genotypes with orange coloured curd were grouped in five categories depending upon curd colour intensity and β-carotene content (light to dark orange, β-carotene content 0.70-1.65 mg/100g FW); and the segregating population were advanced. However, green curd genotype is good source of glucosinolates, but very late in maturity (>110 days), poor in harvest index (<20%) and inferior in seed setting. Hence, crosses between green curd and white curd were made, evaluated and being advanced to next generation for transferring green curd trait in tropical backgrounds.

Tropical cabbage and broccoli

The back-crosses were made in eight genotypes to transfer Ogura-CMS system in cabbage/broccoli (BC_1F_1 to BC_2F_1). Nine genotypes of tropical cabbage and seven of tropical broccoli have been evaluated for various traits such as head shape, size and compactness, and advanced to next generation. Three genotypes of tropical cabbage such as VRCAB-112, VRCAB-116 and VRCAB-111 were found promising having small frame size (40-45 cm), higher harvest index (65-70%), and head is medium in size and weight (14-16 cm & 900-1150 g), round in shape and compact.

Tropical kale

Institute is having two distinct genotypes of tropical kale namely such as VRKALE-1 (smooth leaf) and VRKALE-9 (trichome leaf) which initiates flowering

Fig. 49: Flowering in VRKALE-1

during 3rd week of February, doesn't require vernalization and sets healthy seeds in Varanasi conditions (Fig. 49). Seed boldness (1000 seed weight) of VRKAKE-1 is showing increasing trend during course of acclimatization i.e. 1.512 g, 1.502 g, 1.555 g, 1.746 g, 1.832 g, 2.450 g and 2.545 g since 2013-14, 2014-15, 2015-16, 2016-17, 2017-18, 2018-19 and 2019-20, respectively. The leaves of both genotypes become ready for first picking in 25-30 days after transplanting and have biomass yield potential of 40-45 t/ha. The F_1 crosses between trichome and non-trichome indicated that the presence of trichomes on petiole and leaf lamina is governed by monogenic recessive gene.

Documentation, conservation and maintenance of cole crops: Kashi Kale-1 (INGR20035, VRKALE-1), a genotype of tropical kale has been registered as unique germplasm by NBPGR, New Delhi. Three genotypes of kale/cauliflower have been documented with NBPGR, New Delhi whose IC numbers are 0632940 (VRKALE-1), 0632941 (VRCF-110) and 0632942 (VRCF-111). A sum of 93 genotypes/accesions, including 75 of cauliflower, 9 of cabbage, 7 of broccoli and 2 of kale are being maintained.

Radish

CMS lines and F_1 hybrids in radish: To harness heterotic potential and economize F_1 seed production; 21 back-cross population have been advanced to various stages (BC_1F_1-BC_7F_1) for development of robust CMS system in the traits of economic importance such as leaf morphology (lyrate, sinuate, entire), root colour (white, red, purple), root shape (tapering, blunt) and adaptability (winter, spring, summer). Five stable CMS lines i.e. VRRAD-11, VRRAD-14, VRRAD-41, VRRAD-198 and VRRAD-201 have been developed through back-crossing which are stable and uniform to their respective maintainer. Unlike to popular Ogura CMS system in radish, another novel CMS i.e. Kashi CMS system has been identified in which anthers failed to develop functional pollen grains (Fig. 50). Eight best promising heterotic CMS-based F_1 hybrids for various traits of economic importance are VRRAD-204×VRRAD-213, VRRAD-11×Kashi Mooli-40 & VRRAD-201×Kashi Mooli-40 (lyrate leaf, less tapering root, winter season); VRRAD-201×VRRAD-216 (entire leaf, less tapering root, winter season); VRRAD-41×VRRAD-202 & VRRAD-201×Kashi Sweta (sinuate leaf, tapering root, autumn/winter/spring season); and VRRAD-41×VRRAD-200 & VRRAD-201×VRRAD-200 (sinuate leaf, tapering root, autumn/winter/spring/summer season; Fig. 51); and their parents are ready for commercial use.

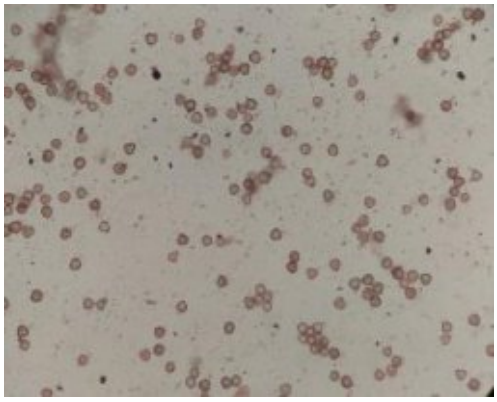


Fig. 50: Non-functional pollen grains of Kashi CMS

Fig. 51: Performance of heat tolerant CMS-based F_1 hybrid (VRRAD-201×VRRAD-200) during May-June at farmer's field

Evaluation of radish: A total of 76 genotypes, including 41 promising lines, varieties & germplasm, and 35 hybrids were evaluated and characterized for leaf morphology (lyrate, sinuate & entire), root colour (white, red, purple, yellow & black), root shape (tapering, blunt & globose), maturity (<30, 30-45, >45 days), heat tolerance and flower colour (white, purplish-white, purple & dark purple). The following genotypes were found to be promising for yield and quality namely Kashi Mooli-40, VRRAD-204, VRRAD-200, VRRAD-202 and Kashi Aardra (white root); Kashi Lohit (VRRAD-131-2), VRRAD-170, VRRAD-171 and VRRAD-173 (red root); and VRRAD-134 and VRRAD-131 (purple exterior). For introgression of the traits of economic importance, three types of population such as (i) sinuate leaf with blunt root [(VRRAD-4×VRRAD-202)×VRRAD-4], (ii) entire leaf with blunt root [(VRRAD-4×VRRAD-150)×VRRAD-4] and (iii)

sinuate leaf with long root [(VRRAD-203×VRRAD-202)×VRRAD-203] were developed following backcross-pedigree method and evaluated in 2nd and 3rd selection cycle (Fig. 52). Moreover, in the study of inheritance pattern of various leaf morphology using F_1 hybrids, test crosses and F_2 population; it reflects the following dominance pattern: Lyrate > Entire > Sinuate leaf shape. Two best promising genotypes (VRRAD-203 and VRRAD-200) are in multi-location testing under varietal trial of AICRP-VC. Moreover, maintenance breeding of four varieties (Kashi Sweta, Kashi Hans, Kashi Lohit and Kashi Mooli-40), and five CMS lines/Maintainers (VRRAD-11, VRRAD-14, VRRAD-41, VRRAD-198 and VRRAD-201) are being done by producing nucleus seed (50-1800 g) in flexible nylon-net cage.

Documentation, conservation and maintenance of radish: First Ogura-CMS line from Public Sector in India i.e. VRRAD-201 (INGR20032) with better combining ability, heterotic potential and sinuate type of leaf shape has been registered as unique germplasm by NBPGR, New Delhi; and also IC number was alloted for a genotype i.e. 0632943 (VRRAD-204). Total 95 genotypes (varieties, advance lines, germplasm) of white, red, purple, black and yellow coloured radish are being maintained at this institute.

Fig. 52: An introgressed line with entire leaf and blunt root

Carrot

CMS lines and F_1 hybrids in carrot: Sixteen back-cross populations of petaloid-CMS system have been advanced to next generations (BC_1F_1-BC_5F_1) in red, black, yellow, orange and rainbow coloured roots. Three stable CMS lines i.e. VRCAR-211 & VRCAR-214 (Red carrot) and VRCAR-252 (Black carrot) have been developed through back-crossing at ICAR-IIVR, Varanasi which are very uniform to their respective maintainer (Fig. 53). Forty-two F_1 cross combinations (7×6) were evaluated for various traits of economic importance; among these following eight F_1 hybrid combinations VRCAR-211×VRCAR-86, VRCAR-214×VRCAR-86, VRCAR-214×VRCAR-201 & VRCAR-211×Kashi Arun (red root); VRCAR-241×VRCAR-131 (orange root); VRCAR-252×VRCAR-125 (black root); and VRCAR-291×VRCAR-89-1 & VRCAR-252×VRCAR-107-2 (rainbow) have been found to be potentially heterotic for yield and quality traits.

Fig. 53: VRCAR-211, a petaloid CMS line of carrot

Evaluation of carrot: A total of 96 genotypes (red, black, orange, yellow, cream, white and rainbow carrots) including 49 of varieties, promising lines & germplasm, and 47 hybrids of tropical carrot were evaluated and characterized for various traits (Fig. 54). The most promising genotypes with higher root yield and better quality traits (self-coloured small core, fewer secondary roots, lesser root scars) are VRCAR-86, Kashi Arun (VRCAR-186) & VRCAR-201 (red root); Kashi Krishna, VRCAR-125 & VRCAR-89-1 (black root); VRCAR-142, VRCAR-132 & VRCAR-131 (orange root); VRCAR-154, VRCAR-127 & VRCAR-153 (yellow root); VRCAR-160 (cream root); and VRCAR-107-1 & VRCAR-107-2 (rainbow-type root). Moreover, black carrot variety Kashi Krishna could be used as potential pigment source by pharmaceutical industries as this is one of the excellent sources of anthocyanins (275-300 mg/100 g FW), high antioxidant ability (20-25 times higher than red/orange), having root potential yield of 225-250 q/ha and able to produce anthocyanins to the tune of 68-70 kg/ha. For transfering the traits of temperate carrot (dark orange colour, smooth and scar free roots) in tropical genotypes, ten population of a cross (temperate and tropical orange carrot) have been evaluated in 3rd selection cycle, and advanced in next generation (Fig. 54).

Fig. 54: VRCAR-132, a tropical orange carrot

Two varieties i.e. Kashi Krishna and Kashi Arun, and three CMS lines & their maintainers are being maintained by producing nucleus seed (50-2500 g of each) in flexible nylon-net cage. Total 78 genotypes including varieties, promising lines, accesions and germplasm of 7 di erent coloured roots (red, black, orange, yellow, cream, white and rainbow) are being maintained at ICAR-IIVR, Varanasi.

Project 1.13: Biotechnological Interventions including Transgenics for Managing Stresses in Vegetables

In-planta transformation in okra: Transgenic okra through tissue culture independent, in-planta transformation of okra in the cultivar Kashi Kranti was initiated. A total 143 seedlings were raised from 5 T1 events in pots under containment proof insect house and 20 days old seedlings were sprayed with 100 mg/l of kanamycin (Fig. 55). After five to six successive sprays the Bt-positive plants survived but the non-transgenic plants died. Further, from survived plants total DNA was extracted, the presence of npt II gene confirmed only in 3 T2 events by PCR using npt II specific primers (Fig. 56). Selfing was performed on fully grown plants for multiplication and T_2 seeds of mature selfed fruits from three plants were harvested and stored. Further, in-planta transformation of okra in the cultivar Kashi Kranti was repeated Transformed plants were transferred to the screen house in normal condition for further growth and development. The genomic DNA isolated from new leaf and screened for npt-II gene with gene specific primer. The npt-II positive plants were transferred to big pots further growth and development. A total 3000 seedlings transformed.

Mapping of Quantitative Trait Loci (QTLs) of agri-horticultural traits in eggplant: To accelerate trait-specific breeding and assist molecular marker-assisted

Fig. 55: Development of Fruit borer resistant Cry1Ac gene containing Transgenic okra

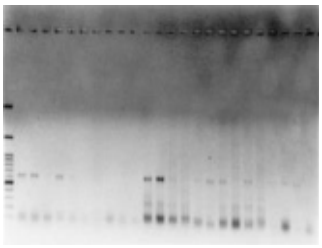


Fig. 56: PCR analysis of the transformed plants showing npt II DNA fragment Transgenic okra

selection for genetic improvement of eggplant, two morphologically diverse accessions of eggplant *S. melongena* and *S. incanum* were used as parental lines of a mapping population of 114 RILs for identification of quantitative trait loci (QTLs) associated with agri-horticultural traits in eggplant. The mapping population was phenotyped for 33 traits related to leaf, flower, fruit and plant morphology. Phenotypic data and genotyping information of RILs revealed the occurrence of 36 statistically significant QTLs detected using Composite Interval Mapping (CIM) method. 17 QTLs classified as 'major', were identified to be a ecting fruit and yield-related components such as fruit color and dimensions, length and axis of pedicel, relative fruit calyx length and fruits per plant. Using the CIM method combined with multiple-marker regression analysis, 36 statistically significant QTLs were detected for important horticultural and yield-related traits in eggplant. These QTLs were found to be evenly mapped on all LGs from SmLG01 to SmLG12 exhibiting a uniform distribution. Six, twenty and ten of these QTLs were significant at 0.1%, 1%, and 5% level of the LOD threshold, respectively. Percentage of phenotypic The proportion of PVE was estimated by coe cient of determination or R2 values variability explained (PVE %) by di erent QTLs varied from 7.39 to 25.32%. which ranged from 0.0739 to 0.253. Further, the QTLs were considered to be significant when the LOD score value was ≥ 2.5. QTLs detected on each LG are depicted in Fig 57. The average number of QTLs detected per trait was 1.09. The average number of QTL identified on each LG was 3 with maximum number of QTLs on SmLG04, SmLG08, and SmLG10 (4 QTLs on each) and least on SmLG03 and SmLG12 (only 1 on each). Highest numbers of QTLs were identified for the traits relative fruit calyx length (Rfcl) and fruit color distribution (Fcd). Many of the fruit related QTLs tend to cluster in the specific chromosomal regions which reflects linkage phenomenon.

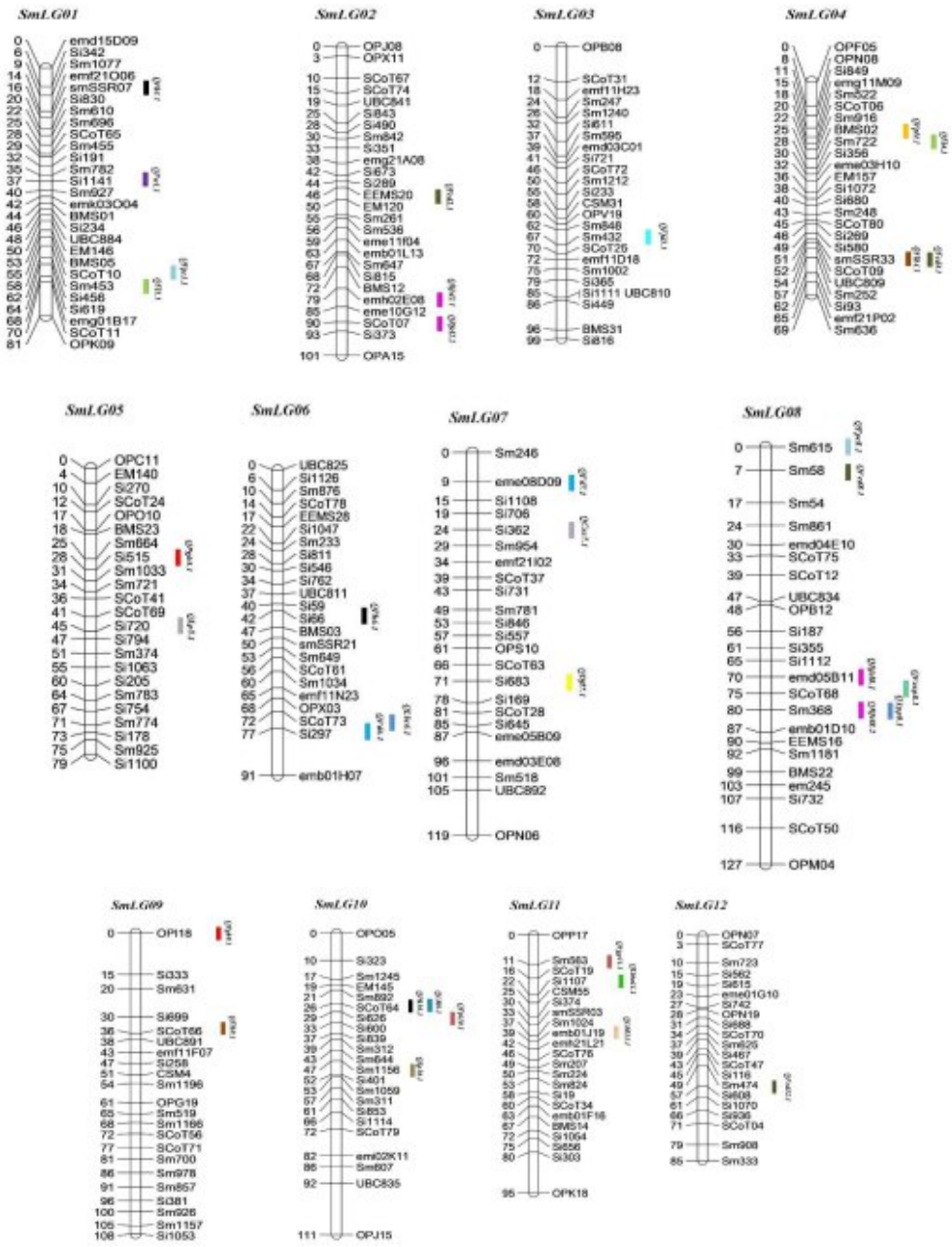


Fig. 57: QTLs detected in the mapping population

Project 1.14: Genetic Improvement of Under-exploited and Future Vegetables

Winged bean

Germplasm augmentation and Characterization: With the aim to identify the Winged bean germplasm lines suitable for vegetable purpose, a total of 40 new accessions of Winged bean were augmented from NBPGR Regional Station, Akola, Maharashtra during 2019-20. These lines were sown to characterize them for di erent horticultural traits viz. pod colour (light green, green, dark green and purple-green colour), average number of pod per cluster (2- 2.5), days anthesis (70-100), days to fruiting (18-23), pod length (15.6 -25.0 cm), average pod weight (16.1-28.0 g), average pods per plant (28.0-59.0) pod yield per plant (975.0-1670.0 g) and dry weight per pod (1.2-4.6 g). However, genotypes EC 178292 (72 days), IC 95237-1 (75 days) observed

early and IC 17005 (104 days) as late genotype for days to first flowering (Fig.58). Genotypes EC 178292 (84 days), I C 95237-1 (87 days) as early and IC 17005 (116 days) as late for days to first fruiting traits. Maximum pod length was recorded in IC 95239 (25.0 cm) while minimum in genotype IC 95237-1 (14.5 cm). Maximum pod width (1.96cm) recorded in genotype IC 15018 while minimum pod width noticed in EC178295 (1.65 cm). Maximum number of pod per plant recorded in genotypes EC 178275 and IC 17009 (95) while minimum in IC 17005 (28). Maximum green pod yield per plant recorded in EC 178282 (1670.0 g) while minimum in IC 17005 (975.0 g). Maximum pod yield recorded in EC 178282 (150.3 q/ha) while minimum in IC 17005 (87.8 q/ha). However, maximum dry weight recorded in genotype EC 389561 (4.62 g) while minimum in IC 95239 (1.01 g).

Genotype - EC 178282 **Genotype - IC17009** **Genotype- IC95237-1**

Fig. 58: Promising genotypes of winged bean

Evaluation & characterization of diverse genotypes: In addition to newly augmented germplasm lines, a total of 252 germplasm lines of winged bean were also characterized for di erent horticultural traits viz., pod colour (light green, green, dark green, purple-green colour and dark purple colour), average days to anthesis (62-73), days to edible maturity (14-21), pod length (19.5-25.33 cm), pod weight (19.3-21.9 g), pod per cluster (2-3.7), pods per plant (107-178), yield per plant (2140.0-3560.0 g), dry weight per pod (2.0-4.18 g), tuber length (12.2 -16.8 cm), tuber width (1.35-2.68 cm), number of tuber per plant (3-8) and tuber yield per plant (200-1000g). Genotypes viz., VRWBH- 27-18, VRWBH- 39-18, VRWBH- 46-18, VRWBH- 21-17, VRWB- 19, VRWB- 54, and VRWB- 21 were identified as promising for green pod yield and related traits and genotype VRWB-69 and VRWB-54 were adjudged as promising for tuber yield and associated traits.

Hybridization: 30 F_1 crosses were attempted to target the traits viz., earliness, more number of pod per plant and higher green pod yield per plant. To get higher number of pod per plant, crosses were attempted by utilizing the parents' viz., EC-918088 X VRWB-3, EC-918083 X EC-918084, EC-918082 X EC-918081, EC-918082 X EC-918083, EC-918083 X EC-918087, VRWB -29 X VRWB-28, VRWB-19 X VRWB-17, VRWB-4 X VRWB-12, VRWB-28 X VRWB-39, VRWB-11 X VRWB-32, VRWB-79 X VRWB-81, VRWB-18 X VRWB-19, VRWB-49 X VRWB-43, EC-918081 X VRWB-26, EC-918084 X EC-918087,VRWB-57 X VRWB-89, VRWB-41 X VRWB-83, VRWB-59 X VRWB-31, VRWB-9 X VRWB-12, VRWB- 9 X VRWB-17, VRWB-52 X VRWB-43, VRWB-98 X VRWB-79, VRWB-61 X VRWB-82, VRWB-56 XVRWB-77, VRWB-66 XVRWB-77, VRWB-66 XVRWB-97, VRWB-86 XVRWB-97 VRWB-66 XVRWB-97, VRWB-96 XVRWB-107.

Advancement of generation: 55 F_1 lines were advanced to F_2 population. 11 F_2 lines were advanced to F_3 generation.

Molecular characterization of winged bean germplasm through SCoT and IISR markers: A total of Seventy five Star Codon Targeted (SCoT) markers were used to assess genetic diversity and population structure of Winged bean germplasm lines which were morphologicaly diverse. Among these 39 were polymorphic, 25 monophorphic and 11 were not ampliphied. The genetic diversity and population structure was also done through 10 IISR markers of which all were polymorphic (Fig.59a & b).

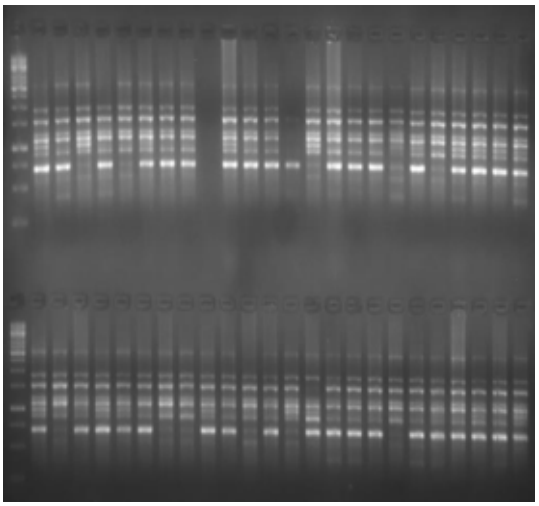


Fig. 59a: Molecular characterization of Winged bean

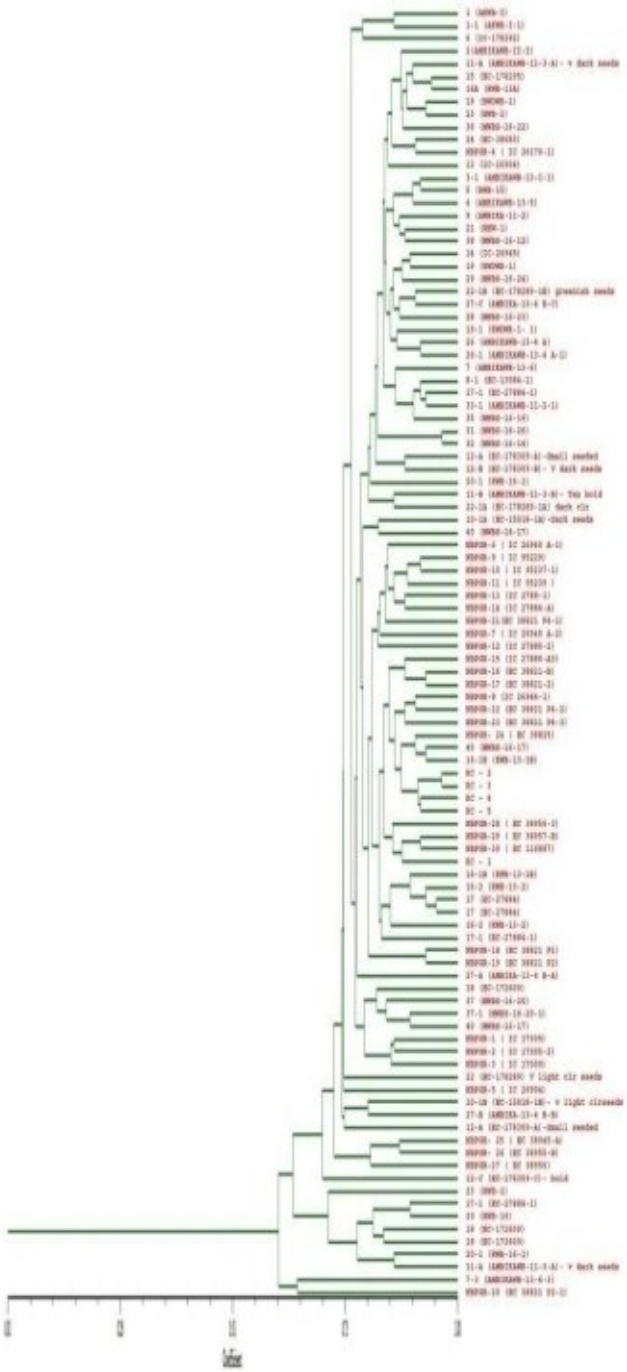


Fig. 59b : Winged bean –IISR dendogram

Vegetable Soybean

Inheritance of pubescence type: The glabrous pods or grey pubescence is highly preferred trait for the vegetable soybean cultivars since the appearance of the cooked pods is clean compare to brown or dark pubescence pods. Inheritance of this traits was worked out by utilizing glabrous genotype AGS-406 of vegetable soybean and that was crossed with normal pubescence cultivar AGS-346 and "*Swarna Vasundhara,* the commercially released cultivar of vegetable soybean in India. The segregation ratio of the F_2 population was fit to the expected ratio of 3:1, and the glabrous phenotype was found to be controlled by a single dominant gene (Fig. 60).

Fig. 60: Segregation of plants for glabrous trait in F2 Population of AGS-406 × Swarna Vasundhara

Advancement of generation and maintenance breeding of germplasm: A total of seven F_1, six F_2 crosses and 249 F_3 lines of a cross 'AGS-461×SL-95' were grown during the seasons and advanced to their next higher generation using single plant selection approach. The plants were selected based on overall desirability for horticultural traits along with resistance to YMV. A total of 102 germplasm lines of soybean were grown and maintained during the season. The genotypes were grown in Augmented Block Design and maintenance breeding was done through true to type single plant selection.

Characterization of promising lines: A total of 102 genotypes of vegetable soybean were grown and characterized for various horticultural traits from July to October 2020. The lines *viz.*, AGS-339, AGS-447, AGS-459, AGS-460, AGS-461, AGS-328, AGS-423, AGS-429 and AGS-430 were found earliest for days to flowering (≤35 days). Pod length was found to vary from 3.3 to 6.4 cm pod width from 0.8 to 1.8 cm, average pod weight from 1.1 to 2.7 g, pods per plant from 15 to 86 (No), plant height from 18.0 to 40 cm, and pod yield per plant from 30 to 156.0g. Based upon overall performance the genotypes *viz.*, AGS-339, AGS-447, AGS-429, AGS-465, AGS-346, AGS-466, AGS-292, 431/GC04008-YO-2-1, AGS-610, AGS- 471 and *Swarna Vasundhara* were found superior for various horticultural traits (Table 20 & Fig. 61).

Table 20: Characterization of genotypes for various horticultural traits

Traits	Promising genotypes
Days to 50 % flowering (=35 days)	AGS-339, AGS -447, AGS -459, AGS -460, AGS-461, AGS -328, AGS -423, AGS -429 7 & AGS-430
Pod length (=5.0 cm)	AGS-339, AGS -447, AGS-457, AGS-459, AGS-460, AGS-328, AGS-423, AGS-429, AGS-456, AGS -469, AGS-472, AGS-292, GC03004-602, 8/GC04008 -154-8-1-2, AGS-465, AGS-346, AGS-610, AGS-910, AGS-471, AGS-123 & *Swarna Vasundhara*
Pod width (=1.3cm)	AGS-447, AGS-457, AGS-430, AGS -910 &*Swarna Vasundhara*
Plant height (40-80cm)	AGS-447, AGS -429, AGS -430, AGS -466, GC02008206-1, 431/GC0400 8-YO-2-1, AGS-465, AGS -346 & *Swarna Vasundhara*
Average pod weight (2-2.5 g)	AGS-457, AGS-328, AGS-429, AGS-466, AGS-292, AGS-465, AGS-346, 56/GC05012-197-2, AGS-910, AGS-471 & *Swarna Vasundhara*
Pods/plant (50-86)	AGS-123, AGS -910, AGS -610, AGS -346, AGS-292, AGS -406 & *Swarna Vasundhara*
Seeds per pod (2.6-2.8 No.)	AGS-447, 4 AGS -57, AGS -460, AGS -466, 431/GC04008-YO-2-1, AGS-465, AGS-346, AGS-366, AGS-471, AGS-123 & *Swarna Vasundhara*
Pod yield per plant (50-176 g)	AGS-429, AGS -466, AGS -472, AGS-292, GC03004-602, 431/GC04008-YO-2-1, AGS-346, AGS -610, 56/GC05012-197-2, AGS-471 & *Swarna Vasundhara*

Fig. 61: Variation for pod characters in promising lines of vegetable soybean

Fig. 62: Promising cluster bean line VRCB-95

Cluster bean

A total of 150 genotypes of cluster bean were evaluated for high yield, earliness, better pod quality and resistant/tolerant to viruses. All the entries were barcoded and field book was synchronized in mobile for data recording. Eighteen entries (selected on the basis of previous two year's performance) were evaluated for yield and horticultural traits in RBD with 2 replications. VRCB-47, VRCB-48, VRCB-95 and Dilojan-3 were found promising for morphological traits. VRCB-48 and VRCB-95 of cluster bean outperformed checks for second consecutive year (table) and were included in AICRP (VC) trials for 2020-21. Under breeding programme, 24 F_1 and 16 F_2 populations were advanced to next generation with an aim to develop superior variety of cluster bean for vegetable purpose (Table 21 & Fig. 62).

Table 21: Performance of VRCB-95 and VRCB-48 along with check

Genotype	Year	Pod Length (cm)	Days to 50 % flower	Days to First pod Set	Plant Height (cm)	Fruit Yield (q/ha)
VRCB-95	2018-19	6.5	48	57	98.3	179.4
VRCB-95	2019-20	6.1	51	59	122.6	169.8
VRCB-48	2018-19	6.6	50	58	102.8	168.3
VRCB-48	2019-20	6.4	53	62	124.6	172.2
Pusa Navbahar (C)	2018-19	15.8	43	52	61.3	170.4
PusaNavbahar (C)	2019-20	12.4	46	56	65.7	156.3

Faba bean

Five genotypes of faba bean were introduced from 3 districts of Bihar during 2020. A total of 115 faba bean genotypes were evaluated during *Rabi* 2019-20 for yield and horticultural traits. All genotypes were characterized for important horticultural traits viz. early maturity, high yield, better pod quality and resistant/tolerant to disease. Further, a station trial comprising 5 entries in replicated block design with two replications was also conducted. Muradabad-103, EC- 628941, EC- 628929, and Cherry emerged as superior genotypes for yield, varietal purity and disease tolerance in 2nd consecutive year of testing (Fig 63). All the genotypes were maintained true to type using nylon bag and successfully harvested. Some of the promising genotypes identified for key horticultural traits have been enlisted in table 22 given below:

Table 22: Promising Faba bean genotypes for key horticultural traits

Trait	Genotypes
Disease resistance/ Charcoal rot	EC 841536, EC 841541, EC 628930, Muradabad-103, ET -3134, ET -1119, ET - 1119
Long Pod	EC 841541, EC 628930, EC 8 41531, ET-3134, ET-5108, ET-3112
Good plant architecture	EC 841519, EC 628941, EC 591784
More number of pods	Muradabad-103, EC- 628941, Cherry, ET-5121, ET-1107
High yield	Muradabad-103, EC - 628941, EC-628929, Cherry

VRBB-1 (Selection of Muradabad -103) **VRBB-2 (EC 628941)**

Fig. 63: Promising Faba bean genotypes

Dopamine estimation in Faba bean: In addition to Faba bean's agricultural potential, it is also known for its industrial value as it is rich in levodihydroxy phenylalanine (L-DOPA), the precursor of dopamine. Its consumption can increase the levels of L-DOPA in the blood, with a marked improvement in the motor performance of the patients su ering from Parkinson disease, without any side e ects. L-DOPA may be isolated and purified to take advantage for pharmaceutical applications by technological interventions, including the possibility of exploring genetic diversity to increased L-DOPA content in faba bean. Collaboration was made with BHU for estimation of dopamine content in dry seeds of faba bean and protocol was established (Fig. 64). Seven genotypes of faba bean were evaluated for L-dopamine content in seed through HPLC and genotype EC-628921 was found with highest L-DOPA content (1.425mg/g dry seed). Moreover, seed coat was having less L-DOPA content than the dry seed powder.

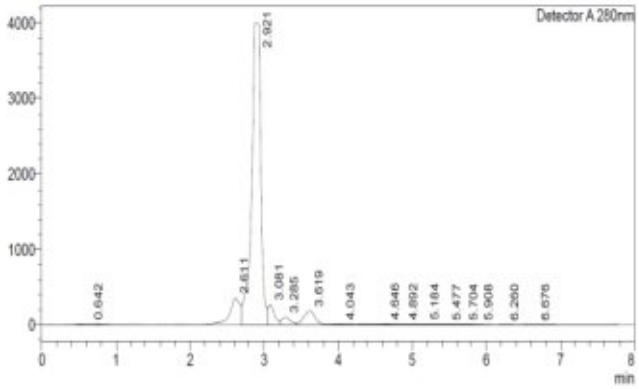


Fig. 64: L-DOPA estimation through HPLC technique

Water chestnut

Germplasm augmentation and multiplication: A total of 2 new accessions were augmented from di erent part of the country. These lines were multiplied for next season (Fig. 65).

Rooting and nut development **Variability in nuts at IIVR**

Fig. 65: Water chestnut rooting, nut development and variability

Germplasm characterization: Twelve genotypes of Water chestnut grown in water pond/drainage channel of Institute were characterized for di erent horticultural traits. Average number of leaves per plant varied between (28.8-36.0), number of fruit per plant (3-5.8), Average leaf length (3.0 - 4.4 cm), average leaf width (5.5- 6.7 cm), average fruit pedicel length (4.0 -5.6 cm), number of spine per fruit (2 - 2.0), average fresh fruit weight (10.0-17.5 g), average shelled fruit weight (5.0 - 11.5 g), Dry fruit weight (0.43- 2.9 g), dry matter content (8.2-22.6 %), TSS (4.4- 5.6 ^{0} Brix) and fruit yield per pond (28.5-36.50 kg). Among the genotypes, VRWC-1 adjudged as promising genotype for dry matter content and fruit yield. Genotype VRWC-4 had green husk colour.

Lotus

Germplasm augmentation and characterization: With the aim to identify the suitability of lotus cultivation, 4 new germplasm lines were augmented from di erent part of the country. Genotype VRL-1was found promising for di erent horticultural traits. Nursery was raised in pots and lotus plants were planted in ponds (Fig. 66).

Blooming in lotus

Floral parts of lotus

Fig. 66: Blooming and floral parts of Lotus

Standardization of propagation of lotus through stem cutting: Lotus is usually propagated by the seed or division of enlarged rhizomes. Since enlarged rhizomes are divided and transplanted for propagation in late March, before the sprouting of terminal buds, the propagation of lotus is limited to a relatively short period of the year when lotus does not grow actively. During the growth period in early summer, farmers who cultivate edible lotus generally use rhizome straps with enlarged rhizomes as materials for propagation. They consider that rhizome straps without enlarged rhizomes would not be suitable as materials. However, excavation of enlarged rhizomes from lower depths in soil is tedious and the buds often break in response to heavy pruning. Rhizome straps without enlarged rhizomes may have the potential to produce many roots, and it could be possible to develop a propagation method that uses rhizome straps. In view of this, studies were undertaken to determine whether lotus could be propagated through some other plants parts than seeds or rhizomes with good survival rate. The plant survival rate was found to be 90%. The present findings validated and encourage for rapid multiplication technique of lotus by stem cuttings proven as easy and most e ective method of propagation of lotus over seed /rhizome propagation methods (Fig. 67 & 68).

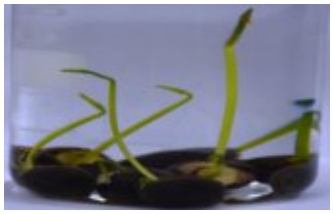


Fig. 67: Seed germination in control condition

Fig. 68: Lotus plant raised through stem cutting

Water spinach

Germplasm augmentation: Four new germplasm lines were augmented from di erent parts of country. These lines were characterized for various horticultural traits and crop plants were multiplied for next season.

Germplasm characterization: A total of 29 germplasm lines of water spinach were characterized for di erent horticultural traits viz., leaf length (4.28-13.5 cm), petiole length (4.5-6.5 cm), leaf width (2.5- 8.5 cm), number of vine/plant (4.0- 5.8), vine length (70.0-180.0 cm), internodal length (3.0-7.5 cm), number of nodes / vine (9-16), number of cuttings /month (2-4) and fresh weight of 50 leaves (35.0-85.0g). The genotypes VRWS-1, VRWS-2, VRWS-3, VRWS-25, VRWS-26, VRWS-27, VRWS-28 and VRWS-29 were found to be promising for di erent horticultural traits (Fig. 69).

Fig. 69: Fruit setting in water spinach

Development of package of practices for water spinach cultivation in 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 cultivation of water spinach in field conditions and promising results were obtained for the same. This technology can prove to be simple and be cultivated round the year which can serve as boon for the socio-economic upliftment of farmers of this region (Fig. 71 & 71).

Fig. 70: Water spinach - Field view at IIVR, Varanasi

Fig. 71: Water spinach - View at Farmer's field

Baby corn and Sweet corn

Germplasm maintenance: Thirty-two sweet corn inbreds and sixty baby corn inbred lines were maintained

Hybrid evaluation: Nineteen sweet corn hybrids including four commercial hybrids (Priya, Maduri, ADVSW-1 and ADVSW-2) were evaluated for yield and

quality characters. Hybrids SC 19 × SC 27, SC 32 × SC 10, SC 19 × SC 3 and SC 19 × SC 10 performed better than commercial hybrids with respective TSS and with better average green cob weight without husk 212.7, 214.2, 215.1 and 209.5 g, respectively.

Advancing segregating families for high prolificacy: Twenty-two F_4 families with cob number 3-4 per plant were advanced to next generation. Single F_2 plants from three di erent hybrids were advanced to next generation based on higher prolificacy of 3 or more than 3 cobs per plant.

Beet leaf [*Beta vulgaris* L. subsp. *vulgaris* (Cicla Group); Palak]

Twelve genotypes/variety of beet leaf (Palak) were evaluated for morphological traits and seed multiplied for further evaluation. In October sowing, the biomass yield potential of most promising three genotypes i.e. VRPLK-2, VRPLK-7 and VRPLK-14 ranged from 650-700 q/ha. The promising genotype 'VRPLK-2' was compared with popular variety i.e. All Green by sowing in four seasons. The respective biomass yield (q/ha) of VRPLK-2 and All Green was 125 & 55 q/ha in mid-February, 190 & 115 q/ha in mid-May, 475 & 300 q/ha in mid-August, and 700 & 520 q/ha in mid-October sowing which is correspondingly 127.3%, 65.2%, 58.3% and 34.6% higher than check variety All Green. The flowers of beet leaf are small, sessile, bisexual, bracteate (leafy) and are borne in a group of 1-3 having 5 stamens opposite to perianth lobes (tepal) on a fleshy disc within unilocular semi-inferior ovary with 2-3 stigmas (Fig. 72). Additionally, VRPLK-2, VRPLK-7 and VRPLK-14 showed delayed bolting habit i.e. 20-30 days late as compared to other entries. Two genotypes of palak were documented with NBPGR, New Delhi with IC number 0632944 (VRPLK-2) and 0632945 (VRPLK-7). A sum of 14 genotypes/accesions of beet leaf are being maintained.

Fig. 72: Bisexual flower of beet leaf

Leafy chenopod (*Chenopodium album*, Bathua)

Maintenance breeding of two varieties of leafy chenopod i.e. Kashi Bathua-2 with green leaves and Kashi Bathua-4 with purplish-green leaves are being done by producing basic seed (3-5 kg of each). The biomass yield potential of seven accessions/varieties varied from 330-415 q/ha in 4-5 cutting. Another genotype VRCHE-7 with greenish-purple leaves found to be promising for luxuriant plant growth, 210-230 cm plant height and biomass yield of 410 t/ha (Fig. 73) .

Fig.73: VRCHE-7 with greenish-purple leaves

Amaranthus

The amarathus crop was raised during *Kharif* 2020, which continued its ontological development during Rabi 2020-21. This year, 13 new germplasm of *A. tricolor* and 2 new germplasm of *A. dubious* were collected, maintained and multiplied for evaluation during next year. A total of 141 genotypes/germplasm were grown and evaluated for horticultural traits and yield. Out of the 141 germplasms, the *A. tricolor* constitutes 128 accessions while the *A. dubious*constitutes 8 accessions. *A. magnostenus* and *A. blitum* were four and one accessions respectively. Among the *A. tricolor*genotypes, the most promising for yield were VRAM-1, VRAM–2A, VRAM–9, VRAM–17, VRAM-44, VRAM-45, VRAM-64, VRAM–306, VRAM–312, VRAM–323, VRAM–324, VRAM–364, VRAM–367 and VRAM–370. This year, two genotypes VRAM-44 (red) and VRAM-308 (green) entered the IET varietal evaluation trials of AICRP(VC).

Occurrence of new disease in Amaranthus: Based on two year of observations it was found that a new disease with leaf spot/blight symptoms appeared on the leaves of all the amaranth accessions (Fig). After isolation of pathogen the potential causal organism was *Curvularia lunata.* The culture of this pathogen is maintained and Koch postulate for this pathogen will be established artificially. The same pathogen is reported to cause leaf spot of *Amaranthus spinosus,* but no report is available

of this disease in *A. ticolor*. It was also observed that all the *A. ticolor* accessions were showing symptoms of leaf blight but, all the *A. dubious* were immune to this disease over the two years of observations. It is however worth mentioning that this type of symptoms mainly appears during the end of *Kharif* season, as we have not observed this during summer amaranth cultivation (Fig. 74).

Fig. 74: Leaf blight symptoms on the leaves of amaranth plant

Laipatta

A new Laipatta breeding programme was initiated during Rabi season 2017-18. Selections were made for isolation of di erent types of plants di ering in morphology and flowering. A total of 27 germplasms were grown and maintained by selfing during 2018-19, which were also crossed to generate variation. The selfed and crossed seeds were planted during Rabi 2019-20. The 27 germplasm were maintained by selfing. 191 F_1 crosses have also been advanced to the next generation (F_2) through selfing. Data for leaf length, width, colour etc. was recorded for the germplasm (Fig. 75). The leaves of genotype VRLP-15, VRLP-18 and VRLP-19 has pubescence on the lower surface. Based on one year of observation it was found that the genotypesVRLP-8, VRLP-18 and VRLP-33 were best performing in term of late flowering and green yield. The yield potential of VRLP-33 was found to be 265 quintals/ha followed by VRLP-8 (248 q/ha) and VRLP-18 (2013 q/ha). Replicated trial of these entries along with check Pusa Saag is in progress during the Rabi season 2020-21.

Fig. 75: Morphological variation for leaf characteristics in laipatta

Project 1.15: Genetic Improvement of Vegetatively Propagated and Perennial Vegetable Crops

Pointed gourd

Status of germplasm: In pointed gourd,148 accessions of diverse female clone showing variability for fruit size, fruit shapes and colour *i.e.,* round, oval, elliptical and oblong; dark green, green fruited, light green fruit colour; fruits with or without white stripes on the surface and seeded, less seeded or seedless were maintained at IIVR. Additionally, 20 accessions of 4 di erent 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 148 female clones of pointed gourd were evaluated during summer and rainy season 2020 for various horticultural traits *i.e.*, days to first flowering after sprouting, number of node at first harvest, inter nodal length, fruit length, fruit diameter, average fruit weight, number of fruits per plant, yield per plant and seed per fruit. All the horticultural trait under consideration showed considerable variability in the evaluated germplasm. Days to first flowering and number of node at first harvest varied from 58-82 days with a mean value of 73 days and 6-20 with mean of 11, respectively while internodal length also had di erentiable variation of 11.00-22.00 cm with a mean of 15.10 cm. Fruit length, fruit diameter and average fruit weight varied from 5.90-12.25 cm with mean of 9.6 cm, 3.75-5.5 cm with mean 4.20 cm and 11.30-54.00g with mean 34.25g, respectively. Nevertheless, number of fruits/plant, yield/plant and seeds/fruit also showed appreciable variability with a value 86-414 & 209 (mean), 2.85-11.70 kg & 5.50 kg and 5-29 & 17, respectively.

Evaluation of advance lines: A total of 13 advance lines (VRPG-5, VRPG-8, VRPG-10, VRPG-19, VRPG-101, VRPG-103, VRPG-133, VRPG-141, VRPG-173, VRPG-215, VRPG-210, VRPG-217 and VRPG-220) of pointed were evaluated during summer and rainy along with Kashi Alankar, Kashi Suphal and Kashi Amulya as check. With respect to yield performance, these advance lines where found either superior (VRPG-101, VRPG-103, VRPG-133, VRPG-141, VRPG-173, VRPG-215, VRPG-210, VRPG-217, VRPG-220) or at par (VRPG-5, VRPG-8, VRPG-10, VRPG-19). Numbers of fruit/plant, average fruit weight and yield/plant varied from 350-400 fruits, 42-55g and 9.10-12.25kg, respectively (Fig. 76).

Fig. 76: Advance lines of pointed gourd

Evaluation of pointed gourd genotypes for micronutrients contents: A set of 53 female clones were evaluated for micronutrients (Fe, Cu, Mn and Zn) content in the fruits. Sufficient variation was reported for Fe, Cu, Mn and Zn content in the fruits. Fe content in the evaluated female clones ranged from 62.23-407.35 ppm with mean 150.57 ppm & deviation 6.54 fold. Maximum Fe content reported in VRPG-151. Range of Cu content was 2.31-10.85ppm with mean 4.68 ppm & deviation 4.69; highest being reported in VRPG-208. While Mn and Zn content varied from 7.85-42.55 ppm with mean of 18.52 ppm & deviation 5.42 fold, 37.58-180.88 ppm with mean 60.47 ppm & deviation 4.81 fold, respectively.

Production of planting material and clonal multiplication of selected clones in pointed gourd: About 8000 planting materials of Kashi Alankar, Kashi Suphal and Kashi Amulya were produced and 6000 planting materials distributed to the farmers of Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand and West Bengal. All the advance lines of pointed gourd were clonally multiplied to enhance the plant population. Beside this, approximately 500 planting materials were produced for VRPG-141, VRPG-103, VRPG-171 and VRPG-101for farmers' field trial.

Teasle gourd

Germplasm maintenance, evaluation and characterization: Sixty lines of teasle gourd were evaluated and characterized for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2020. A highly significant di erence were observed in the germplasm for all the traits under studied. Based on the primary screening, some of the potential genotypes have been identified for various horticultural traits that are given in the table 23 & fig. 77.

Table 23: Potential genotypes identified for various horticultural traits in Teasle gourd

Traits	Promising genotypes
Node number to first pistillate flower appearance	VRSTG-41 (12.00), VRSTG -10 (12.67), VRSTG-15 (13.00), VRSTG -51 (13.00), VRSTG-12 (14.0 0), VRSTG -17 (14.00), VRSTG-34 (14.00)
Days to first pistillate flower anthesis	VRSTG-22 (74.67), VRSTG -51 (75.33), VRSTG-54 (75.67), VRSTG -46 (76.00), VRSTG-52 (76.67),
Days to first harvest	VRSTG-22 (85.33), VRSTG -51 (87.00), VRSTG-46 (87.33), VRSTG -2 87.67), VRSTG-52 (87.67)
Peduncle length (cm)	VRSTG-5 (19.30), VRSTG -3 (19.27), VRSTG-56 (17.50), VRSTG -53 (17.43), VRSTG-28 (17.30)
Polar circumference of fruit (cm)	VRSTG-44 (24.13), VRSTG -1 (22.27), VRSTG-42 (20.80), VRSTG -57 (20.61), VRSTG-6 (20.13)
Equatorial circumference of fruit (cm)	VRSTG-5 (16.50), VRSTG -55 (16.10), VRSTG-4 (16.00), VRSTG -3 (15.53), VRSTG-38 (15.50)
Length of blossom end (cm)	VRSTG-56 (1.37), VRSTG -4 (1.30), VRSTG-52 (1.27), VRSTG -8 (1.23), VRSTG-60 (1.23)
Number of Fruits per plant	VRSTG-17 (33.33), VRSTG -15 (25.33), VRSTG-54 (21.33), VRSTG -10 (20.33), VRSTG-56 (18.00), VRSTG-60 (18.00)
Average fruit weight(g)	VRSTG-58 (67.00), VRSTG -40 (62.73), VRSTG-18 (60.18), VRSTG -50 (60.14), VRSTG-26 (60.09)
Fruit yield per plant (kg)	VRSTG-17 (1.19), VRSTG -10 (1.08), VRSTG-54 (1.07), VRSTG -15 (1.03), VRSTG-56 (0.967)

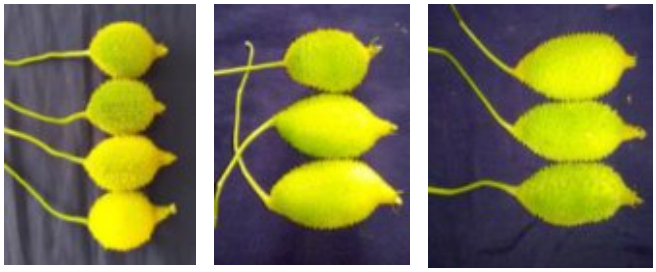


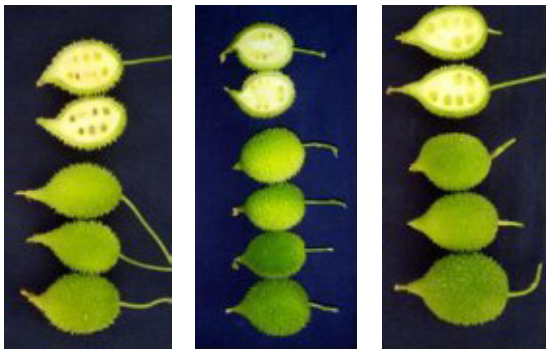
Fig. 77: Promising genotypes of teasle gourd

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, 2020. A significant di erence was observed in the germplasms for all the traits under study. Based on the primary screening, some of the potential genotypes have been identified for various horticultural traits that are given in the table 24 & fig. 78.

Table 24: Potential genotypes identified for various horticultural traits in Spine gourd

Traits	Promising genotypes
Node number to first pistillate flower appearance	VRSEG-7 (10.670), VRSEG -9 (11.00), VRSEG -109 (11.00), VRSEG -113 (12.00), VRSEG -117 (12.33), VRSEG-118 (12.33)
Days to first pistillate flower anthesis	VRSEG-8 (45.33), VRS EG-22 (45.67), VRSEG -113 (48.00), VRSEG -11 (48.33), VRSEG -114 (50.00)
Days to first harvest	VRSEG-22 (57.33), VRSEG -8 (58.33), VRSEG -113 (60.00), VRSEG -11 (60.67), VRSEG -112 (62.67)
Peduncle length (cm)	VRSEG-118 (4.47), VRSEG -20 (4.03), VRSEG -9 (3.43), VRSEG-28 (3.17), VRSEG-102 (2.63)
Polar circumference of fruit (cm)	VRSEG-104 (11.10), VRSEG -118 (10.87), VRSEG-20 (10.73), VRSEG -11 (10.40), VRSEG -36 (10.33)
Equatorial circumference of fruit (cm)	VRSEG-118 (9.60), VRSEG -111 (9.37), VRSEG -28 (9.33), VRSEG-43 (9.30), VRSEG-104 (9.27)
Length of blossom end (cm)	VRSEG-4 (0.63), VRSEG -114 (0.63), VRSEG -117 (0.63), VRSEG -118 (0.63), VRSEG -113 (0.60)
Number of fruits per plant	VRSEG-118 (210.00), VRSEG -11 (142.33), VRSEG-8 (138.00), VRSEG -114 (131.67), VRSEG-20 (100.00)
Average fruit weight(g)	VRSEG-43 (10.43), VRSEG -117 (10.31), VRSEG-7 (9.70), VRSEG -114 (9.64), VRSEG -28 (9.55)
Fruit yield per plant (kg)	VRSEG-118 (1.72), VRSEG -114 (1.27), VRSEG -11 (1.19), VRSEG-8 (1.07), VRSEG-20 (0.876)



VRSEG-118 **VRSEG-114** **VRSEG-11**

Fig. 78: Promising genotypes of spine gourd

Ivy gourd

Germplasm maintenance, evaluation and characterization: A total of 28 lines of ivy gourd were evaluated for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2020. Highly significant variability were observed in the germplasm for all the traits under study. Based on the primary screening, some of the potential genotypes have been identified for various horticultural traits that are given in the table 25 & fig. 79.

Table 25: Potential genotypes identified for various horticultural traits in Ivy gourd

Traits	Promising genotypes
Node number to first pistillate flower appearance	VRIG-17 (9.33), VRIG -2 (10.00), VRIG-1 (11.33), VRIG -25 (11.67), VRIG-3 (12.00), VRIG -21 (12.00), VRIG-23 (12.00)
Days to first pistillate flower anthesis	VRIG-17 (56.33), VRIG -22 (57.67), VRIG-28 (57.67), VRIG -27 (58.00), VRIG-30 (60.33)
Days to first harvest	VRIG-17 (63.67), VRIG -22 (65.33), VRIG-28 (65.33),VRIG -27 (65.67), VRIG-30 (68.33)
Peduncle length (cm)	VRIG-16 (4.80), VRIG -19 (4.13), VRIG-15 (4.03), VRIG -5 (3.93), VRIG -6 (3.83)
Polar circumference of fruit (cm)	VRIG-21 (16.40), VRIG -8 (16.27), VRIG-22 (15.57), VRIG -19 (15.47), VRIG-25 (15.03)
Equatorial circumference of fruit (cm)	VRIG-25 (10.27), VRIG -3 (9.90), VRIG-4 (9.87), VRIG -15 (9.80), VRIG -19 (9.73),
Number of fruits per plant	VRIG-17 (553.6 7), VRIG -25 (504.67), VRIG-18 (410.67), VRIG -16 (390.67), VRIG-3 (356.67)
Average fruit weight(g)	VRIG-4 (27.80), VRIG -19 (26.30), VRIG-15 (26.12), VRIG -14 (24.24), VRIG-25 (23.40)
Fruit yield per plant (kg)	VRIG-17 (12.59), VRIG -25 (11.70), VRIG-18 (8.7 5), VRIG -27 (7.87), VRIG-14 (7.74)

VRIG-17 **VRIG-25** **VRIG-18**

Fig. 79: Promising genotypes of ivy gourd

Basella

A total of 70 basella genotypes were grown in augmented block design during summer season of 2020, and the ontological cycle of the genotypes continued till the Rabi season of 2021. The data was recorded for horticultural and yield traits. Among the genotypes, maximum vein thickness was observed to be 11.30 mm and minimum was 2.45 mm in VRB-5 and VRB-16, respectively. The genotypes with promising vein thickness were VRB–7, VRB–9, VRB–15, VRB–17, VRB–23, VRB–28, VRB–29, VRB–48, VRB–54 and VRB–32. The leaf length was found to be in the range of 5.32 cm to 12.86 cm. The genotype VRB-4 (5.32 cm) has smallest leaves and the VRB-17 (12.86) has longest

leaves. The promising genotypes with good leaf length were VRB–9, VRB–17, VRB–20, VRB–34, VRB–54, VRB–66, VRB–68 and VRB–68–1. The leaf width ranged from 2.58 cm to 8.80 cm. The promising genotypes for leaf width were VRB–7, VRB–8, VRB–17, VRB-18, VRB–10. The plant height ranged from 44 cm to 388 cm at the time of maturity. The petiole length of leaves varied from 0.98 cm to 5.46 cm. Longest petiole was found in VRB-10 and smallest petiole was reported in VRB-4. Only one genotype i.e. VRB-48-1 produced the white flowers, while others were producing white-pink flowers. Maximum yield per plant was found to be 4.32 kg in VRB-3. The promising genotypes with good per plant yield were VRB–1, VRB-5, VRB–10, VRB–17, VRB–41, VRB-48 and VRB–61-1.

Screening of Basella genotypes against charcoal rot

Artificial screening of basella genotypes was carried out in the glass house conditions. Total 55 genotypes were evaluated against the charcoal rot pathogen. All the genotypes were found to be susceptible to this pathogen.

Moringa

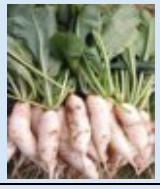
The moringa genotypes were evaluated for flowering and fruiting throughout the year. 22 moringa selections and two checks (PKM-1 and PKM-2) were evaluated for horticultural traits and fruit yield. Two predominant seasons of flowering and fruiting was observed in these genotypes. First flush of fruiting appeared in the month of April end while, the second flush was observed during last week of October. The highest fruiting was observed in the genotype VRMO-13 (1450 fruits) followed by VRMO-21 (895 fruits), VRMO-23 (700 fruits), VRMO-4 (625 fruits) and VRMO-5 (475 fruits). As contrast to previous year, a smaller number of fruits were seen the genotype VRMO-17 (280 fruits). Highest fruit length was observed in the PKM-2 (95cm) followed by VRMO-13 (82 cm), VRMO-12 (80 cm) and VRMO-19 (76 cm).

Table 26: IIVR Varieties Identified by AICRP(VC) in its meeting held in September 2020

Name of Crop & Var.	Recommended Area
Brinjal (round) IVBR-17	U.P., Bihar, Punjab and Jharkhand
Brinjal Hyb. (long) IVBHL-20	MP, Maharashtra and Goa
Cowpea (bush) VRCP-12	U.P., Bihar, Punjab and Jharkhand
Carrot (tropical) VRCAR-186	MP, Maharashtra, Goa, Karnataka, T.N., Kerala and Puducherry
Dolichos bean (bush) VRBSEM-3	Rajasthan, Gujarat, Haryana, Delhi, MP, Maharashtra, Goa, Karnataka, T.N., Kerala and Puducherry
Dolichos bean (bush) VRBSEM-9	MP, Maharashtra and Goa
French bean (bush) VRFBB-91	J&K, HP and Uttarakhand
Pumpkin VRPK-230	C.G., Odisha and A.P.
Sponge gourd VRSG-195	U.P., Bihar, Punjab, Jharkhand, Rajasthan, Gujarat, Haryana and Delhi

Table 27: IIVR Varieties Notified by CVRC in its meeting held in October 2020

Name of Crop & Variety	Important Characters	Recommended Area	Photograph
Brinjal (long) IVBL-23 [Kashi Vijay]	Plant bushy with sturdy stems. Fruits medium long, purplish pink. Yield potential 470 -530q/ha. Tolerant to Phomopsis blight and Fusarium wilt in field conditions.	Uttar Pradesh, Bihar, Jharkhand & Punjab	
Tomato K. Tamatar-8 [Kashi Chayan]	Indeterminate, high yielding, having dark green shoulder and tolerant to ToLCV carrying Ty3 gene.	Uttar Pradesh, Bihar, Jharkhand, Punjab, MP, Maharashtra, Goa.	
French bean VRFBP-14 [K. Baingani]	Purple-podded variety of vegetable French bean. Pods green for first 5-7 days, and turn completely purple in the next 8 -10 days. Pod length 14 -15 cm. Flowers 70 -80 days after sowing. Av. pod yield 160 q/ha.	J&K, HP, Uttarakhand, MP, Maharashtra, Goa, Karnataka, TN, Kerala, Puducherry.	

Radish VRRAD-150 [Kashi Aardra]	Attractive dark -green soft leaves. Roots white, tapered or iciclical, 22-24 cm long weighing 150-225g. First harvesting starts 40 -45 days after sowing and continues up to 60 days at regular interval. Av. root yield 350q/ha	West Beng al and Assam	
Longmelon Kashi Santusti (VRSLM-16)	It is medium viney with green foliage. The average fruit length of this variety is 30 cm and fruit weight 50 -60g. The fruit is crispy, light green coloured with smooth prominent ridges. It has yield potential of 150-200 q/ha..	Punjab, U.P., Bihar and Jharkhand	

Sharing of Germplasm with different organizations by IIVR

Promising germplasm as well as released varieties/hybrids developed and maintained at the institute were supplied to di erent organizations for research, evaluation and demonstration purpose after signing of Material Transfer Agreement (MTA). During the year 2020, 528 accessions in 15 vegetable crops were provided to 15 organizations. Details of the germplasm provided along with the recipient organizations are given in table 28.

Table 28: Sharing of Germplasm with different organizations

Crop	Recipient organization
Watermelon (30)	CCSHAU, Haryana (15); ANDUA&T, Faizabad (15)
Cowpea (99)	GBPUA&T, Pantnagar (58); BBAU, Lucknow (16); RLBCAU, Jhansi (25)
Cauliflower (29)	RHRTS, Kangra (16), YSPUH&F, Palampur (13)
Sponge gourd (13)	BBAU, Lucknow (6), RARI, Durgapura (3); Sakai Seeds Pvt. Ltd. (1), Hyderabad; ANDUA&T, Faizabad (3)
Muskmelon (15)	ANDUA&T, Faizabad (15)
Cucumber (63)	BHU, Varanasi (3); SVPUA&T, Merrut (12); ANDUA&T, Faizabad (48)
Dolichos bean (7)	RLBCAU, Jhansi (7)
Chilli (60)	RLBCAU, Jhansi (30); SVPUA&T, Merrut (30)
Carrot (20)	College of Horticulture & Forestry, Neri Hamirpur (20)
Okra (84)	PAU, Ludhiana (1); UHS, Bagalkot (31); BHU, Varanasi (32); SVPUA&T, Merrut (20)
Tomato (39)	NIPGR, New Delhi (2); Sakai Seeds Pvt. Ltd. (1), Hyderabad; Institute of Sciences, BHU, Varanasi (6); RLBCAU, Jhansi (30)
Brinjal (41)	Institute of Sciences, BHU, Varanasi (5); RVSKVV-KVK, Mandsaur (20); Sakai Seeds Pvt. Ltd. (1), Hyderabad; SVPUA&T, Merrut (15)
Spinach (3)	Institute of Sciences, BHU, Varanasi (3)
Bottle gourd (10)	ANDUA&T, Faizabad (10)
Pumpkin (15)	ANDUA&T, Faizabad (15)

MEGA PROGRAMME-2 : SEED ENHANCEMENT IN VEGETABLES

Programme Leader: Dr. P.M. Singh

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

Seed priming with humic acid: Okra cv. Kashi Kranti seeds were primed with di erent concentration of humic acid (0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, 5.0%, distilled water, dry seeds without priming) for 12h at 25°C. The priming duration was restricted to 12h, because extending duration results radicle protrusion. After priming, the seeds were dried back to their original moisture content. During 2019 the seed quality parameters i.e. seed germination, seedling length, dry weight, vigour index I and vigour index II were observed. Based on these laboratory results three priming treatments of humic acid (T1-0.5%, T2-1.0%, T3-1.5%) along with priming with distilled water (T4) and dry seeds without priming (T5) were tested in open field condition (plot size- 3 x 3m, four replication). Among the treatments, seeds primed with 0.5% of humic acid recorded significantly highest field emergence (78.5%) and number of fruits per plant (14.5) (Table 29). Whereas, plant height, pod dimensions (length and width) and number of seeds per fruit was una ected.

Breeder and TL seed production of important vegetable crops: A total of 19380.45 kg vegetable seeds of ICAR-IIVR varieties of tomato, brinjal, chilli, okra, cowpea, pea, bottle gourd, bitter gourd, pumpkin,

Table 29: Effect of seed priming with humic acid on plant and seed growth parameters

Treatment	Field emergence %	No of fruits/plant	Plant height (cm)	Pod length (cm)	Pod width (cm)	No of seeds/fruit
T1	78.5	14.5	60.75	13.53	5.88	35.50
T2	74.25	13.75	58.75	13.22	5.82	35.65
T3	71.25	12.5	57.65	13.55	5.66	33.55
T4	68.5	12	59.50	13.44	5.72	34.25
T5	67.25	11.25	60.23	13.59	5.85	35.50
CD@ 5%	2.01	0.32	2.52	0.49	0.24	1.84

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, 16054.10 kg was truthfully labelled seeds of the open pollinated varieties of IIVR (Table 30), 43.45 kg F_1 hybrid seeds of tomato, brinjal, chilli and sponge gourd (Table 31) and 3283.00 kg breeder seeds (Table 32). The National indent for breeder seeds from IIVR for 2019-20 was 224.95 kg, which was completely fulfilled. Monitoring of breeder seed production plots was carried out for indented crops by the monitoring team consisting of representatives of State Seed Certification Agency, NSC, seed production scientists and respective breeders (Fig. 80). Single plant selection was carried out as a part of maintenance breeding in all the varieties. Seed quality (germination%) of 468 samples were tested at seed testing laboratory for seed quality assurance. A total of 30823 kitchen garden packets of ICAR-IIVR varieties were prepared for 17 vegetable crops and distributed among the growers. At the Regional Research Station, Sargatia, a total of 53565.30 kg wheat, paddy and vegetable seed were produced. In addition to di erent seeds, 81.26 quintals planting material of turmeric and 137.71 quintals elephant foot yam were also produced at ICAR-IIVR-RRS, Sargatia (Table 33).

Fig. 80: Monitoring of vegetable breeder seed crops by the monitoring team

Table 30: TL Seed produced during 2020 at ICAR-IIVR, Varanasi

Crop	Variety	Quantity (Kg)
Chilli	Kashi Anmol	64.80
	Kashi Abha	11.50
	Kashi Gaurav	4.25
Brinjal	Kashi Taru	0.40
Tomato	Kashi Anupam	0.70
	Kashi Vishesh	21.50
	Kashi Aman	36.00
	Kashi Adarsh	15.90
Cauliflower	Kashi Gobhi -25	7.50
French bean	Kashi Rajhans	260.00
	Kashi Sampann	225.00
Indian bean	Kashi Haritima	89.00
Radish	Kashi Hans	13.00
	Kashi Shweta	10.25
	Kashi Mooli-40	16.90
	Kashi Lohit	17.00
Summer Squash	Kashi Shubangi	13.00
Palak	All Green	171.00
Carrot	Kashi Arun	82.00
	Kashi Krishna	0.30
Garden pea	Kashi Nandini	3690.00
	Kashi Udai	7050.00
	Kashi Mukti	1720.00
	Kashi Ageti	765.00
Musk melon	Kashi Madhu	2.00
Cucumber	Kashi Nootan	6.90
Bitter gourd	Kashi Mayuri	3.00
	VRBTG- 10	11.70
Pumpkin	Kashi Harit	283.00
Cow pea	Kashi Nidhi	930.00
	Kashi Kanchan	53.00
	Kashi Gauri	8.00
Okra	Kashi Chaman	170.00
	Kashi Lalima	48.00
Ridge gourd	Kashi Shivani	36.00
Spong gourd	Kashi Shreya	132.00
	Kashi Jyoti	30.00

Bottle gourd	Kashi Ganga	22.50
	Kashi Kirti	3.00
Satputiya	Kashi Khushi	8.00
Ash gourd	Kashi Dhaval	21.00
	Kashi Surbhi	1.00
	Total	**16054.10**

Table 31: Hybrid seed produced during 2020 at ICAR-IIVR, Varanasi

Crop	Kg	Quantity (kg)
Brinjal	Kashi Sandesh	8.90
Tomato	Kashi Abhimaan	2.30
Chilli	Kashi Ratna	19.50
	Kashi Surkh	1.75
Sponge gourd	Kashi Rakshita	11.00
	Total	**43.45**

Table 32: Breeder seeds produced during 2020 at ICAR-IIVR, Varanasi

Crop	Variety	Quantity(Kg)
Ash gourd	Kashi Dhawal	2.00
	Kashi Surabhi	2.00
Bitter gourd	Kashi Mayuri	4.00
Bottle gourd	Kashi Ganga	20.00
	Kashi Kirti	10.00
Brinjal	Kashi Taru	2.00
Carrot	Kashi Krishna	3.00
Cauliflower	Kashi Gobhi-25	2.00
Chilli	Kashi Anmol	4.00
	Kashi Abha	1.50
	Kashi Gaurav	0.75
Cowpea	Kashi Kanchan	100.00
	Kashi Nidhi	130.00
	Kashi Gauri	2.00
French bean	Kashi Rajhans	10.00
	Kashi Sampann	10.00
Indian bean	Kashi Haritima	100.00
Muskmelon	Kashi Madhu	1.00
Okra	Kashi Kranti	82.00
	Kashi Pragati	95.00
	Kashi Chaman	30.00
	Kashi Lalima	70.00
Pea	Kashi Ageti	225.00
	Kashi Mukti	600.00
	Kashi Nandini	609.00
	Kashi Samridhi	100.00
	Kashi Udai	900.00
	Kashi Shakti	45.00
Pumpkin	Kashi Harit	15.00
Radish	Kashi Hans	28.00
	Kashi Shweta	26.75
	Kashi Mooli-40	5.10
	Kashi Lohit	5.00
Ridge gourd	Kashi Shivani	11.00
Satputia	Kashi Khushi	2.00
Sponge gourd	Kashi Shreya	14.00
	Kashi Jyoti	4.00
Summer Squash	Kashi Shubhangi	2.00
Tomato	Kashi Adarsh	1.00
	Kashi Aman	5.00
	Kashi Amrit	0.40
	Kashi Anupam	1.00
	Kashi Vishesh	2.50
	Total	**3283.00**

Table 33: TL seed and planting material produced during 2020 at RRS, Sargatia

S. No.	Crop	Variety	Quantity (kg)
A.	**TL Seed**		
1.	Pumpkin	Kashi Harit	69.00
2.	Cowpea	Kashi Kanchan	31.00
		Kashi Nidhi	42.00
3.	Bitter gourd	Kashi Mayuri	21.00
4.	Ridge gourd	Kashi Shivani	31.00
5.	Okra	Kashi Chaman	135.50
		Kashi Kranti	105.00
6.	Cauliflower	Kashi Gobhi-25	28.00
7.	Radish	Kashi Lohit	28.00
8.	Carrot	Kashi Krishna	5.00
9.	Sponge gourd	Kashi Divya	1.00
10.	Muskmelon	Kashi Madhu	0.80
11.	Cucumber	Kashi Nutan	3.00
12.	Lentil	IPL-316	4600.00
13.	Mustard	RH-749	1533.00
14.	Wheat	HD-2967	17100.00
		DBW-187	4000.00
		DBW-252	6242.00
15.	Paddy	S-52	11850.00
		BPT-5204	5280.00
		Sambha Sub-1	2460.00
		Total	**53565.30**
B.	**Planting material**		
1.	Elephant foot yam	Gajendra	13771.00
2.	Turmeric	Megha Turmeric-1	8126.00
		Total	**21897.00**

Project 2.2: Pollination Studies for Seed Augmentation in Vegetables including Support of Honey Bees

A study was conducted to know the foraging behaviour of pollinators in okra flowers and the e ect of pollinator attractants on seed qualitative as well as quantitative parameters at during Summer, 2020. Di erent pollinators visiting okra cv. Kashi Chaman flowers during peak flowering period were recorded and their activity was studied. Pollinators' visit was studied at di erent time interval i.e. from 7-8 am, 9-10 am and 11am-12 noon. Ants were the major flower visitors followed by lepidopteran insects mainly moths and butterflies *viz. Pelopidas* spp., *Papilio polytes, Udaspes folus*, *Eurema hecabe* followed by *Apis* species mainly

A. cerana indica, A. dorsata and *A. florea* (Fig. 81).

Least visits were recorded for dipteran insects and coleopteran insects in okra. Okra flowers were open for pollination in between 6.00 am-2.00 pm. Pollinator's major activity was observed from 9-10 am followed by 7-8 am and then least activity was observed in 11 am-12 pm. Thus, in conclusion, ants, lepidopteran moths including butterflies and *Apis* species were the major flower visiting insects whose peak activity was observed at 9-10 am. Various insects such as butterflies, houseflies, and honeybees have been seen around the okra flower, producing nectar that encourage insects to them. Immediately after opening of flower, ants were observed to visit it. Okra pollen grain is heavy and sticky and could not easily be spread by wind, so insects are responsible for moving pollen grains and thus okra plants are cross-pollinated.

Fig. 81: Insect visit to flowers of Okra cv. Kashi Chaman

A study was repeated with the following treatments in okra cv. Kashi Chaman to know the e ect of pollinator attractant spray on seed yield and quality enhancement. E ect of pollinator attractants was studied by spraying di erent pollinator attractants at weekly intervals starting from 10 % of flowering. The treatment details are as followed:

Treatment code	Treatment Name
T1	5% sugar solution
T2	5% jaggery solution
T3	5% sugar+5% jaggery
T4	Hand pollination
T5	open pollination
T6	5% sugar solution +50ppm boron
T7	5% jaggery soltion+50ppm boron
T8	5% sugar+5% jaggery+50ppm boron
T9	Hand pollination+50ppm boron
T10	No pollination

Increase in pollinator visits was observed after the spray of pollinator attractants. The results revealed that a combination of 5% sugar+5% jaggery+50ppm boron (T8) significantly enhanced the seed yield and seed quality parameters like pod length (15.3cm), number of seeds per pod (48.7), seed yield per plant (19.52g), seed yield per plot (2.34kg), total seed yield (13.14q/ha), enhanced vigour index II (2066). No significant di erence in pods per plant, 100 seed weight (g), germination (%), Seedling length (cm), dry weight of seedling (mg) and vigour index I was observed. Though pollen load was high in hand pollination, it didn't show significant enhancement in seed yield (Table 34 and 35).

Table 34: Effect of pollinator attractant spray on enhancement in yield parameters and seeds yield of okra cv. Kashi Chaman

Treatments	Average number of pods per plant	Pod length (cm)	Number of seeds per pod	Seed yield per plant (g)	Seed yield per plot (kg)	Seed yield per (q/ha)
T1	6.9	13.80	47.1	16.34	1.96	11.28
T2	7.2	14.27	45.8	17.52	2.10	11.80
T3	7.1	13.83	47.8	16.28	1.95	11.25
T4	6.5	14.13	48.1	16.42	1.97	11.32
T5	6.4	14.03	45.1	16.13	1.93	10.86
T6	7.1	13.90	48.5	16.51	1.98	11.30
T7	7.4	14.77	48.7	18.68	2.24	12.58
T8	7.6	15.30	49.5	19.52	2.34	13.14
T9	6.7	14.70	49.2	18.24	2.18	12.28
T10	6.6	14.47	44.3	14.52	1.74	9.78
CD (0.05)	NS	0.64**	2.0**	0.58**	0.23**	0.81**
CV(%)	7.3	2.6	2.4	1.98	6.75	4.07

Table 35: Effect of pollinator attractant spray on seed quality enhancement in okra cv. Kashi Chaman

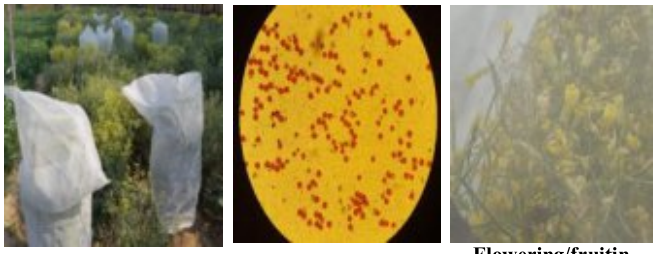
Treat ments	100 seed weight	Germina tion (%)	Seedling length (cm)	Dry weight (mg per seedling)	Vigour index I	Vigour index II
T1	5.3	84	21.2	20.5	1791	1727
T2	5.4	86	20.6	21.6	1766	1853
T3	5.1	88	21.7	22.4	1900	1962
T4	5.3	85	21.8	22.1	1848	1870
T5	5.6	90	21.6	21.7	1934	1947
T6	5.2	87	21.2	22.2	1849	1936
T7	5.3	86	21.4	21.5	1834	1845
T8	5.7	91	21.9	22.8	1983	2066
T9	5.5	90	21.2	21.6	1903	1935
T10	5.3	87	20.8	21.1	1809	1837
CD (0.05)	NS	NS	NS	NS	NS	163.5 *
CV(%)	6.2	4.1	2.9	3.4	4.9	5.0

Effect of pollen spray on seed yield in cauliflower: A study was conducted to see the e ect of artificially sprayed pollen on seed yield of cauliflower. Pollens were collected every day from the freshly opened flower, with the help of mortar and pestle with gentle crushing of the flowers/anthers in distil water. Pollen count was made with the help of Counter (heamocytometer) that ranged from 1.54 to 2.18 lakh pollen/ml. Randomly selected plants were individually caged with 40 mesh white nylon net and three plants in each of the five treatments were maintained for spraying.

A total of five treatments include pollen spray on every day, alternate day, every fourth day along with water spray every day and without spray as control i.e. open pollination. Among the pollen-sprayed treatments, every day pollen spraying gave maximum seeds per siliqua, however, open pollination was found to be the best for various traits such as plant height, length of siliqua and numbers of seed and siliqua/plant (Table 36). Number of siliqua ranged from 311 with alternate pollination to 1094 per plant under open pollination while seed count was 1.28 with distil water to 8.23 per siliqua in open pollination.

Table 36: Effect of pollen spray on various plant and seed parameters in cauliflower

Treatments	Plant height (cm)	No. of siliqua/ plant	Av. siliqua length (cm)	Av. No. of seeds/ siliqua	Seed Germinati on %
Distill Water	99.33	407.00	3.08	1.28	70.0
Pollen spray (twice in a week)	97.67	352.33	3.50	1.72	51.5
Pollen spray (alternate day)	96.00	311.00	3.40	2.32	59.5
Pollen spray (every day)	98.67	351.67	4.02	2.89	63.5
Control (open pollination)	109.00	1094.67	4.25	8.23	82.5



Caged cauliflower test plant | Pollen viability in cauliflower | Flowering/fruitin g in sprayed plants under cage

Fig. 82: Pollen spraying in cauliflower for seed production

Project 2.3: Drying and Storage Studies on Vegetable Seeds

Standardization of seed storage methods with zeolite beads and silica gel: Seeds of radish cv. Kashi Hans was stored in air tight container with zeolite beads and silica gel @1:10 (desiccant: seeds) at room temperature and cold storage (10^0 C). Seeds were also stored in cloth bag, polythene bag and air tight container without desiccants for comparison. Following treatments were studied.

Treatment code	Treatments
T1	Seed with zeolite beads in airtight container in room temperature
T2	Seeds without zeolite beads in airtight container in room temperature
T3	Seeds in cloth bag in room temperature
T4	Seeds in polythene bag in room temperature
T5	Seeds stored with silica gel in room temperature
T6	Seed with zeolite beads in airtight container in cold storage
T7	Seeds without zeolite beads in airtight container in cold storage
T8	Seeds in cloth bag in cold storage
T9	Seeds in polythene bag in cold storage
T10	Seeds stored with silica gel in cold storage

Among the storage condition, seed stored in cold storage (T6 – T10) recorded highest seed quality than seeds stored in room temperature (T1 – T5). Among the storage containers seed stored with zeolite beads recorded significantly highest seed quality after 36 months of storage period under both the storage conditions (T1 and T6). In conclusion, after 36 month of storage, seeds stored with zeolite beads recorded highest speed of germination and vigour indices in radish (Table 37). Other parameters such as germination (%), seedling length and seedling dry weight also recorded highest value when seeds were stored with zeolite beads.

Table 37: Effect of storage duration and different storage conditions on seed quality of radish variety Kashi Hans after 36 months of storage

Treatments	Seed germination%	Seedling length (cm)	Seedling DW (mg/seedling)	VI-I	VI-II	EC (µS/cm)	Speed of germination
T1	88.5	23.3	8.5	2062.9	752.25	86.2	27.3
T2	74.5	19.4	7.5	1447.2	558.75	127.2	18.8
T3	0	0.0	0	0.0	0.00	525.3	0.0
T4	48	23.8	11	1141.4	528.00	174.0	12.0
T5	83	24.2	8.1	2010.7	672.30	72.9	23.9
T6	92.5	25.7	9.2	2374.0	851.00	72.6	31.4
T7	91.5	19.5	8.5	1788.4	777.75	75.2	30.5
T8	86.5	21.9	9	1896.9	778.50	69.6	26.8
T9	92.5	23.1	9	2133.5	832.50	92.6	30.0
T10	93.5	25.6	9.7	2389.4	906.95	67.4	30.5
CD @5%	2.7	1.0	0.41	201.5	116.20	13.2	0.9

MEGA PROGRAMME 3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT

Programme Leader: Dr. R.N. Prasad

Project 3.1: Technologies for Protected Vegetable Production

Evaluation of gynoecious cucumber hybrids for polyhouse production: There was a significant variation for yield and related parameters among the polyhouse cucumber hybrids (Table 1; Fig. 1). Results demonstrate significant difference in fruit yield, which varied among the studied hybrids and ranged from 2.19 kg to 2.86 kg per plant. It was found that parthenocarpic cucumber Y-225 followed by Defender were suitable under protected conditions.

Table 1: Evaluation of parthenocarpic F_1 cucumber hybrids under naturally ventilated polyhouse conditions

Variety	No. of fruits per vine	Fruit length (cm)	Fruit dia. (cm)	Fruit weight (g)	Yield (kg)
Melis	12.41	15.49	3.78	194.21	2.41
Defender	12.94	16.02	4.05	196.25	2.54
Bayaz	19.35	10.33	3.91	113.14	2.19
Rica	15.99	14.15	3.54	148.20	2.37
Y-225	20.62	15.73	3.86	138.71	2.86
$CD_{0.05}$	1.82	0.94	0.35	28.93	0.293

Fig. 1: Bearing in gynoecious cucumber F_1 under polyhouse

Influence of different training systems in cucumber under naturally ventilated polyhouse: In order to develop a suitable training system in cucumber, four training systems *viz*., Drape (the apical meristem is not removed and the plant is draped over the top cable wire at 8 feet height; all other side branches are removed), Pinch (the apical meristem is removed at 8 feet height and a lateral shoot is trained over the cable wire at 8 feet height and back down to the floor), Umbrella (the apical meristem is removed at 8 feet height and allowing two stems to develop, which are then draped over the trellis to grow) and the Control (without any pruning) were evaluated. It was revealed that the Umbrella (3.17 kg) system followed by the Drape system (2.75 kg) and Pinch system (2.38 kg) recorded significantly higher values for yield per plant in cv. Y-225, while control registered the lowest value (2.18 kg/plant). The fruit quality and overall sensory acceptability are presented in Table 2 and Fig. 2.

Table 2: Quality of five parthenocarpic cucumber cultivars grown under protected cultivation

Name	TSS (°B)	MC (%)	DM (%)	Radical Scavenging Capacity (%)	Ascorbic acid (mg/100 g FW)	Total Phenolics content (µg GAE/g FW)
A - Y 225	4.5 ± 0.2	95.3 ± 0.4	4.75 ± 0.4	9.99 ± 1.3	8.3 ± 0.2	146.3 ± 8.3
B – Rica	4.4 ± 0.1	95.3 ±0.7	4.71 ±0.7	10.89 ± 1.1	8.3 ± 0.4	118.8 ± 8.3
C – Bayaz	4.7 ± 0.1	95.5 ± 0.9	4.53 ±0.9	8.03 ± 1.3	8.0 ± 0.7	122.3 ± 12.3
D – Melis	5.2 ± 0.1	94.7 ± 0.2	5.32 ± 0.2	8.36 ± 2.2	8.1 ± 0.1	153.1 ± 22.0
E- Defender	4.7 ± 0.1	95.3 ± 0.2	4.72 ± 0.2	9.99 ± 0.5	7.8 ± 0.2	173.1 ± 19.5

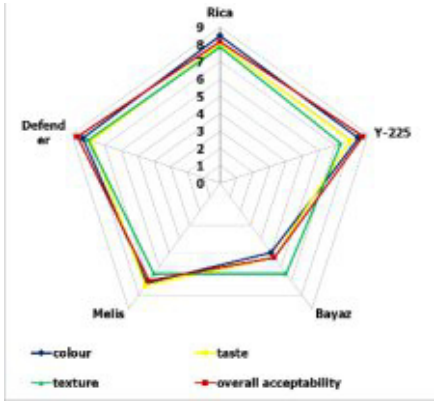


Fig. 2: Overall sensory acceptability of cucumbers

Seed germination and vigour as affected by seed-treatment with phenolic growth regulators: Seed treatment of gynoecious cucumber with salicylic acid (SA) and azealic acid (AZA) @ 100 µM resulted in improved germination and vigour as compared to control (Table 3). SA and AZA application resulted in higher germination, vigour index (VI- I and VI- II) and speed of germination (Table 3; Fig. 3).

Table 3: Effect of seed treatment with phenolic growth regulators on germination of gynoecious cucumber

Treatment	Germination (%)	VI-I	VI-II
SA	90	2565.06	1.46
AZA	86	2504.32	1.44
Control	82	2081.16	0.98

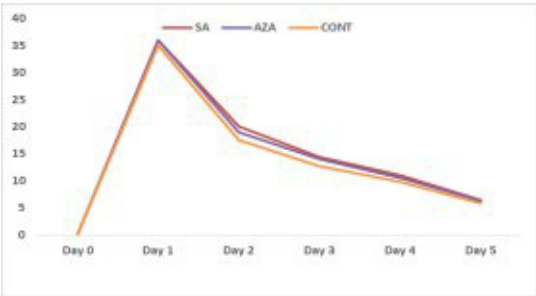


Fig. 3: Speed of germination as influenced by seed treatment in gynoecious cucumber.

Performance of polyhouse tomato on different training system: Tomato plants grown in a vertical culture tied to strings were trained onto one-stem and two-stem systems for canopy management under naturally ventilated polyhouse, while an unpruned plant served as control. Among different training systems, plants trained to two-stem recorded highest numbers of clusters (25.78) and yield per plant (9.46) in variety NS-4266 (Table 4, Fig. 4). However, the maximum average number of fruits per cluster (6.31), fruit length (4.74 cm), fruit diameter (4.41), fruit weight (63.57 g) was noted in plants trained onto one-stem. Unpruned control registered lower value for all the attributes studied.

Table 4. Performance of polyhouse tomato cv. NS-4266 as affected by different training system.

Attributes	Single stem	Double stem	Unpruned	$CD_{0.05}$
No. of clusters	16.47	25.78	14.16	2.172
No. of fruits/ cluster	6.31	6.22	5.75	1.059
Fruit length (cm)	4.74	4.29	4.02	0.356
Fruit width (cm)	5.41	4.91	4.85	0.434
Fruit weight (g)	63.57	58.96	51.75	8.655
Yield / plant (kg)	6.61	9.46	4.22	0.773

Similar trend was noted in other hybrid Heem Sohna as well.

Sizing of tomato as per AGMARK standard: Influence of training systems on fruit sizes of tomato cvs. NS-4266 and Heem Sohna were also studied. It was observed that up till IV cluster and III cluster in one-stem and two-stem system, respectively, one can harvest fruits graded as size 5 (57-66 mm dia.) as per AGMARK standards in NS-4266, while up to size grade 4 (47-56 mm) can be harvested till the harvest of last cluster (Table 5). In Heem Sohna, irrespective of pruning

Table 5: Sizing of tomato (as per AGMARK standard) as influenced by pruning

Cluster No.	Size Code					
	NS-4266			Heem Sohna		
	Single stem	Double stem	Control	Single stem	Double stem	Control
I	5	5	5	5	5	4
II	5	5	5	5	5	4
III	5	5	4	5	5	4
IV	5	4	4	4	4	4
V	4	4	4	4	4	4
VI	4	4	4	4	4	3
VII	4	4	3	4	4	3
VIII	4	4	3	3	3	3

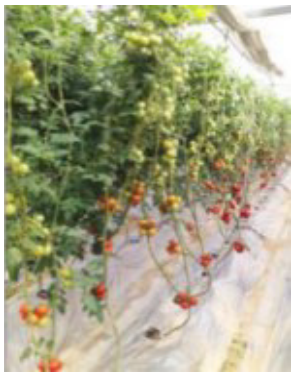


Fig. 4: Bearing in cv. Heem Sohna

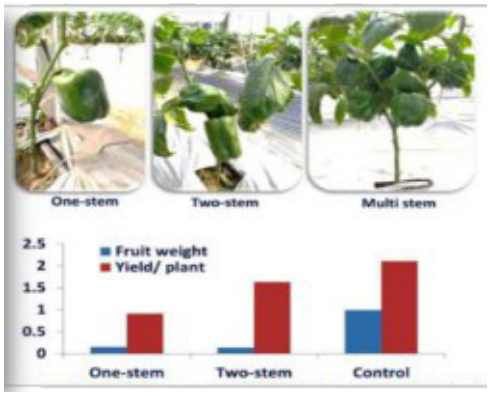


Fig. 5: Fruit weight and yield as affected by different training systems in capsicum

system, fruit grade size 5 could be harvested till III cluster only.

Evaluation of tomato varieties: The performance of tomato varieties developed by ICAR-IIVR, Varanasi was also evaluated during Autumn-Winter. The varieties *viz*., Kashi Aman, Kashi Adarsh and Kashi Chayan yielded 3.39 kg, 2.63 kg and 2.71 kg per plant, respectively under polyhouse conditions. During Spring-Summer, varieties namely, Indus 1206, Ayushman, Horsley and Aryan-60 yielded 3.31 kg, 3.08 kg, 2.73 kg and 2.16 kg fruits per plant, respectively with the application of PCPA during flowering.

Yield and attributing characters as the function of pruning system in capsicum: In Capsicum plants grown in a vertical culture, One-stem produced heavier, larger, blocky shaped fruits, however, it produced the lowest yield. The two-stem on the other hand produced not only the good size and blocky shaped fruits but also had comparatively higher yield. On the contrary, multiple stem (control) registered the highest yield but of lighter weight and misshapen (Fig. 5).

Evaluation of muskmelon varieties: Four varieties namely, Kashi Madhu, Hara Madhu, Sultan and NS-910 were evaluated for their performance in polyhouse. Kashi Madhu registered the highest yield of 3.35 kg/plant followed by Hara Madu (2.98 kg) and Sultan (2.29 kg), while the least was recorded in NS-910 (1.67 kg).

Pruning in muskmelon: In muskmelon cv. Kashi Madhu, three pruning systems were compared *viz*., main stem with two lateral branches, main stem with four lateral branches and unpruned control during July-November (Fig. 6). Side branches were trained on horizontal wires running parallel along the rows, while main stem was allowed to grow vertically. The highest yield was recorded in 4-lateral followed by control and 2-lateral. However, average fruit weight was noted to be the highest in 2-lateral followed by 4-lateral and control (Table 6).

Fig. 6: Kashi Madhu under polyhouse (Inset: harvested fruits)

Table 6: Comparison of pruning systems in muskmelon

Pruning system	Attributes		
	No. of fruits	Fruit weight (kg)	Yield (kg/plant)
2-lateral	4.14	0.81	3.39
4-lateral	5.32	0.72	3.87
Unpruned control	5.69	0.61	3.46
$CD_{0.05}$	0.115	0.077	0.179

Project 3.3: Vegetable Based Cropping System

Vegetable based cropping system for sustainability and profitability

Ten different cropping systems were evaluated during 2019-20. After completion of cropping cycle, the system productivity in terms of Rice Equivalent Yield (REY) was worked out. The data presented in table 7 revealed that highest total productivity (482.60 q REY/ha) was obtained with cowpea-tomato-okra cropping sequence followed by okra-tomato-cowpea (472.82. q REY/ha). However, with Paddy-wheat, the productivity was only 91.75 q REY/ha.

Soil fertility status

Soil fertility status under different cropping systems after completion of second cycle revealed significant difference for N, P and K content of the soil, but no considerable change was observed in the pH, EC and organic carbon content of the soil due to different cropping systems (Table 8).

Benefit cost ratio:

Cowpea-Tomato-Okra cropping system was found profitable with net income of Rs. 658396 and highest BC ratio of 3.71. This system was followed by Okra-tomato-cowpea cropping system with net income of Rs.640127. and Benefit-cost ratio of 3.63 and Bottle gourd-wheat-Amaranth cropping system ranked third place with net returns of Rs. 443498/ ha (Table 8).

Table 7: Productivity (q/ha) of crops in different cropping sequence during 2019-20

Cropping Sequence	Yield (q/ha)			Rice Equivalent Yield(q/ha)			
	Rabi 2019	Zaid 2020	Kharif 2020	Rabi 2019	Zaid 2020	Kharif 2020	Total
Paddy –wheat	38.21	0.00	52.38	39.37	0.00	52.38	91.75
Paddy -Wheat- Coriander	37.28	12.25	51.78	38.42	29.51	51.78	119.71
Paddy–tomato-Mung bean	490.62	12.80	48.92	262.64	47.96	48.92	359.52
Paddy -Cauliflower-cowpea	320.85	128.34	52.67	171.76	123.66	52.67	348.09
Bottle gourd-wheat -Amaranth	38.08	125.67	325.42	39.30	80.73	208.77	328.8
Maize- pea – Pumpkin	105.82	302.82	162.63	113.48	162.11	87.06	362.65
Brinjal- Cowpea	0.00	126.62	425.27	-	122.01	273.20	395.21
Okra-tomato-cowpea	495.72	124.82	135.72	265.37	120.27	87.18	472.82
Paddy -Pea-Okra	99.38	132.42	53.02	106.40	85.06	51.20	242.66
Cowpea-Tomato-Okra	498.62	130.52	136.82	266.92	83.84	131.84	482.60

Table 8. Soil fertility status under different cropping systems after second cycle

Cropping sequence	pH	EC (ds/ m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Total Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
Paddy –wheat	7.45	0.19	0.375	215.0	39.0	212.7	100400	171389	70989	1.71
Paddy -Wheat-Coriander	7.46	0.19	0.380	228.5	39.5	222.0	165400	223618	58218	1.35
Paddy–tomato-Mung bean	7.48	0.18	0.363	237.5	38.0	221.5	224450	671583	447133	2.99
Paddy -Broccoli-cowpea	7.46	0.17	0.385	235.0	38.2	227.5	219050	650232	431182	2.97
Bottlegourd-wheat-Amaranth	7.46	0.19	0.367	230.0	39.5	220.8	170700	614198.	443498	3.60
Maize- pea – Pumpkin	7.47	0.18	0.365	227.0	37.6	230.0	188650	677430	488780	3.59
Brinjal- Cowpea	7.45	0.17	0.360	242.0	36.8	230.5	211050	738252	527202	3.50
Okra-tomato-cowpea	7.45	0.18	0.372	228.0	34.5	229.0	243100	883227	640127	3.63
Paddy -Pea-Okra	7.47	0.17	0.382	225.9	35.9	228.5	192150	453288	261138	2.36
Cowpea-Tomato-Okra	7.49	0.18	0.379	235.0	34.5	221.7	243100	901496	658396	3.71
Initial	7.50	0.18	0.35	210.2	31.0	210.4	-	-	-	-
CD	NS	NS	NS	17.84	3.21	12.65	-	-	-	-

Price of different crops (Rs. /kg): Rice - 18.68, Wheat-19.25, Bottle Gourd-12.00, Maize-10.00, Brinjal- 12.00, Okra-12.00, Cowpea-18.00, Tomato-10.00, Cauliflower-10.00, Pea-12.00, Coriander-45.00, Moong Bean-70.00, Amaranth-12.00, Pumpkin-10.00

Project 3.10: Agronomic Bio-fortification Studies in Vegetable Crops

Preparation and evaluation of crop group specific micronutrient formulations

Crop-group specific micronutrient formulations four each for Solanaceous crops, Cole crops, Legumes and Okra were prepared and evaluated for their efficacy on tomato, cabbage and cauliflower during Rabi 2019-20, Cowpea and Okra during Zaid and Kharif-2020, respectively. A commercial formulation available in the market as well as the "Vegetable Special" from ICAR-IIHR, Bengaluru were also taken for comparison.

Effect of micronutrient formulations on Cabbage and Cauliflower

The four prepared micronutrient formulations (Micromix A, Micromix B, Micromix C and Micromix D) and a commercial formulation were applied @ 1 g/l three times at 10 days intervals after 30 days of planting. The ICAR-IIHR formulation Vegetable Special was sprayed @ 5 g/l as per the recommendations thrice at 10 days intervals after 30 days of planting.

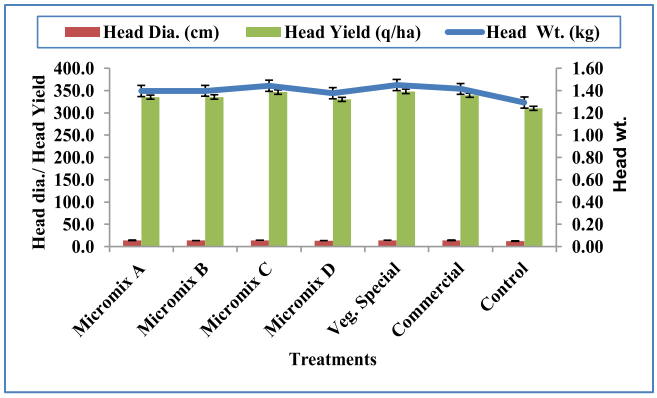


Fig. 7. Response of cabbage to foliar application of micronutrient formulations

In control plot, only water was sprayed for similarity. The data on growth and yield parameters were recorded at the time of harvest. The results presented in Fig. 7 & 8 indicate that all the micronutrient formulations significantly improved the yield and yield attributing parameters of cabbage and cauliflower as compared to the control. Although all the tested micronutrient formulations proved statistically equally effective in improving the growth and yield, however, among the four prepared formulations, Micromix C proved better recording numerically higher values for all the parameters in both the crops.

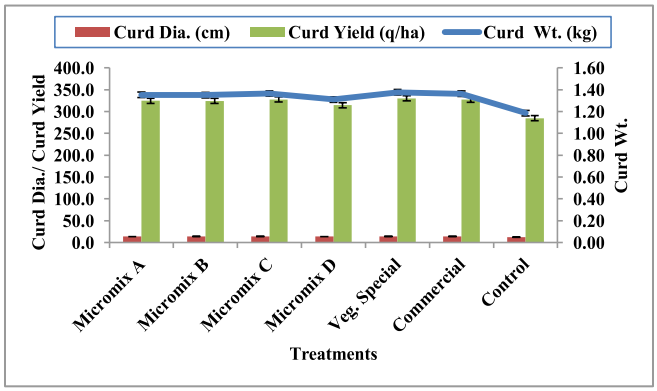


Fig. 8. Response of cauliflower to foliar application of micronutrient formulations

Effect of micronutrient formulations on Tomato: It is evident from the results (Fig. 9) that all the micronutrient formulations under test significantly improved the growth and yield of tomato as compared to the control. It is also evident from the data that there was no significant difference among the micronutrient formulations. However, Micromix A proved slightly better recording numerically maximum fruit yield (245.9 q/ha).

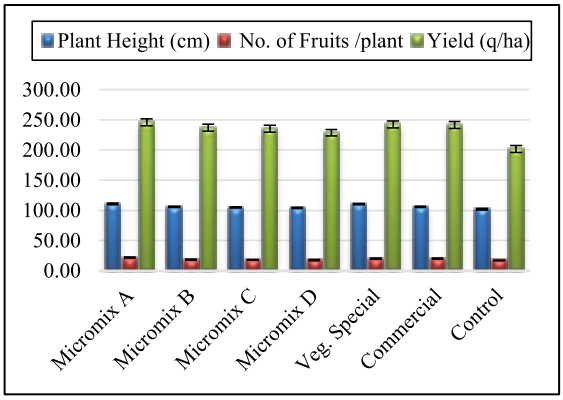


Fig. 9. Response of tomato to foliar application of micronutrient formulations

Zaid 2020

Effect of micronutrient formulations on Cowpea and Okra: The data presented in Fig. 10 and 11 revealed that foliar application of the micronutrient formulations significantly influenced the number of pods/plant and pod yield of cowpea and okra over control. The highest pod yield of 108.2 q/ha in cowpea was recorded with Micromix A. In Okra Micromix -A resulted into numerically maximum number of fruits/ plant (69.0) and total fruit yield (118.1 q/ha).

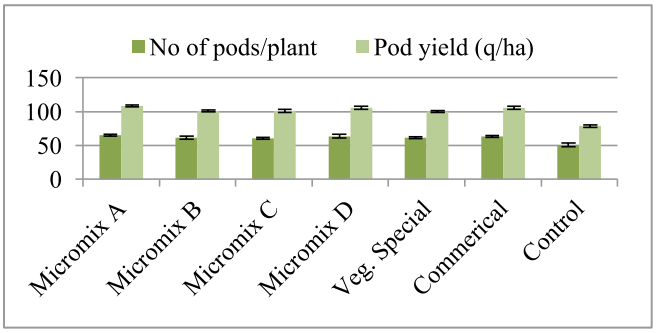


Fig. 10: Response of cowpea to micronutrient formulation at Varanasi

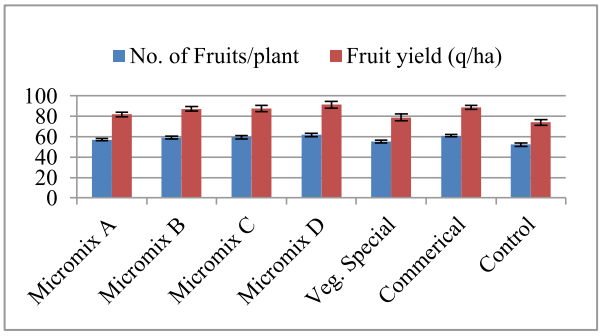


Fig.11. Response of Okra to micronutrient formulations

Kharif 2020: During *Kharif* season, two experiments, one each on cowpea and okra, were conducted to study the response of foliar spray of the micronutrient formulations prepared for legumes and okra crops.

Effect of micronutrient formulations on Cowpea: It is evident from the data presented in Fig. 12 and 13 that foliar application of different micronutrient formulations significantly improved the pod yield of cowpea and okra over control during *kharif*-2020. However, no significant difference was observed among different formulations. At Sargatia, Kushinagar, among different formulations, Micromix D proved more effective as compared to the others (Fig. 14, 15 & 16) in okra while Micromix C proved more effective as compared to the others in cowpea.

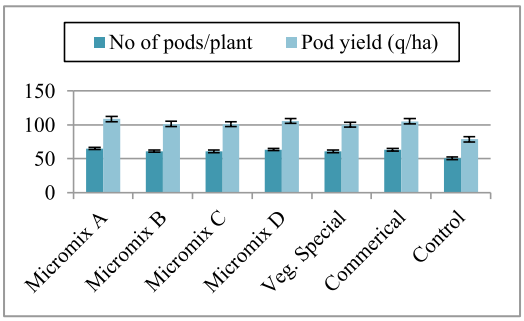


Fig.12. Pod yield of cowpea in relation to micronutrient formulations

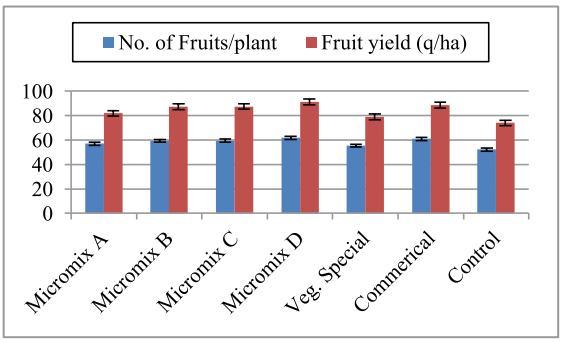
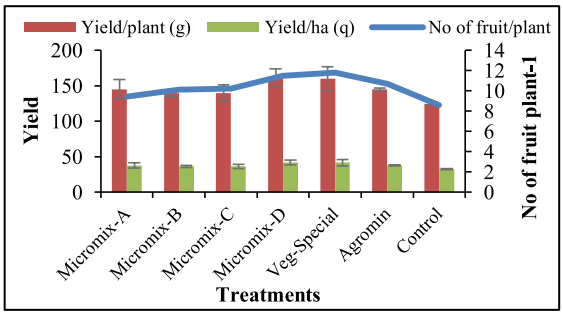
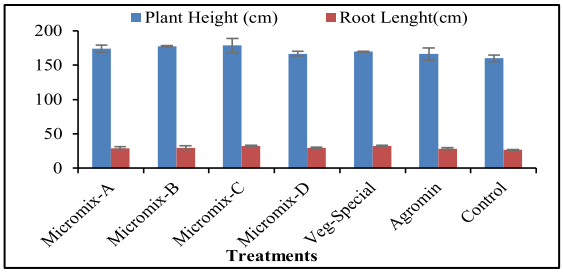


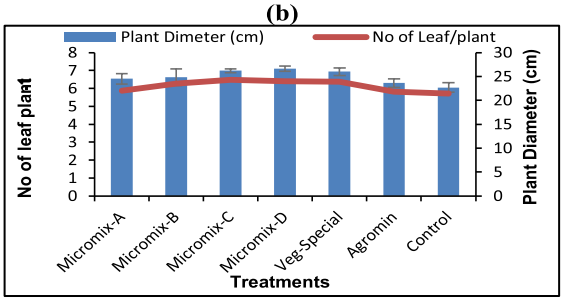
Fig. 13. Response of Okra to micronutrient formulations



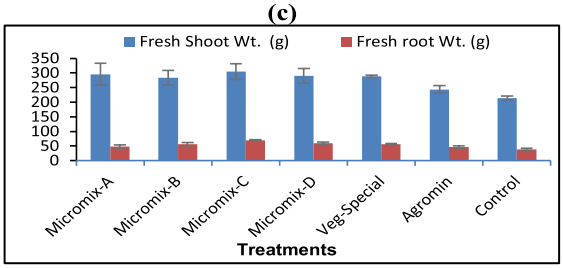
(a)



(b)

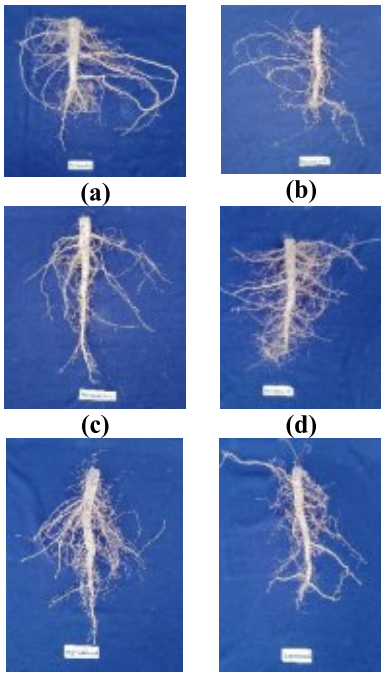


(c)



(d)

Fig. 14: Effect of micronutrient formulations on physiomorphological and yield parameters of okra (yield per plant, yield per ha; a), (plant height, root length; b), (plant diameter, no of leaf per plant; c), (fresh shoot weight and fresh root weight; d).



(a) (b) (c) (d) (e) (f)

(g)

Fig. 15: Okra root growth under different treatment conditions (a) Micromix-A, (b) Micromix-B, (c) Micromix-C, (d) Micromix-D, (e) Veg-Special (f) Agromin (g) Control

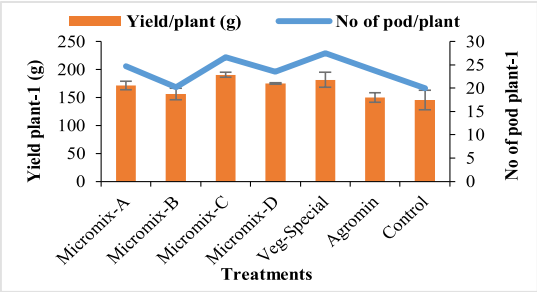


Fig. 16: Effect of micronutrient formulations on cowpea yield per plant and no of pod per plant

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

A field experiment was conducted having fourteen treatments replicated thrice in split plot design, during *Rabi* season of 2019 on three test crops namely pea, broccoli and tomato. These crops were harvested during January-March 2020. During summer and *Kharif* season of 2020, bottle gourd, cowpea and Dhaincha were grown. The growth and yield performance of *Rabi*, summer and *Kharif* crops are reported hereunder.

Performance of *Rabi* season crop

Broccoli: The performance of broccoli crop was assessed under non-mulch and two types of mulch at three rates of three different organic manures. The result revealed that weed mat mulch produced highest yield (23.39 t/ha) of broccoli which was 43.4 and 20 percent higher over no mulch and paddy straw mulch (applied @6t/ha) respectively. Application of vermicompost @ 10 t/ha recorded the yield of 22.37t/ha which was significantly higher over Inorganic fertilizer application (20.53t/ha). The maximum yield was recorded with application of vermicompost @10 t/ha under weed mat mulching (29.52t/ha) and minimum yield was noted under control (6.64 t/ha, Fig. 17). Among the three organic sources, though vermicompost increased the broccoli yield however all the three organic sources were at par .

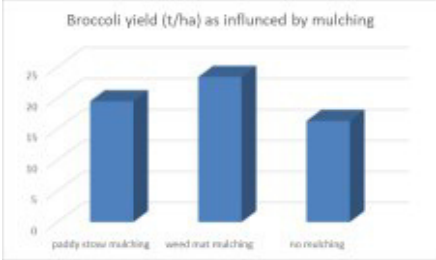


Fig. 17: Broccoli yield as influenced by mulching

Tomato: The performance of tomato crop was assessed under weed mat mulching and without mulching condition at variable rates of three organic manures. The result revealed that weed mat mulching produced 30.12 percent higher yield of tomato over no mulching irrespective of rates of organic manure application. Among the organic manure treatments, highest yield of tomato(35.13t/ha) was recorded with application of FYM @25t/ha which was significantly superior to all the organic manure treatment except 20t FYM/ha, 10t VC/ha and inorganic treatment which were at par. The highest yield of tomato (40.98 t/ha) was noted with application of 25 t FYM/ha under weed mat mulching, while minimum yield was noted under control treatment without any fertilizer and manure application. Among the three organic sources, there was no significant effect of sources on tomato yield.

Pea: The vegetable pea was grown under three variable rates of three organic manures application. The highest yield of vegetable pea (9.70t/ha) was recorded under application of FYM @ 20t/ha which was significantly higher to rest of the organic treatment except FYM@25t/ha, VC@ 7.5 t/ha and VC@10t/ha. There was no significant effect of three sources on pea yield

Performance of summer season crops

During summer season bottle gourd and cowpea were grown.

Bottle gourd: The results revealed that bottle gourd crop grown after pea crop recorded higher yield than bottle gourd grown after broccoli. Application of NADEP Compost @ 25t/ha recorded highest yield of 268.23 and 256.12q/ha in bottle gourd grown after pea and broccoli, respectively, which was significantly higher to inorganic treatment. Among the organic sources, there was no significant difference between sole application of FYM, VC and NADEP compost or their combinations. The increasing dose of organic manures improved the yield of bottle gourd. The lowest bottle gourd yield was noted

in control plot. Similar trend was observed in bottle gourd grown after broccoli.

Quality parameters: The quality of vegetables in terms of vitamin C content was better under organic system as compared to inorganic system in cowpea and bottle gourd. The ascorbic acid, total phenol and anti-oxidant content increased by 18.2, 13.6 and 9.2 % in cowpea and 21.8, 16.6 and 12.4 percent in bottle gourd over inorganic system.

Table 9: Quality of Bottle gourd grown under Organic practices

Treatment	TSS (°B)	Moisture Content (%)	Ascorbic acid (mg/100g FW)	Radical scavenging capacity (%)
FYM 15t per ha	2.8± 0.05	95.7 ± 0.15	16.6 ± 0.25	41.9 ± 1.22
FYM 20 t per ha	3.6 ± 0.15	95.9± 0.15	16.0± 0.55	42.1 ± 1.79
FYM 25t per ha	3.4 ± 0.09	96.0± 0.01	17.7±0.11	40.8±1.16
VC 5t per ha	3.4± 0.11	95.8± 0.54	17.9± 0.25	34.6 ± 1.46
VC 7.5 t per ha	3.0± 0.09	95.6± 0.42	16.9±0.15	29.0 ± 0.42
VC 10 t per ha	3.8± 0.06	94.9± 0.52	16.3±0.18	24.9 ± 0.52
NADEP 15 t per ha	3.6± 0.11	94.6± 0.14	16.8±0.07	27.4 ± 1.48
NADEP 20 t per ha	4.4±0.22	94.8± 0.72	17.4±0.19	26.5 ± 3.41
NADEP 25 t per ha	4.2± 0.31	95.4± 0.52	17.2±0.14	24.0 ± 1.14
Inorganic	3,28± 0.05	96.6 ± 0.15	12.3 ± 0.12	21.28± 0.62

Cowpea: Cowpea crop was grown after tomato, broccoli and wheat crop. Cowpea crop after broccoli tomato and wheat was sown on 21.02.2020, 22.3.2020 and 20.04.2020 respectively. The cowpea crop after tomato produced higher yield than crop grown after broccoli and wheat. The highest pod yield (89.91q/ha) of cowpea following tomato was recorded with application of NADEP compost @ 25t/ha followed by FYM @ 25t/ha (70.98q/ha), while in the crop after broccoli

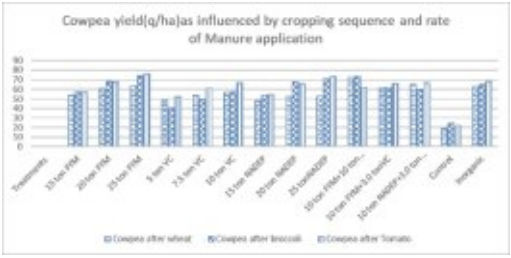


Fig. 18: Cowpea yield as influenced by cropping sequence and rate of manure application

highest yield of 73.24q/ha was noted with application of FYM @ 25t/ha. The cowpea crop after wheat, recorded highest yield of 72.12qha with combined use of FYM @ 10t/ ha + NADEP compost @ 10t/ha (73.20 q/ha) as against pod yield of 64.26 q/ha recorded under inorganic system with application of chemical fertilizers at recommended dose (Fig. 18).

Performance of cropping system: The statistical analysis of the second-year data revealed that green manuring of dhaincha increased the yield of broccoli, tomato and pea by 11.0, 9.56 and14.76 percent respectively. Highest productivity in terms of wheat equivalent yield was recorded in bottle gourd-Pea-bottle gourd sequence (247.22q/ha) followed by BG – Tomato - Cowpea sequence (243.6q/ha). The lowest WEY was recorded in GM-Pea-Wheat-cowpea cropping sequence. Loss of one crop due to green manuring could not be compensated by increase in yield of crops following green manuring as a result significantly lower WEY was noted in the cropping sequences having green manuring as one of the crops in the system (Fig. 19). The highest net return of Rs 212000/ha was recorded in BG-Pea-BG sequence and maximum benefit cost ratio (2.06) was in noted in Green manure- broccoli-cowpea sequence followed by BG-Vegetable pea -BG sequence (1.87) .

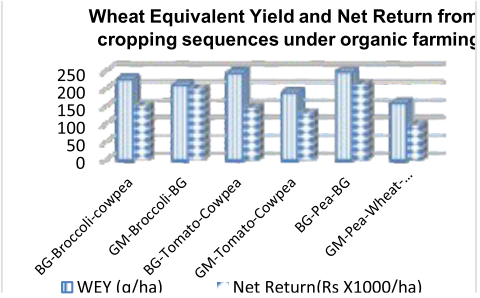


Fig. 19: Wheat equivalent yield and net return from cropping sequences under organic farming

The rate of organic manures influenced significantly the productivity of the cropping systems (Fig. 20). The highest productivity (263.99q/ha) was observed with application of FYM @ 25t/ha to all the crops followed by FYM @ 20t/ha to all the crops, NADEP @ 25t/ha to all the crops and Vermicompost @ 10 t/ha to all the crops in that order. The net return and B:C ratio followed the similar trend. The productivity of inorganic system where recommended dose of chemical fertilizer was applied was at par to the organic system. In all the cropping rotations highest WEY was noted with application of FYM @ 25 t/ha to all the crop, except in

GM- broccoli -bottle gourd sequence where highest yield was noted with application of NADEP compost @ 25 t/ha to all the crops.

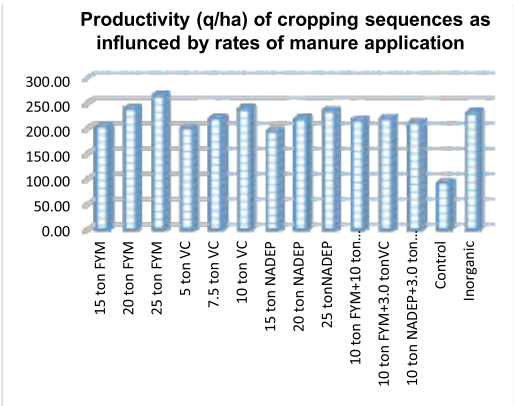


Fig. 20: Productivity of cropping sequences as influenced by rates of manure application

Performance of kharif season crops: During kharif season 2020 each plot was divided in to three equal parts. In one-part green manuring with Dhaincha crop was done and in second- and third-part cowpea and bottle gourd crops, respectively 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 (Fig. 21). The result revealed that among the two systems, significantly higher yield was recorded under flatbed system (33.94 t/ha) as compared to bower system (26.01 t/ha) The higher yield obtained under flatbed was associated with significantly higher number of fruits/unit area though the average fruit weight was higher under bower system Among organic manures, FYM application @ 25t/ha produced highest yield (39.29t/ha) which was significantly higher than rest of the treatments. The combination of FYM @10 t/ha +VC@ 3.5t/ha and FYM @ 10t/ha + NADEP @10t/ha was at par to sole FYM application@20 t/ha. The increasing rate of organic

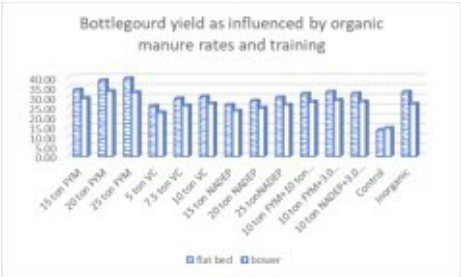


Fig. 21: Bottle gourd yield as influenced by organic manure rates and training

manures increased the yield of bottle gourd irrespective of bower or flatbed system. Among the three sources FYM application produced significantly higher yield over NADEP compost however it was at par to VC and Inorganic nutrition.

Green manure: The green manure crop of Dhaincha was sown with the seed rate of 30kg/ha during kharif season. The Dhaincha crop of 42 days old was turned down in to the soil with mould board plough. The average dry matter added in the organic treatments ranged between 1.4 to 2.21 t/ha while in the control and inorganic treatments it was 1.04 and 1.63 t/ha respectively. Among the cropping systems highest green manure dry matter was produced with broccoli-cowpea sequence (1.91t/ha) followed by Pea-okra sequence (1.66t/ha) and tomato-moong bean sequence (1.46).

Cowpea: During Kharif season cowpea was sown on riges in ridge and furrow system. The result revealed that, application of FYM@25 t/ha produced highest yield (89.52 q/ha) which was at par to application of FYM @20 t/ha (88.67 q/ha) and inorganic treatments (85.21q/ha) but significantly higher than rest of the treatments. Among the three sources FYM application produced significantly higher yield over vermicompost but was at par to NADEP compost

Rabi season crops: During rabi season 2020 tomato, cauliflower, pea was grown. 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. The crop condition is good condition.

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

Effect of drip irrigation scheduling on yield and water use efficiency in tomato, cauliflower and cabbage

Tomato: Study on drip irrigation scheduling in tomato was carried out in 2018-19 with two quantities of water through drip irrigation (100% and 75% ET) compared with conventional furrow irrigation (Table 10). Drip irrigation was scheduled at 2 or 3-days intervals. In this study, maximum number of fruits (55.8) and yields (3.98 kg/ plant, 387.42 q/ha) was obtained with drip irrigation at 2 days interval with 100% ET (T1), however fruits

yields obtained under this treatment was at par to DI 100% ET scheduled at 3 days intervals (T2). T1 treatment registered 18.77% higher yields over conventional irrigation and 24-29.8% more yields over 75% ET (T3 and T4). Water use e ciency among the drip irrigation treatments were not varied significantly, however it was remarkably higher over conventional irrigation (9.12 q/ha/cm).

Cabbage and cauliflower: Drip irrigation scheduling study was also conducted in cabbage and cauliflower during November to March 2018-19 (Table 10). There were five treatments with 5-replications including control (conventional irrigation). In cabbage, maximum head weight (2.617 kg), circumference (60.43 cm), dry matter production (212.6 g/ plant) and head yield (527.47 q/ha) was reported in treatment comprising DI at 100% ET with scheduling at 2 days interval (T1), however maximum WUE (34.85 q/ha/cm) was achieved under T3 (DI at 2 days with 75% ET) (Fig. 22).

In cauliflower, T1 (DI 100% ET at 2 days interval) reported maximum curd weight (1.322 kg), polar diameter (19.36 cm), yield (491.05 q/ha) and WUE (36.37 q/ha-cm) followed by T2 (DI 100% ET at 3 days). Perusal of data (Table 10) revealed that 93.88% and 83.86% higher curd yields were achieved in T1 and T2, respectively as compared to conventional furrow irrigation. In T1, there was an appropriate portioning of biomass in di erent parts of cauliflower plants, and there was proportional higher biomass in curd than stems and roots.

As far as water savings was concerned, there was 30.5% and 33% less water was used, respectively in cabbage and cauliflower under drip irrigation at 100% ET as compared to conventional furrow irrigation system.

Fig. 22: A view of cabbage field

Table 10: Effect of drip irrigation scheduling on yield and water use efficiency in tomato, cauliflower and cabbage

	Tomato		Cauliflower		Cabbage	
Irrigation scheduling	**Fruit yield (q/ha)**	**WUE (Q/hacm)**	**Curd Yield (q/ha)**	**WUE (Q/ha-cm)**	**Head Yield (q/ha)**	**WUE (Q/ha-cm)**
T1= Drip irrigation at 2 days with 100% ET	387.42	15.65	491.05	36.37	527.45	31.56
T2= Drip irrigation at 3 days with 100% ET	359.84	14.53	465.67	34.49	474.86	28.42
T3= Drip irrigation at 2 days with 75% ET	312.39	16.25	287.43	28.40	436.67	34.85
T4= Drip irrigation at 3 days with 75% ET	298.33	15.52	264.99	26.18	385.50	30.77
T5= Conventional furrow irrigation	326.21	9.12	253.27	12.58	270.28	11.24
SEm±	8.34	-	22.33	-	12.42	-
CD $_{0.05}$	24.29	-	65.20	-	36.26	-

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

Inter-specific grafting study in tomato under polyhouse and in open field: Grafting study was conducted in naturally ventilated polyhouse with three brinjal rootstocks (IC-354557, IC-111056 and Surya) and three tomato scion cultivars i.e. Kashi Aman and Kashi Adarsh (determinate), and NS-4266 (indeterminate hybrid). It was compared with un-grafted tomato. In Kashi Aman, the plant biomass was unaffected with grafting while in Kashi Adarsh and NS-4266 there was 25.6 - 27.4% and 10.0-31.25% reduction in biomass with grafting. A significant reduction in number of fruits/plants were also observed with grafting. Tomato yields have reduced significantly with rootstock IC-354557 and IC-111056, while on Surya rootstock yield *at par* to un-grafted plants was registered in all three tomato varieties. Polar diameter of fruit was increased in Kashi Aman and Kashi Adarsh, while it decreased significantly in NS-4266 with use of IC-354557 and Surya rootstock. Equatorial fruit diameter in Kashi Aman was higher with IC-354557 (59.20 mm) and Surya (55.17 mm), however in Kashi Adarsh and NS-4266 it was significantly lower with IC-354557

Table 11: Response of tomato cultivars to yields and quality traits with different brinjal rootstocks (under NVP)

Rootstock x Scion	PH	FPB	NFP	FW	FYP	PD	ED	TSS	TA	AsA
Determinate tomato										
IC-354557 x Kashi Aman	171.33	5.976	56.3	89.40	5.17	54.13	59.20	3.0	3.50	22.17
IC-111056 x Kashi Aman	172.00	6.172	52.3	95.87	5.40	50.13	53.73	3.3	3.77	22.80
Surya x Kashi Aman	178.67	6.605	51.3	94.33	5.69	50.30	55.17	2.8	3.57	23.50
K. Aman un-grafted	*218.00*	*6.122*	*64.0*	*85.39*	*5.23*	*47.67*	*52.40*	*2.9*	*4.00*	*23.27*
IC-354557 x Kashi Adarsh	245.67	4.007	41.7	70.60	3.12	47.53	52.00	3.3	4.33	23.60
IC-111056 x KashiAdarsh	233.67	4.104	52.3	62.30	3.40	51.73	54.13	3.4	4.40	24.00
Surya x Kashi Adarsh	231.00	4.096	50.3	70.27	3.61	45.40	53.93	2.8	4.63	24.80
K. Adarsh un-grafted	316.33	5.519	61.7	74.90	4.26	43.60	54.47	3.3	4.67	25.10
Mean	**220.83**	**5.33**	**53.75**	**80.38**	**4.48**	**48.81**	**54.38**	**3.10**	**4.11**	**23.65**
SE±	**16.11**	**0.357**	**2.32**	**4.15**	**0.34**	**1.14**	**0.73**	**0.09**	**0.15**	**0.32**
$CD_{0.05}$	**46.39**	**1.030**	**6.45**	**11.54**	**0.93**	**3.17**	**2.04**	**0.24**	**0.43**	**0.90**
Indeterminate tomato										
IC-354557 x NS 4266	428.50	6.825	112.0	57.00	5.83	43.40	50.53	4.9	4.87	26.20
IC-111056 x NS 4266	398.33	6.166	113.7	51.70	5.19	48.07	54.07	4.9	5.17	26.77
Surya x NS 4266	519.33	8.076	121.0	65.67	6.92	44.87	54.80	4.3	5.43	27.23
NS 4266 un-grafted	472.67	8.969	131.7	59.61	7.14	49.43	55.63	4.4	5.67	27.17
Mean	**454.71**	**7.51**	**119.6**	**58.50**	**6.27**	**46.44**	**53.76**	**4.60**	**5.28**	**26.84**
SE±	**22.86**	**0.544**	**3.88**	**2.51**	**0.40**	**1.21**	**0.97**	**0.13**	**0.15**	**0.21**
$CD_{0.05}$	**67.45**	**1.603**	**11.05**	**7.16**	**1.13**	**3.44**	**2.77**	**0.38**	**0.43**	**0.59**

PH = Plant height (cm); **FPB**= Fresh plant biomass (kg); **NFP**= No. of fruits/plant; **FW**= Fruit weight (g), **FYP** = Fruit yield/ plant (kg); **PD**=Polar diameter of fruit (mm); **ED**= Equatorial diameter (mm); **TSS**= Total soluble sugars (°Brix); **TA**=Titrable acidity (%) and **AsA** = Ascorbic acid (mg/ 100 g FW).

rootstock (52.00 mm and 50.53 mm, respectively). TSS content in fruit was unaffected in both Kashi Aman and Kashi Adarsh tomato cultivars, but with use of IC-111056 rootstock TSS content was enhanced by 11-36% over ungrafted control. Acidity of fruit was either unaffected or declined slightly with grafting. Ascorbic acid content ranged from 22.17 to 27.23 kg/100 g, and its content varied with cultivars (Table 11).

Grafting study in tomato was also conducted in open field condition with three brinjal rootstocks (IC-354557, IC 111056 and Surya) and three improved cultivars of tomato (Kashi Aman, Kashi Adarsh and Kashi Chayan). Maximum number of fruits *i.e.* 45.8, 47.4 and 48.2/ plant were observed when these cultivars were grafted over brinjal rootstock IC-111056. Fruit weight in Kashi Aman and Kashi Chayan was maximum (104.18 and 115.18 g)

Table 12: Response of tomato cultivars to yields and quality traits with different brinjal rootstocks (in open field)

Graft combination	NFP	FW	PD	ED	FYP
Kashi Aman	35.4	104.18	54.44	58.40	1.698
IC-111056 +Kashi Aman	45.8	76.55	54.16	53.84	1.352
IC-354557 +Kashi Aman	39.0	80.02	54.52	56.16	1.552
Surya+ Kashi Aman	35.2	77.99	56.72	56.96	2.055
Kashi Adarsh	36.2	77.22	52.96	57.32	1.531
IC-111056 +Kashi Adarsh	47.4	80.64	54.04	58.00	1.965
IC-354557 +Kashi Adarsh	47.0	74.01	53.00	54.64	1.888
Surya + Kashi Adarsh	45.0	79.93	52.60	55.72	1.621
Kashi Chayan	41.2	113.18	53.40	63.20	1.916
IC-111056 +Kashi Chayan	48.2	80.57	50.60	57.52	1.605
IC-354557 +Kashi Chayan	37.2	84.30	50.96	58.64	1.436
Surya + Kashi Chayan	42.2	80.00	51.28	60.68	1.379
Mean	41.7	84.05	53.22	57.59	1.667
SE +/-	1.37	3.30	0.48	0.71	0.066
CD (0.05)	4.02	9.68	NS	2.07	0.195

in ungrafted control, however in Kashi Adarsh it was not varied significantly. Polar diameter of fruit was unaffected with grafting. Furthermore, maximum fruit yield of 2.055 kg/plant was registered in Kashi Aman grafted over Surya followed by Kashi Adarsh on IC-111056 (1.965 kg) and on IC-354557 (1.888 kg) (Table 12).

Grafting study in cucurbitaceous vegetables: Grafting study was carried out in cucumber, bitter gourd and muskmelon using different inter-specific cucurbitaceous rootstocks. In cucumber, four rootstocks *i.e.* ash gourd, ridge gourd, sponge gourd and bottle gourd were used with three scion cultivars *i.e.* Kashi Nutan, Kalyanpur Green and Kashi Green Long. Maximum number of fruits (23.33 and 24.67) and yield (4.244 and 5.174kg/plant) in Kashi Nutan and Kalyanpur Green was recorded with sponge gourd rootstock, respectively. These two cultivars produced 17.26% and 115.13% higher fruit yield over ungrafted control. Minimum yield was registered when bottle ground was used as rootstock (Table 13). Maximum fruit weight in Kashi Nutan (177.93g) and Kalyanpur Green (181.93 g) was also noticed with sponge gourd rootstock.

Table 13: Effect of inter-specific cucurbitaceous rootstocks on production of Cucumber

Rootstocks	NFP	AFW	FL	FD	YPP
	Scion- Cucumber (cv. Kashi Nutan)				
Ash gourd	19.67	153.80	17.17	3.68	3.863
Ridge gourd	19.00	169.70	15.85	4.66	3.557
Sponge gourd	23.33	158.82	16.42	4.95	4.244
Bottle gourd	6.33	177.93	14.49	4.65	1.213
Ungrafted Kashi Nutan	20.00	163.10	16.81	4.62	3.619
Mean	**17.67**	**164.67**	**16.15**	**4.51**	**3.299**
SE±	**2.62**	**3.77**	**0.42**	**0.19**	**0.478**
CD	**7.04**	**10.70**	**1.23**	**0.53**	**1.405**
	Scion- Cucumber (cv. Kalyanpur Green)				
Ash gourd	19.00	150.70	17.21	4.97	3.585
Ridge gourd	20.00	162.80	18.08	5.00	3.870
Sponge gourd	24.67	181.93	16.52	4.77	5.174
Bottle gourd	6.00	173.27	16.19	4.95	1.182
Ungrafted Kalyanpur Green	12.67	170.33	16.27	4.37	2.405
Mean	**16.47**	**167.81**	**16.85**	**4.81**	**3.243**
SE±	**2.89**	**4.70**	**0.32**	**0.10**	**0.605**
CD	**7.79**	**12.63**	**0.85**	**0.28**	**1.628**

In bitter gourd two long type cultivar *i.e.* VRBTG-10 and Porvika and one small fruited hybrid-Atom were used as scion. VRBTG-10 was unaffected with rootstock, whereas significantly higher number of fruits (54.33) and fruit yield (2.908 kg/plant) in Porvika was reported with sponge gourd rootstock. Small fruited bitter gourd (Atom) also registered maximum number of fruits (65.67) and yield (1.741 kg/plant) with sponge gourd rootstock as compared to ungrafted control (46.00 and 1.144 kg/plant). In muskmelon cv. Kashi Madhu has registered significantly higher number of fruits (5.3/plant) and yield (4.15 kg/plant) when sponge gourd was used as rootstock, and it has registered 58.4% higher fruit yields than the ungrafted plants (Table 14).

Table 14: Effect of inter-specific grafting on bitter gourd and muskmelon production

Graft combination (Rootstock x Scion)	NFP	AFW	FL	FD	FYP
	Long fruited hybrids				
Ridge gourd x VRBTG 10	20.33	209.89	17.07	2.50	0.805
Sponge gourd x VRBTG 10	13.33	243.00	14.92	2.15	0.611
VRBTG 10 (non-grafted)	30.33	196.58	16.32	2.40	1.169
Sponge gourd x Porvika	54.33	276.10	16.27	2.67	2.908
Ungrafted Porvika	38.33	228.90	12.41	2.05	1.696
Mean	**31.33**	**230.89**	**15.40**	**2.35**	**1.438**
SeM	**5.84**	**11.27**	**0.67**	**0.09**	**0.336**
CD	**16.76**	**32.35**	**1.93**	**0.26**	**0.964**
	Small fruited hybrid- Atom				
Ridge gourd x Atom	65.67	26.39	8.53	1.82	1.741
Ungrafted Atom	46.00	25.84	7.72	1.65	1.144
Mean	**55.83**	**26.12**	**8.12**	**1.73**	**1.443**
SeM	**6.97**	**0.19**	**0.29**	**0.06**	**0.212**
CD	**18.55**	**0.51**	**0.76**	**0.16**	**0.563**
	Muskmelon-Kashi Madhu				
Ash gourd x Kashi Madhu	3.3	782.67	9.1	11.4	2.19
Ridge gourd x Kashi Madhu	4.3	901.33	10.9	12.4	3.63
Sponge gourd x Kashi Madhu	5.3	928.33	11.0	12.2	4.15
Ungrafted Kashi Madhu	4.3	795.67	9.3	11.3	2.62
Mean	**4.3**	**852.00**	**10.1**	**11.8**	**3.15**
SE	**0.35**	**31.86**	**0.43**	**0.23**	**0.24**
CD	**0.98**	**88.57**	**1.20**	**0.64**	**0.67**

Grafted pomato production: Two indeterminate tomato hybrids viz., NS 4266 and TR 4637, and three determinate tomato cultivars such as Kashi Aman, Kashi Adarsh and Kashi Chayan were grafted over white potato (Kufri Bahar) for pomato production. Experimental findings revealed that potato production ranged between 505 to 745.67 g while tomato production was in range of 826-3090 g from single pomato plant (Table 15 & 16). Lycopene, β-carotene, acidity, ascorbic acid, reducing and non-reducing sugars and TSS were also analysed in both tubers and fruits. In quality traits, no definite patterns have been observed and it varied considerably, and thereby need to be revalidated.

Table 15: Effect of different tomato scions on pomato production

Potato + Tomato	Fruits (no.)	Tubers (no.)	Tuber yield/ plant (kg)	Tomato yield/ plant (kg)	Total yield /plant (kg)
NS-4266 (Tomato-Indt.)	85.8	0	0	4.536	4.536
TR 4637 (Tomato-Indt.)	53.4	0	0	3.255	3.255
K. Aman (Tomato)	23.0	0	0	1.130	1.130
K. Adarsh (Tomato)	28.6	0	0	0.988	0.988
K. Chayan (Tomato)	12.8	0	0	0.943	0.943
Potato + NS-4266	83.8	9.2	0.530	3.090	3.620
Potato + TR 4637	46.6	14.6	0.746	1.553	2.299
Potato + K. Aman	15.4	10.4	0.505	0.638	1.143
Potato + K. Adarsh	19.6	16.0	0.681	0.771	1.452
Potato + K. Chayan	8.8	15.2	0.699	0.826	1.525
Potato control	0	17.4	0.813	0	0.813

Table 16: Stionic effect on quality attributes of pomato {tomato (T) and potato (P)}

Rootstock x scion	CCI	LYC	β-CAR	TA	AsA	RS	NRS	TSS
Potato x NS-4266(T)	45.7	4.99	4.18	0.51	30.00	1.48	2.21	3.69
Potato x K. Aman (T)	53.2	6.75	6.44	0.51	27.50	1.11	1.66	2.77
Potato x K. Adarsh (T)	50.2	6.33	5.61	0.64	27.50	2.10	3.15	5.25
Potato x K. Chayan (T)	52.1	6.96	6.49	0.64	20.00	2.28	3.42	5.70
Potato x TR-4637(T)	48.9	4.67	3.73	0.45	22.50	0.95	1.42	2.37
Ungrafted NS-4266(T)	50.2	3.73	2.99	0.58	30.00	1.69	2.54	4.23
Ungrafted K. Aman(T)	50.8	4.79	3.86	0.38	22.50	1.19	1.79	2.98
Ungrafted K. Adarsh(T)	52.3	5.18	4.20	0.51	20.00	1.86	2.78	4.64
Ungrafted K.Chayan (T)	53.6	6.43	5.92	0.70	17.50	2.60	3.90	6.51
Ungrafted TR-4637(T)	48.3	5.27	4.46	0.51	25.00	1.75	2.62	4.37
Potato x NS-4266 (P)	-	-	-	-	12.50	0.03	0.04	0.07
Potato x K. Aman (P)	-	-	-	-	10.00	0.13	0.20	0.33
Potato x K. Adarsh (P)	-	-	-	-	12.50	0.07	0.10	0.16
Potato x K. Chayan (P)	-	-	-	-	15.00	0.08	0.12	0.20
Potato x TR-4637 (P)	-	-	-	-	10.00	0.09	0.14	0.23
Potato (P) Control	-	-	-	-	15.00	0.088	0.132	0.22
Mean	**50.54**	**5.51**	**4.79**	**0.54**	**19.84**	**1.09**	**1.64**	**2.73**
SE	**0.735**	**0.316**	**0.369**	**0.029**	**1.63**	**0.21**	**0.32**	**0.53**
CD	**2.169**	**0.933**	**1.089**	**0.086**	**4.79**	**0.63**	**0.95**	**1.58**

CCI= Chlorophyll concentration index, **LYC**=Lycopene content (mg/100), **β-CAR**= β-carotene content (mg/100 g), **TA**= Titrable acidity (%), **AsA**= Ascorbic acid content (mg/100 g), **RS**= Reducing sugar (mg/100g), **NRS**= Non-reducing sugars (mg/100g), **TSS**= Total soluble sugars (°B)

Project 3.14: Weed Management in Vegetable Crops

The field experiment had following ten treatments replicated thrice in split plot design. During rabi season of 2019, one crop French Bean, was grown and harvested during February- March 2020. During summer and Kharif season,2020 okra and cowpea were grown. The growth and yield performance of rabi, summer and kharif crops are reported hereunder.

Weed management in French bean: The perusal of the data (Table 17) revealed that black polythene mulch recorded highest weed control efficiency (97.4) in French beam with minimum weed dry weight of 3.67g/m2 and highest pod yield of 127.8q/ha. Among herbicide treatments maximum weed control index (94.8) was noted in Pendimethalin @750 g a.i /ha.as pre-emergence followed by Imazethapyr @ 100g a.i. / ha as post emergence at 25 DAS(T_2) followed by Pendimethalin @750 g a.i /ha.as pre- emergence followed by Imazethapyr @70 a.i. / ha as post emergence at 25 DAS with corresponding weed dry weight of 5.14 and 7.32g and green pod yield of 108.5 and 114.2q/ha respectively.

Table 17: Effect of Different weed management treatment on weed dry weight, yield and weed control index in French bean

Treatment	Weed dry wt (g)	WCI	Green Pod yield(q/ha)	WI
Pendimethalin @ 750 g a.i / ha. (PE) + Imazethapyr @ 70g a.i. / ha at 25 DAS	7.32	94.8	114.2	13.16
Pendimethalin @ 750 g a.i / ha. (PE) + Imazethapyr @ 100 g a.i. / ha at 25 DAS	5.14	96.3	108.5	17.49
Pendimethalin @ 750 g a.i / ha. (PE) + quizalofop-p-ethyl @ 40g a.i. / ha at 25 DAS	34.3	75.5	88.4	32.78
Pendimethalin @750 g a.i. / ha. (PE)	36.2	74.2	97.5	25.86
Organic mulch	10.12	92.8	121.5	7.60
Black Polythene mulch	3.67	97.4	127.8	2.81
Two hand weeding at 25 and 40 DAS	14.12	89.9	116.5	11.41
Weed Free	0	100.0	131.5	0.00
Weedy Check	140.24	0.0	32.5	75.29
CD (P=0.05)	12.4	-	14.2	-

Weed management in Okra: During summer season seven weed management treatment were applied to okra crop and assessed in RBD design with three replications. The perusal of the data (Table 18) revealed that black polythene mulch recorded highest weed control efficiency (93.5) in Okra with minimum weed dry weight of 10.4g/m2 Among herbicide treatments maximum weed control index (85.8) was noted in Pendimethalin @750 g a.i /ha.as pre- emergence followed by one hand weeding. The highest fruit yield 94.3q/ha was recorded with organic mulch applied @ 6t/ha (T_4) followed by use of Polythene mulch (86.2q/ha). The pre-emergence application of Pendimethalin @750 g a.i /ha. followed by one hand weeding was at par to polythene mulch in terms of yield of okra.

Table 18. Effect of Different weed management treatment on weed dry weight, yield and weed control index in Okra

Treatment	Weed dry wt (g)	WCI	Green Pod yield(q/ha)	WI
Pendimethalin @ 750 g a.i / ha. (PE)	46.5	71.0	65.8	30.2
Pendimethalin @ 750 g a.i / ha (PE)+ one HW	22.8	85.8	77.4	17.9
Black Polythene mulch	10.4	93.5	86.2	8.6
Organic mulch	16.8	89.5	94.3	0.0
Two hand weeding at 25 and 40 DAS	21.1	83.7	90.3	4.2
Weed Free	0	100.0	92.5	1.9
weedy Check	160.4	0.0	22.4	76.2
CD(P=0.05)	8.3	-	11.24	-

Weed management in cowpea: During Kharif season ten weed management treatments were applied to cowpea crop and tested in split plot design with three replications. The perusal of the data (Table 19) revealed that black polythene mulch recorded highest weed control efficiency (96.3) in Cowpea with minimum weed dry weight of 6.75g/m2. Among herbicide treatments maximum weed control index (95.2) was noted in Pendimethalin @750 g a.i /ha.as pre- emergence followed by Imazethapyr @ 100g a.i. / ha as post emergence at 25 DAS (T7),. Application of combination of pre and post emergence herbicides produced sustainable cowpea pod yield in the range of 119-124q/ha

Table 19: Effect of Different weed management treatment on weed dry weight, yield and weed control index in cowpea

Treatment	Weed dry wt (g)	WCI	Green Pod yield (q/ha)	WI
Pendimethalin @ 750 g a.i / ha. (PE) + Imazethapyr @ 70g a.i. / ha at 25 DAS	12.30	93.3	110.61	24.08
Pendimethalin @ 750 g a.i / ha. (PE) + Imazethapyr @ 100 g a.i. / ha at 25 DAS	8.84	95.2	123.69	15.10
Pendimethalin @ 750 g a.i / ha. (PE) + quizalofop-p-ethyl @ 40g a.i. / ha at 25 DAS	54.19	70.7	118.46	18.69
Pendimethalin @750 g a.i / ha. (PE)	54.66	70.4	123.93	14.94
Organic mulch	17.10	90.7	134.13	7.93
Black Polythene mulch	6.75	96.3	121.16	4.97
Two hand weeding at 25 and 40 DAS	23.72	87.1	138.45	16.84
Weed Free	0.00	100.0	145.69	0.00
weedy Check	185.12	0.0	40.30	72.34
CD(P=0.05)	16.5	-	17.2	-

Project 3.15: Conservation Agriculture under Vegetable based Cropping System

***Rabi* 2019-20:** During rabi season, pea var. Kashi Nandini was grown under three tillage (zero tillage, reduced tillage and conventional tillage) and two crop residue (with residue mulch and without residue mulch) management systems. The results presented in Fig. 23 indicate that residue mulch significantly improved pod yield under all the tillage practices as compared to no mulch. Among different tillage practices, pod yield of pea was maximum (94.29 q/ha) under conventional tillage with residue mulch while it was minimum (79.85 q/ha) under zero tillage without crop residue mulch.

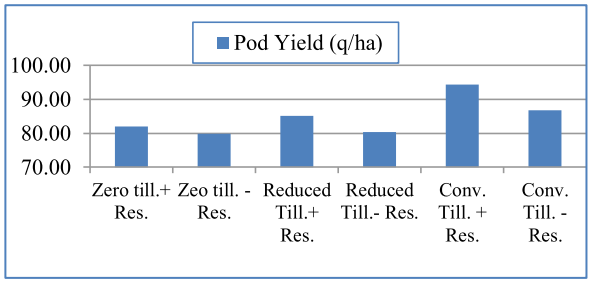


Fig. 23: Green pod yield of pea as influenced by tillage and residue management systems

***Zaid* 2020:** Okra var. Kashi Kranti was taken as test crops during zaid season. The data presented in Fig. 24 indicate that irrespective of residue management

systems, crop yield was maximum under conventional tillage as compared to reduced and zero tillage practices. Similarly, irrespective of tillage systems, the yield was higher under crop residue mulch as compared to no mulch system.

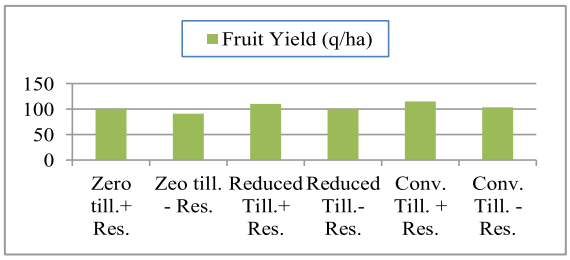


Fig. 24: Fruit yield of okra under different tillage and residue management systems

***Kharif* 2020:** During kharif season sweet corn was grown under the same treatments. The green cob yield data presented in Fig. 25 reveal that conventional tillage recorded higher cob yield as compared to other two tillage systems. However, irrespective of tillage systems, the cob yield was higher under crop residue mulch as compared to no mulch conditions.

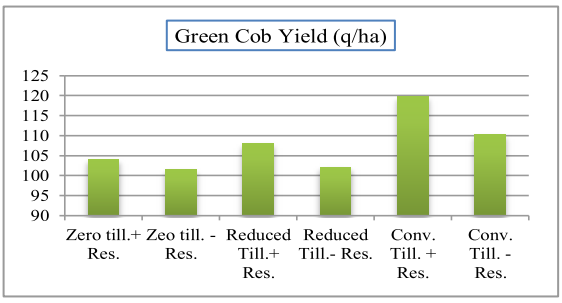


Fig. 25: Green cob yield of sweet corn under different tillage and residue management systems

Soil organic carbon: Soil analysis for organic carbon content (Fig. 26) indicate that it was maximum under zero tillage with residue mulch (0.51%) whereas the lowest content was recorded under conventional tillage without crop residue mulch.

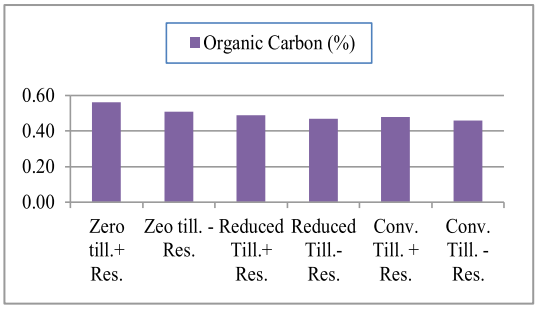


Fig. 26: Soil organic carbon under different tillage and crop residue management systems

Project 3.16: Offseason Cultivation of Vegetables under Protected Environment

1. Evaluation of Parthenocarpic cucumber during off season

A total of 10 varieties / advance lines of Parthenocarpic cucumber were sown on 9th of October, 10th November and 10th December, 2020 to evaluate the performance during off season (Dec. to Feb.). The observations on morphological and quality characters given in the table 20 clearly reflect that the plant height, average fruit weight, TSS was recorded maximum in variety Pant Parthenocarpic cucumber-3. The maximum fruit length (22.4 cm), and maximum fruit diameter (4.70 cm) was noted in variety Pant Parthenocarpic Cucumber-2. The maximum vitamin 'C' content was noted in variety Fadia and maximum Phenol content (16.1 mg GAE/100 g) in variety AC-1261. It was observed that sowing of cucumber on 10th November and 10th December does not perform well.

Table 20 : Morphological and quality parameters in off season grown cucumber.

Parthenocarpic cucumber	Vine Length (cm)	Fruit length (cm)	Fruit Diameter (cm)	Average fruit wt. (g)	TSS (^{0}Brix)	Ascorbic acid (mg/ 100g FW)	Phenol (mg GAE/100 g)
PPC-3	275.56	21.22	4.10	243.33	3.61	8.30	13.3
PPC-2	241.32	22.40	4.70	216.76	3.39	8.70	11.3
Hiltan	210.67	14.76	3.25	108.30	3.56	9.20	14.7
Fadia	215.67	11.90	4.00	108.33	3.50	9.50	12.1
King Star	225.20	18.16	4.00	233.30	3.42	8.20	13.9
Multi Star	192.75	16.26	4.50	200.33	3.40	8.10	15.7
AC-1261	265.55	18.26	3.50	210.00	3.51	8.10	16.1
Punjab Kheera-1	242.70	10.76	3.80	148.32	3.48	8.80	11.7
DDPCG-4	210.33	17.26	4.66	220.00	3.50	8.60	13.8
DDPGG-1	225.67	15.66	4.30	183.30	3.32	8.40	12.7
CD at 5%	11.12	3.25	1.20	9.35	0.52	1.16	1.45

Table 21 : Morphological parameters in off season grown tomato.

Tomato	Plant Height (cm)	No of Flower/ Bunch	No. of Fruits/ Bunch	Fruit length (cm)	Fruit Diameter (cm)	Average fruit wt. (g)
VRNTH 19083	123.5	4.10	2.44	3.23	3.15	32.75
VRNTH 19095	95.5	3.85	2.67	3.55	3.40	38.67
VRNTH 18283	112.3	3.84	2.42	2.95	2.92	30.65
VRNTH 19088	105.6	4.44	2.76	3.65	3.33	45.33
VRNTH 19089	123.5	4.30	2.56	3.10	2.85	28.35
VRNTH 19091	113.3	4.23	2.50	3.33	3.22	35.50
CD at 5%	4.25	0.22	NS	0.14	0.35	11.25

2. Evaluation of Muskmelon during off season

To judge the performance of musk melon during off season, the seeds of four varieties namely Hara Madhu, Kashi Madhu, Madhuras and Durgapur Madhu were sown on 14th July 2020. The analyzed data on morphological and quality characters given in the table below, clearly reflect that the fruit diameter and average fruit weight was recorded maximum in variety Kashi Madhu i.e. 12.6 cm and 415.5 g respectively. The fruit length (11.3 cm), and T.S.S. (11.80 brix) was noted maximum in variety Hara Madhu. The maximum plant height (235.7 cm) was noted in variety Madhuras.

Evaluation of Tomato line for offseason cultivation

Six heat tolerant lines of tomato VRNTH 19083, VRNTH 19095, VRNTH 18283, VRNTH 19088, VRNTH 19089 and VRNTH 19091 were transplanted on 10th March and 15th July, 2020 to judge the performance of tomato during off season. The analyzed data revealed that the highest number of flower per cluster, number of fruits per cluster, fruit length and average fruit weight was recorded in VRNTH 19088. The plant height was noted maximum in VRNTH 19083 where as the fruit diameter was noted in VRNTH 19095. The performance of 10th March transplanting was better than 15th July (Table 21).

MEGA PROGRAMME 4: POSTHARVEST MANAGEMENT AND VALUE ADDITION

Programme Leader: Swati Sharma

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

Cucumber is a high value vegetable crop. It is used primarily as fresh salad crop while its use as fermented product is also popular. It is sensitive to chilling injury at storage below 12°C. This work was carried out to study the effect of synergistic treatment of polyamines (SPD @ 0.5mM (T1), 1.0 mM (T2), 1.5mm (T3), SPM @ 0.5 mM (T4), 1.0 mM (T5), 1.5 mM (T6) and edible coating treatment and T7 (control) on oxidative stress, chilling injury, quality and senescence of cucumber fruit during storage. The weight loss increased continuously. At day 16, it was lower (16.3%) by ~ 1.38-fold in cucumber fruit treated with SPM @ 1.5 mM + chitosan (1%) relative to untreated fruit. The moisture content showed a continual decline during storage which manifests itself as shrinkage and loss in crispiness as edible quality indicators. The moisture content in cucumber declined continually in all treatments. It decreased from 95.2% to 88.3%, respectively in freshly harvested cucumber on initial day and untreated fruit on day 16 of storage. The chilling injury increased sharply after 8 days of storage. At the end of storage, untreated fruit showed maximum amount of pitting relative to other treatments. However, T6 had the lowest pitting and water soaked spots. It was found to be positively correlated with weight loss (r = 0.6245). The soluble solids content were found to vary in the range of 4.1- 5.3 during the storage period. MDA content and electrolyte leakage increased towards the end of storage period. The peak value of malondialdehyde content (1.27 µmol g^{-1}) was recorded in untreated fruit on day 16 of storage while it was lowest (0.58 µmol g^{-1}) in SPM + chitosan treatment (T6) at day 4 of storage. Maximum electrolyte leakage was observed in control fruit. However, no trend was observed for radical scavenging capacity in all treated and control fruit during storage (Fig. 27 & 28).

Bottle gourd fruit is known for its health benefits to prevent chronic ailments. Experiment was conducted to

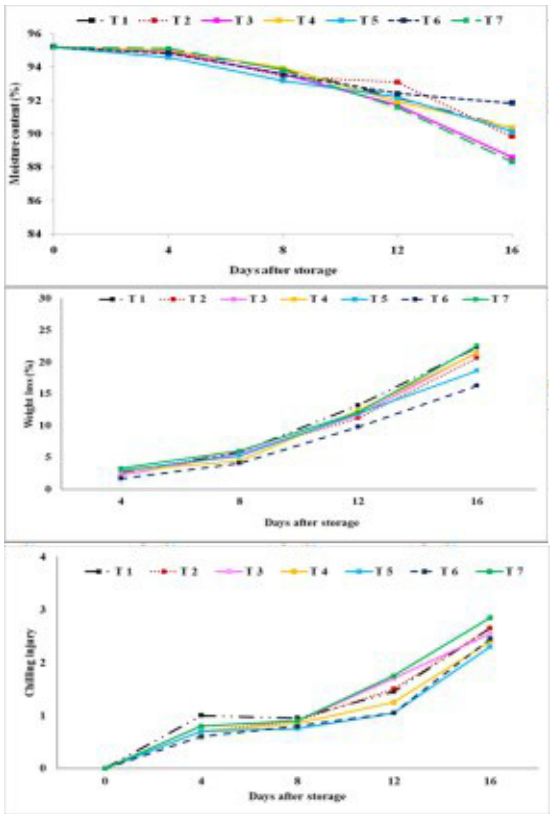


Fig. 27: Effect of polyamines and coating treatment on moisture content, physiological loss in weight and chilling injury of cucumber fruit

evaluate the effects of physical treatments on extending storability of bottle gourd fruit at low temperature storage (5°C). The bottle gourd fruits of Kashi Ganga cultivar were subjected to following postharvest treatments: shellac coating (T1), hot water treatment (T2), intermittent warming treatment (T3) and control (T4) and the change in physico-chemical quality attributes were evaluated during storage at 5°C. During the storage period, chilling injury development was assessed based on development of surface pitting, water soaked spots and surface discolouration. It was noted that all the treatments significantly inhibited and delayed the progression of chilling injury symptoms in bottle gourd fruit. The chilling injury index (1.7) in control (T4) was as high as about 6 to 8-fold over treated fruit. The electrolyte leakage was found to increase sharply in control fruit (2.1-fold) after 10th day of storage while, the lowest electrolyte leakage (42%) was recorded in the shellac coated fruit at the end of storage period (Fig. 29). The pearson correlation co-efficient between these variables was found to be 0.914. Thus, the study revealed that use of postharvest physical treatments such as intermittent warming and hot water can be an effective and low cost technology for lowering the chilling injury development during low temperature storage of bottle gourd.

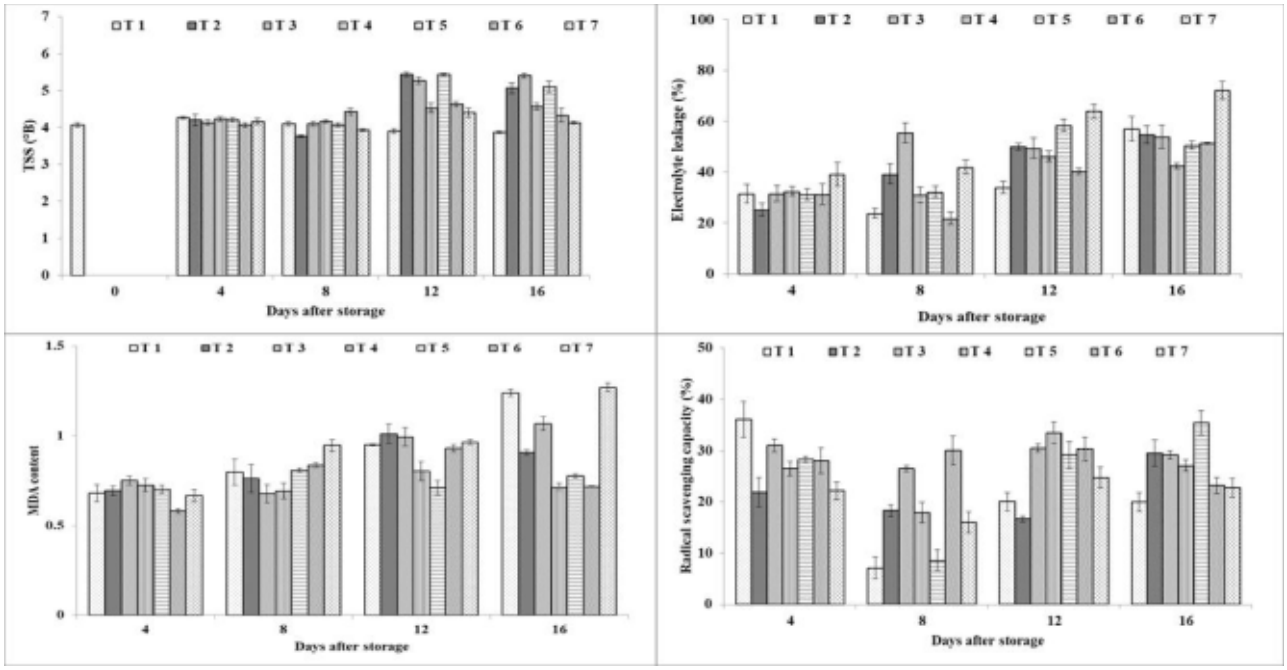


Fig. 28: Effect of polyamines and coating treatment on SSC, electrolyte leakage, malondialdehyde content and radical scavenging activity of cucumber

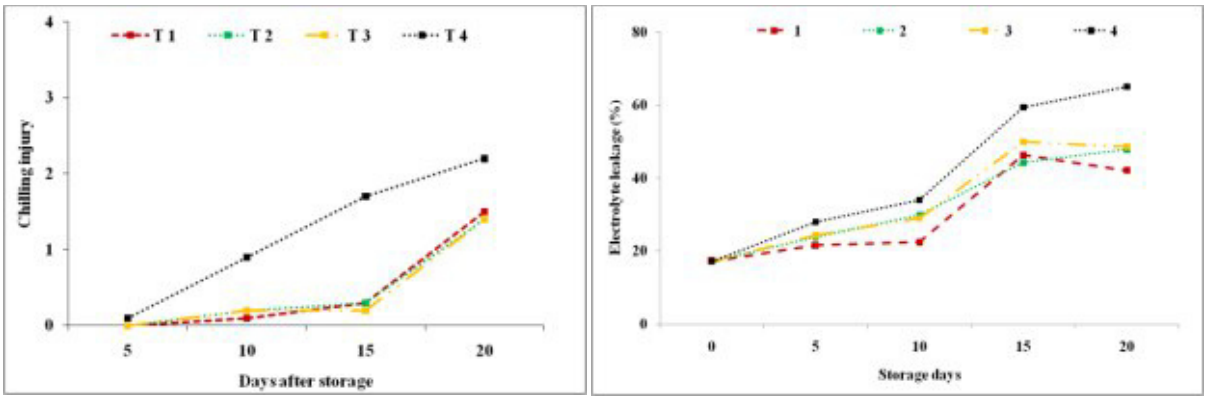


Fig. 29: Effect of shellac coating (T1), hot water (T2), intermittent warming (T3) and control (T4) treatment on chilling injury and electrolyte leakage of bottle gourd stored at 5°C.

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

Programme Leader: Neeraj Singh

Project 5.4: Empowering Rural Youth for Vegetable-Based Entrepreneurship

In the year 2019-20 more than 50 youth vegetable growers from East Champaran district, Bihar had participated in 21 days Entrepreneurship development programmee (EDP) at ICAR-IIVR, Varanasi. They were exposed to different avenues of vegetable production technologies and motivated to become entrepreneur in their respective field. Apart from technical knowhow, it is very important to assess the socio-psychological parameters for entrepreneurship development. That's why socio-psychological parameters were assessed and analyzed in before-after mode. The most important was risk taking ability. Before EDP it was 33.7% which enhanced to 56.6% after two years. Hope of success was 57.33% before EDP which increased to 71.03% after two year interval. Likewise persistence, use of feedback, self-confidence, knowledge, manageability, innovativeness and achievement motivation were assessed before and after EDP. The result is depicted in the Table 22.

Table 22: Entrepreneurial characteristics analysis of the youths of East Champaran, Bihar

Socio-psychological parameters	Before EDP (%)	After EDP (%)
Risk Taking	33.7	56.60
Hope of success	57.33	71.03
Persistence	26.63	42.05
Use of feedback	68.21	86.58
Self confidence	51.55	73.55
Knowledge	48.38	81.55
Perusable	42.53	56.08
Manageability	46.50	53.50
Innovativeness	23.50	63.50
Achievement motivation	72.80	83.55

Project 5.5: Economic Impact Assessment of IIVR Developed Technologies

Primary data from 25 Okra growing farmers were collected separately for K.Pragati, K. Kranti and for okra hybrid/local. The cost of cultivation, marketing cost, returns and BC ratio was calculated. The total cost of cultivation was highest in case of okra hybrids/local (Rs 78560 /acre) as they were of long duration up to 6 months followed by K. Kranti (Rs 66421/acre) and Kashi Pragati (Rs 61711/acre). The net returns from okra cultivation was Rs. 60160/acre for okra hybrids, Rs. 54109 per acre in case of Kashi Kranti and Rs. 13889 per acre from Kashi Pragati as this variety has been facing virus problem in the recent years. But considering both cost of cultivation and gross benefit, the benefit cost ratio was found highest for Kashi Kranti (1.81), followed by okra hybrids/local (1.77) and Kashi Pragati (1.23) (Table 23).

Table 23: Cost of cultivation (Rs. /ac) of Kashi Pragati, Kashi Kranti vis-à-vis Okra hybrid/local for the year 2019-20

Particulars	K. Pragati	K. Kranti	Okra hybrid/local
Variable costs			
Manure	600	600	900
Seeds	1600	1600	8800
Fertilizers	5672	5672	5952
Irrigation	1500	1500	1800
Plant protection chemicals	7500	7500	7500
Human labour	15850	16350	17600

Machine labour	6060	6060	6060
Interest on working capital (@8%)	3103	3143	3889
Total variable cost	41885	42425	52501
Fixed costs			
Land revenue	14	14	14
Rental value of land	12000	12000	12000
Total fixed cost	12014	12014	12014
Market commission @7%	5292	8437	9710
Transportation cost @50Rs./Q	2520	3545	4335
Total Marketing cost	7812	11982	14045
Total cost of cultivation	61711	66421	78560
Average yield (Q/ac)	50.4	70.9	86.7
Average price (Rs./Q)	1500	1700	1600
Gross returns	75600	120530	138720
Net returns	13889	54109	60160
BC Ratio	1.23	1.81	1.77

Feedback from the okra cultivating farmers were taken regarding the performance of the IIVR released okra varieties in comparison with that of the other cultivated okra varieties/hybrids in the region (Table 24). Because of the fruit size and colour, IIVR okra varieties fetched consumer preference and better price in the market than the okra hybrids. Virus problem was commonly seen during the season, but more loss in yield due to it was seen in Kashi Pragati as the variety was very old variety of 19 years released during 2002 and it has reached its saturation as the farmers told that the variety performed very well during a decade back and now in recent years Kashi Kranti an improved variety was grown by them released from IIVR during 2011 which performed good (Table 25).

Table 24. Feedback from the farmers on the features of IIVR okra varieties compared to the local/hybrids

Features	K. Pragati (2002)	K. Kranti (2011)	Okra hybrids/local
Fruit size	Small	Small	Big
Market preference	good as fruit size was small	good as fruit size was small	not prefered as big fruit size
Yield	Low yield compared to hybrid	Low yield compared to hybrid, but more than pragati	High yield
Pest & disease	Virus problem	Partial virus infestation seen in recent years	Resistant
Seed cost	Rs 400/kg	Rs 400/kg	Rs.1600-2800/kg
Fruit maturity/crop duration	Looks more matured with seeds bulged after 2-3 pickings	Early maturing	Long duration
Fruit color	Light green	Green	Dark green
Market price	Low price due to virus	Better price for small fruit size	depends on market
Crop duration	5 months	5 months	Can extend upto 6 months

Table 25: Estimated area (ha) under the selected varieties based on TL seeds & Breeder seeds sale data

IIVR developed variety	Total TL seed sale	Year	Estimated area (ha)	Total Breeder seed sale	Estimated area (ha)	Year	Total Estimated area (ha)	Area coverage/spread	
								Districts	States/ UT
Kashi Kanchan (CP-4)	625342.30	2007-08 to 2019-20	31267.20	1307.85	66962	2008-09 to 2020-21	98229	443	31
Kashi Aman	246.07	2015-16 to 2019-20	492.13	4.85	248320	2016-17 to 2020-21	248812	91	21
Kashi Pragati (VRO-6)	11165.72	2004-05 to 2019-20	930.48	1716.25	329520	2005-06 to 2021-22	330450	123	25
Kashi Nandini (VRP-5)	35184.18	2005-06 to 2019-20	219.90	5320.25	2128	2008-09 to 2021-22	2348	53	14
Kashi Uday (VRP-6)	36031.58	2005-06 to 2019-20	225.20	7999.5	3200	2008-09 to 2021-22	3425	48	15
Kashi Hans	547.50	2005-06 to 2019-20	68.40	49	156800	2008-09 to 2021-22	156868	54	12
Kashi Harit	1247.54	2005-06 to 2019-20	1247.54	23.75	342000	2013-14 to 2021-22	343248	84	18
Kashi Ganga	1406.98	2004-05 to 2019-20	351.77	57.75	92400	2012-13 to 2021-22	92752	112	23

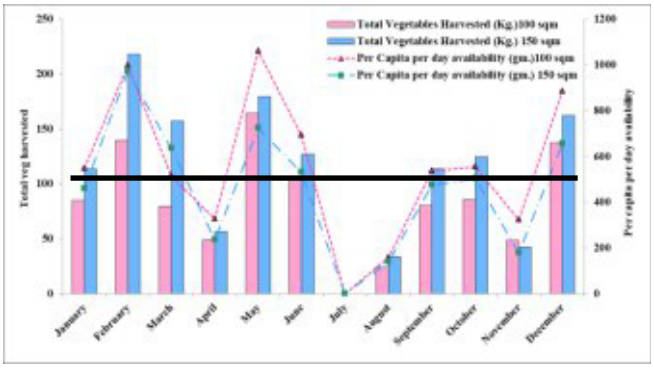
Kashi Uttam	343.55	2004-05 to 2019-20	458.09	-	-	-	458	85	22
Kashi Nidhi (CP-6)	4761.89	2012-13 to 2019-20	238.08	373	19098	2013-14 to 2021-22	19336	54	17
Kashi Anmol	1410.96	2004-05 to 2019-20	1410.96	12.3	492000	2008-09 to 2021-22	493411	106	23
Kashi Kranti	3662.69	2013-14 to 2019-20	305.23	357.5	68640	2014-15 to 2021-22	68945	70	17

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

Nutri-Garden is an important component of rural household food security, contributes to household income and savings, and moreover, improves the health and nutritional wellbeing of the family. The rural people can easily managed nutri-garden at their doorstep with virtually little economic resources, using locally available planting materials, natural

manures and indigenous methods of pest control. Any rural family can afford to make beneficial use of this nutrition garden to make a sustainable contribution to the family's livelihood. Present studies for small family size (5-8 member) have shown that home production of vegetables results in significant improvement in the vegetables availability and consumption for the whole family in general and women & children in particular. Vegetables produced in the garden are largely consumed by household members. Nutri-garden provided a number of benefits to families, ranging from improving nutrition and providing a source for additional household income to improve the status of women in the household. During 2020, trials of 02 nutri-garden module for small family size were conducted during different cropping season at IIVR research farm for an area of 100 m^2 and 150 m^2 with three replications.

Further, 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 vegetables was calculated on the basis of crop duration. Trials conducted during rabi season (2019-20) in 100 m^2 area fetched a total of 475.54 kg of vegetables with daily availability of 4.33 kg while in 150 m^2 area total vegetables fetched was 666.46 kg with daily availability of 5.53 kg. Similarly, trials conducted during zaid (2020) and kharif (2020) in 100 m^2 area fetched a total of 277.71 kg & 244.6 kg of vegetables with daily availability of 3.09 kg and 2.77 kg respectively while trial conducted in 150 m^2 area fetched total vegetables of 346.69 kg and 319.16 kg with daily availability of 3.86 kg and 3.78 kg respectively.



The study revealed that nutri-garden of 100 m^2 area is sufficient for a family size of 5 members, where, on an average one can harvest 997.85 kg of different vegetables round the year with a daily consumption of

547 gm/capita/day which is much more than the daily recommended dose of vegetable consumption by individual for balanced nutrition diet. Similarly, nutri-garden of 150 m2 is sufficient for a family size of 8 members, where, on an average one can harvest 1330.31 kg of vegetables round the year with a daily consumption of 456 gm/capita/day. Further, month wise status of vegetables availability from both size of nutri-garden showed that except in the month of July when lands are kept fallow for other agronomic practices, vegetables are available in every month. The rural families are also getting more vegetables than the recommended quantity of 350 gm/capita for daily consumption except in the month of April and November due to cropping period. These nutri-garden modules of 150 m^2 area were also demonstrated at 37 farmers' field of Dhanapur and Paniyara villages of Varanasi district and Nakkupur village in Mirzapur district where, women and children showed more interest in nutri-garden management at their door-step.

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MEGA PROGRAMME 6: INTEGRATED PLANT HEALTH MANAGEMENT

Programme Leader: Dr. K.K. Pandey

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 bottle gourd: Different pest management modules were evaluated against insect pests of bottle gourd (cv. Kashi Ganga). Among the three tested modules, module 2 (M2) *i.e.*, Integrated pest management module comprising spraying of Dichlorvos @ 0.75 ml/lit during 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var *Kurstaki* @ 2 g /lit at 40 DAS, Imidacloprid @ 0.4 ml/lit at 50 DAS, *Lecanicillium lecanii* @ 5 g/lit at 60 DAS and Azadirachtin 0.03% @ 10 ml/lit at 70 DAS was found superior in terms of reducing red pumpkin beetle (75 per cent over control), whitefly (82.57 PROC), white plume moth (79.37 PROC) and mirid bugs (64.24, 73.03 and 39.50 PROC) on leaf, fruit and twig, respectively, followed by chemical module (Table 1).

Dose optimazation and phytotoxicity of chlorantraniliprole 18.5% SC in brinjal (*Solanum melongena* Linn): Brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* (Gennadius)) causes considerable economic damage to brinjal cultivation. A field experiment was conducted to evaluate the bioefficacy, phytotoxicity of different doses of chlorantraniliprole 18.5 SC in brinjal crop. Three doses of chlorantraniliprole (20, 40, 80 g a.i. ha^{-1}) along with a conventional insecticide (cypermethrin 25% EC at 50 g a.i.ha^{-1}) and untreated control were tested. Applications of chlorantraniliprole at 40 and 80 g a.i. ha^{-1} were equally effective against BSFB and had significantly higher brinjal fruit yield. Chlorantraniliprole treated plots (at 80 g a.i. ha^{-1}) yielded the highest (456.8 q ha^{-1}) fruit yield and was statistically similar to the dose of 40 g a.i. ha^{-1} (451.3 q ha^{-1})). The maximum cost benefit ratio (1:4.30) was achieved in chlorantraniliprole at 40 g a.i. ha^{-1} treatment. Considering the economic and judicious usage, chlorantraniliprole at 40 g a.i. ha^{-1} could be recommended in controlling the shoot and fruit borer of brinjal. Population of borers was reduced by 65% as compared to untreated control after three times application of chlorantraniliprole at 40 g a.i. ha^{-1} as foliar spray at an interval of 15 days. Applications of chlorantraniliprole 18.5 SC at even highest concentrations did not show any phytotoxic symptoms. Natural enemies (predatory pentatomid bug, lady bird beetle and spider) prevailing in the brinjal ecosystem were not affected by chlorantraniliprole application (Table 2).

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

Treatments	Red pumpkin beetle (per 5 leaves /plant)			Whitefly / leaf			White plume moth / apical bud			Mirid bugs per								
										Leaf			Fruit			Twig		
	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC
M1Biointensive	2.98	1.13	57.84	3.25	0.82	67.46	2.19	0.57	69.84	4.08	1.44	52.32	3.91	1.84	48.32	15.80	9.69	16.75
M2 Integrated	3.14	0.67	75.00	3.17	0.44	82.54	2.57	0.39	79.37	3.67	1.08	64.24	3.73	0.96	73.03	14.28	7.04	39.52
M3 Chemical	3.54	0.81	69.78	2.98	0.69	72.62	2.15	0.54	71.43	3.88	1.24	58.94	4.26	1.19	66.57	15.38	8.52	26.80
Control	3.67	2.68	--	3.68	2.52	--	2.69	1.89	--	4.19	3.02	--	4.18	3.56	--	15.63	11.64	--
SEm (±)	--	0.47	--	--	0.63	--	--	0.56	--	--	0.49	--	--	0.66	--	--	0.54	--
LSD (5%)	--	1.02	--	--	1.36	--	--	1.24	--	--	1.07	--	--	1.29	--	--	1.35	--

Table 2: Effect of chlorantraniliprole 18.5 SC on brinjal shoot borer

Treatments (g a.i. ha-1)	PTC*	1st spray		2nd spray		3rd spray	
		Number	PR#	Number	PR	Number	PR
T1, Chlorantraniliprole 18.5% SC @ 20	26.45	13.69 (22.12b)	49.17	10.29 (19.18a)	58.29	10.11 (19.01b)	27.09
T2, Chlorantraniliprole 18.5% SC @ 40	28.95	10.56 (19.43a)	60.79	9.11 (18.06a)	63.07	7.98 (16.93a)	66.13
T3,Chlorantraniliprole 18.5% SC @ 80	27.26	9.47 (18.41a)	64.84	8.64 (17.59a)	64.98	7.23 (16.14a)	69.31
T4, Cypermethrin 25% EC @ 50	28.85	21.06 (27.67c)	21.80	17.26 (24.93b)	30.04	14.85 (23.07c)	36.97
T5, Control	27.06	26.93 (31.58d)	--	24.67 (30.11c)	--	23.56 (29.31d)	--
CD (5%)	--	4.15 (2.59)	--	4.15 (2.60)	--	4.24 (2.67)	--

*PTC: Pre-treatment Count.
#PR: Per cent reduction over control = (control count - treatment count/control count) x 100.
Figures in parentheses are X + 0.5 square root transformed values.
In column, means followed by common letters are not significantly different at (P ≤0.05).

Table 3: Effect of chlorantraniliprole 18.5 SC on brinjal fruit borer

Treatments (g a.i. ha-1)	PTC*	1st spray		2nd spray		3rd spray		Fruit Yield (q ha-1)
		Number	PR#	Number	PR	Number	PR	
T1, Chlorantraniliprole 18.5% SC @ 20	35.29	19.67 (26.69ab)	38.97	15.45 (23.54ab)	56.39	12.37 (21.02a)	68.89	418.5c
T2, Chlorantraniliprole 18.5% SC @ 40	33.46	17.95 (25.44a)	44.31	14.18 (22.53a)	59.98	11.25 (20.05a)	71.71	442.8d
T3,Chlorantraniliprole 18.5% SC @ 80	30.26	16.05 (24.01a)	48.81	12.95 (21.52a)	63.45	10.34 (19.22a)	73.99	449.3d
T4, Cypermethrin 25% EC @ 50	34.47	26.82 (31.51c)	16.79	21.56 (28.01c)	39.15	19.73 (26.73b)	50.38	383.7b
T5, Control	31.41	32.23 (34.90d)	--	35.43 (36.83d)	--	39.76 (39.39c)	--	341.6a
CD (at 5%)	--	3.21 (2.30)	--	4.68 (2.75)	--	6.43 (3.77)	--	4.99

*PTC: Pre-treatment Count.
#PR: Per cent reduction over control = (control count - treatment count/control count) x 100.
Figures in parentheses are X + 0.5 square root transformed values.
In column, means followed by common letters are not significantly different at (P ≤0.05).

Table 4: Economics of different treatments in brinjal

Treatments (g a.i. ha-1)	Average Yield (q ha-1)	Increase in yield over control	Per cent increase in yield over control	Cost (?) of cultivation (A)	Cost (?) plant protection inputs (Three sprays) (B)	Total cost (?) (A+B)	Total return/ income (?)	Benefit cost ratio
T1, Chlorantraniliprole 18.5% SC @ 20	422.9	73.5	21.04	202960/-	3400	204360	845800	1:4.14
T2, Chlorantraniliprole 18.5% SC @ 40	451.3	101.9	29.16	202960/-	6800	209760	902600	1:4.30
T3,Chlorantraniliprole 18.5% SC @ 80	456.8	107.4	30.74	202960/-	13600	216560	913600	1:4.22
T4, Cypermethrin 25% EC @ 50	389.8	40.4	11.56	202960/-	600	203560	779600	1:3.83
T5, Control	349.4			202960/-	--	202960	698800	1:3.44

Average labour charge Rs. 250/day; Average cost of brinjal @ Rs. 2000/Quintal; Cost of cultivation includes all the expenditures to raise the brinjal crop except plant protection measures for brinjal shoot & fruit borer, *L. orbonalis* under Varanasi, Uttar Pradesh, India; Spray volume: 500 lit of water; Cost of chlorantraniliprole 18.5 SC was Rs. 170/10 mL and Cypermethrin Rs. 800/ lit

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

Field evaluation of novel insecticides for lepidopteran insect pest management in cabbage: Diamondback moth (DBM) and cabbage butterfly (CB) were serious cabbage yield limiting factors in India. Considering insecticide resistance development in these pests, a study was conducted to find out the effective chemical molecule for managing these pests. Several novel insecticides were evaluated against DBM and CB during spring season of 2019 and 2020. Amongst the tested insecticides, spinetoram 45 and 60 g a.i. per ha recorded significantly higher larval population reduction (>80%) for both the insect pest population (Table 5 and 6). Spinetoram was found distinctly effective insecticide for the management of DBM and CB with safety to natural enemies like coccinellids and spiders and without any visual symptoms of phytotoxicity (Fig 1). Spinosad, emamectin benzoate, indoxacarb and chlorantraniliprole were the next best treatments in managing DBM and CB. No phytotoxic symptoms were observed in any treatment after spray application. Chlorpyriphos, deltamethrin, lambda-cyhalothrin and flubendiamide were found adverse to natural enemies. Thus, spinetoram, spinosad, emamectin benzoate, indoxacarb and chlorantraniliprole are recommended to manage DBM and CB on rotational basis in the cabbage ecosystem.

Fig 1: Effect of insecticidal treatment over the untreated control for managing the lepidopteran insect pests in cabbage (A= Control (sprayed with only water), B= Spinetoram (60 g a.i. per ha) treatment)

Table 5: Effect of spinetoram and label claim insecticides on larval DBM population in 2018-19 and 2019-20

Treatments	Dose (a.i. g/ha)	DBM, P. xylostella						DBM **	PROC**
		2018-19			2019-20				
		PTC	DBM *	PROC	PTC	DBM *	PROC		
Chlorpyriphos 20% EC	600	5.87	4.04 bc (2.01)	59.27	9.00	6.32 b (2.51)	57.41	5.18 bc (2.26)	58.34
Chlorantraniprole 18.5% SC	30	6.20	3.10 f (1.76)	70.42	8.93	4.39 e (2.09)	70.22	3.75 de (1.93)	70.31
Deltamethrin 2.8% EC	12.5	6.33	4.25 b (2.06)	60.34	9.27	6.39 b (2.53)	58.16	5.32 b (2.29)	59.25
Indoxacarb 14.5% SC	50	6.07	2.94 f (1.71)	71.36	9.07	4.44 e (2.11)	70.32	3.69 de (1.91)	70.84
Lambda-cyhalothrin 5% EC	11	6.53	3.73 cd (1.93)	66.29	9.20	5.43 c (2.33)	64.20	4.58 bcd (2.13)	65.25
Flubendiamide 39.35% SC	48	6.40	3.45 de (1.86)	68.17	8.87	4.82 d (2.12)	67.01	4.14 cde (2.03)	67.59
Emamectin Benzoate 5% SG	25	6.33	3.11 ef (1.76)	71.01	9.13	4.25 e (2.06)	71.78	3.68 de (1.91)	71.40
Spinosad 2.5 % SC	17.5	5.87	2.44 g (1.56)	75.46	9.47	3.84 f (1.96)	75.42	3.14 ef (1.76)	75.44
Spinetoram 1.7% SC	30	6.00	2.35 g (1.53)	76.82	9.33	3.81 f (1.95)	75.22	3.08 ef (1.74)	76.02
Spinetoram 1.7% SC	45	6.40	2.01 h (1.42)	81.44	9.40	2.98 g (1.73)	80.77	2.49 f (1.57)	81.11
Spinetoram 1.7% SC	60	6.20	1.73 h (1.31)	83.54	8.80	2.73 g (1.65)	81.21	2.23 f (1.48)	82.38
Control	-	6.40	10.83 a (3.29)	-	8.73	14.40 a (3.80)	-	12.62 a (3.54)	-
C.D.		NS	0.35	-	NS	0.33	-	1.14	-
SE(m)		0.18	0.12	-	0.17	0.11	-	0.36	-

PTC-Pre-treatment Count, PROC-percent reduction over control,* larval mean population per plant, ** pooled mean for 2018-19 and 2019-20. Data are means of three replications. Figures in parenthesis were transformed by square root transformation during analysis. Means followed by the same letter(s) are not significantly different (P = 0.05) by DMRT.

Table 6: Effect of spinetoram and label claim insecticides on larval CB population in 2018-19 and 2019-20

Treatments	Dose (a.i. g/ha)	CB, *P. brassicae*						CB **	PROC**
		2018-19			2019-20				
		PTC	CB *	PROC	PTC	CB *	PROC		
Chlorpyriphos 20% EC	600	8.80	6.08 b ((2.46)	59.38	5.73	4.25 b (2.06)	54.18	5.16 b (2.26)	56.78
Chlorantraniprole 18.5% SC	30	8.73	4.31 d (2.05)	71.71	5.00	2.53 d (1.59)	72.46	3.37 bcde (1.82)	72.08
Deltamethrin 2.8% EC	12.5	8.13	5.38 bc (2.32)	61.07	5.47	3.78 bc (1.94)	55.91	4.58 bc (2.13)	58.49

Indoxacarb 14.5% SC	50	8.07	3.91 de (1.98)	71.46	5.93	2.47 de (1.57)	70.92	3.19 bcde (1.77)	71.19
Lambda-cyhalothrin 5% EC	11	8.47	5.22 c (2.28)	63.73	5.07	3.28 c (1.81)	63.21	4.25 bcd (2.05)	63.47
Flubendiamide 39.35% SC	48	8.20	5.10 c (2.26)	63.41	6.07	3.24 c (1.80)	62.44	4.17 bcd (2.03)	62.93
Emamectin Benzoate 5% SG	25	8.53	4.03 d (2.01)	72.20	5.53	2.60 d (1.61)	71.03	3.32 bcde (1.81)	71.61
Spinosad 2.5 % SC	17.5	8.27	3.19 ef (1.79)	77.30	5.20	2.06 def (1.44)	76.30	2.63 cde (1.61)	76.80
Spinetoram 1.7% SC	30	8.00	2.96 f (1.72)	78.24	5.93	1.98 ef (1.40)	76.50	2.47 de (1.56)	77.37
Spinetoram 1.7% SC	45	8.40	2.17 g (1.47)	84.80	5.27	1.60 f (1.26)	81.91	1.89 e (1.37)	83.36
Spinetoram 1.7% SC	60	8.33	1.96 g (1.39)	86.14	5.13	1.51 f (1.23)	82.79	1.74 e 1.31)	84.47
Control	-	8.60	14.62 a (3.82)	-	5.73	9.06 a (3.01)	-	11.84 a (3.42)	-
C.D.		NS	0.74	-	NS	0.55	-	2.06	-
SE(m)		0.20	0.25	-	0.26	0.19	-	0.65	-

PTC-Pre-treatment Count, PROC-percent reduction over control,* larval mean population per plant after three sprays, ** pooled mean for 2018-19 and 2019-20. Data are means of three replications. Figures in parenthesis were transformed by square root transformation during analysis. Means followed by the same letter(s) are not significantly different (P = 0.05) DMRT

Dose standardization of chlorantraniliprole 18.5 SC and fipronil 5 SC for the management of red pumpkin beetle and pumpkin caterpillar, *Diaphania indica* of cucumber: A field experiment was conducted to standardize the doses of chlorantraniliprole 18.5 SC and fipronil 5 SC against defoliators (Red pumpkin beetle, *Aulacophora foveicollis* and pumpkin caterpillar, *Diaphania indica*) in cucumber (cv. Kashi Nutan) during the *kharif* season 2020. Among three different doses of Fipronil, the dose @ 2 ml/L was found to be most effective with 83.18% (0.63 beetles/plant) reduction in red pumpkin beetle population. Chlorantraniliprole18.5 SC @ 0.25 and 0.5 ml/L was significantly effective against *D. indica* with 94.01 and 93.19% reduction in larval population, respectively as compared to untreated control (Table 7).

Table 7: Field bio efficacy of new insecticides against major insect pests of cucumber

Treatments	Dose (ml/L)	Avg. no. of Red pumpkin beetle/plant*			Avg. no. of *D. indica* larvae/plant*			BCAs (Avg. no./plant)
		PTC	Avg.	PROC	PTC	Avg.	PROC	
Chlorantraniliprole18.5% SC	0.125	2.67	1.54b	58.63	1.93	0.17ab	91.55	2.01
Chlorantraniliprole18.5% SC	0.25	2.33	1.31b	64.88	1.67	0.12a	94.01	1.86
Chlorantraniliprole18.5% SC	0.50	2.60	1.28b	65.77	1.47	0.14a	93.19	2.01
Fipronil 5% SC	1.00	2.20	1.32b	64.73	1.53	0.34b	83.11	1.81
Fipronil 5% SC	2.00	2.20	0.63a	83.18	1.47	0.29b	85.83	1.69
Fipronil 5% SC	4.00	3.47	0.95ab	74.55	1.00	0.19ab	90.74	1.81
Cyantraniliprole10.26% OD	1.80	2.40	1.21b	67.56	1.47	0.18ab	91.01	1.83
Untreated control	-	1.47	3.73c	-	0.80	2.04c	-	2.16
SEm±			0.08				0.05	
CD (0.05)			0.25				0.15	
CV			12.83				15.52	

*Pooled data of three sprays; PROC = Percent reduction over control

Residue persistence and safety evaluation of chlorantraniliprole (18.5% SC) in okra fruits

The analytical method was validated in terms of the limit of quantitation, linearity, precision, and recovery. The fortification study was carried out by spiking the untreated fruits at 0.01, 0.05, 0.10, and 0.50 mg kg^{-1} levels to determine the recovery levels, and the average recoveries of the method (83.67–89.00 %) were satisfactory (Table 8). The precision of the method in terms of relative standard deviations (RSD) ranged from 3.53 to 7.02 %. Considering a satisfactory recovery percentage (80–120) and RSD values (below 20), the method can be considered appropriate for the estimation of chlorantraniliprole on okra fruit (SANCO 2011). The limit of quantitation (LOQ) was found to be 0.01 mg kg^{-1} and limit of detection (LOD) was 0.005 µg mL^{-1}. The Matrix effects (ME) evaluated by comparing the peak area response of the solvent standard was found less than 20%. The initial deposits of chlorantraniliprole in okra fruits were 0.69 mg Kg^{-1}, which dissipated by 9.76%

within 24 h (Table 9). On the third day, the reduction in the residue was 29.72%. Thereafter, on the seventh day the dissipation was at a faster rate (87.78%) in okra fruits, and the residue concentration was 0.08 mg kg^{-1} (Fig. 2). The reduction in the residues on tenth day was 98.37% in fruits. However, on fifteenth day samples, no residue of chlorantraniliprole was detected (BDL). Half-life period was found to be 1.72 days and waiting period was 1.10 days. The EU–MRL (maximum residue limit) of chlorantraniliprole in okra is fixed at 0.60 mg Kg^{-1} and based on this, the waiting period was calculated. Since the dissipation of chlorantraniliprole application took less time to reach the EU-MRL (0.60 mg kg^{-1}), this chemical can be used safely in okra crop for the management of insect pests.

Table 8: Fortification and recovery of chlorantraniliprole residues in okra fruits

Level of fortification (mg kg-1)	% Mean Recovery	% Relative standard deviation (RSD)
0.01	83.67	3.65
0.05	87.33	4.77
0.1	89.00	7.02
0.5	86.67	3.53

Table 9: Persistence of chlorantraniliprole 18.5% SC residues in okra fruits

Sample collection day	Residues (mg kg-1)	Dissipation %
0 (2 hrs after spraying)	0.69	
1	0.63	9.76
3	0.49	29.72
5	0.27	60.50
7	0.08	87.78
10	0.01	98.37
15	BDL	
21	BDL	

BDL: below detection level

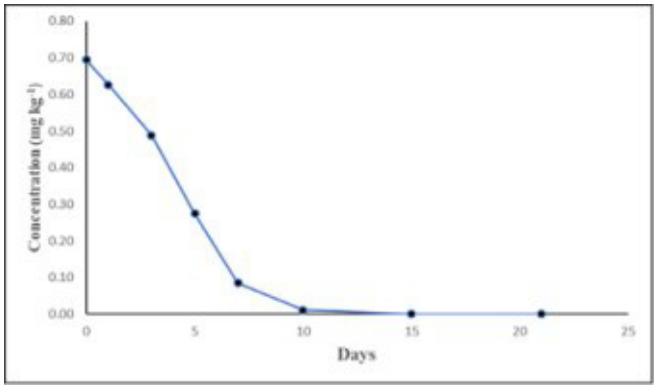


Fig. 2: Degradation pattern of chlorantraniliprole in okra fruits

Table 10: Safety evaluation of day wise residues of chlorantraniliprole in okra fruit

Sample collection day	Residues (mg kg-1)	Dietary exposure (mg person-1 day-1)
0	0.69	0.0065
1	0.63	0.0059
3	0.49	0.0046
5	0.27	0.0026
7	0.08	0.0008
10	0.01	0.0001
15	BDL	-
21	BDL	-

BDL: below detection level

Consumer risk assessment: The residues dissipated to below the default MRL of 0.6 mg kg^{-1} with a similar pattern. The acceptable daily intake (ADI) of chlorantraniliprole is 1.56 mg kg^{-1} body weight day^{-1}. Multiplying the ADI by the body weight of an average child (16 kg), the MPI of chlorantraniliprole was estimated as 24.96 mg $person^{-1}$ day^{-1}. The dietary exposures of the residues on each sampling day based on the average daily consumption of 0.0094 kg okra per day were less than the MPI of 24.96 mg $person^{-1}$ day^{-1} on all the sampling days (Table 10). Thus, chlorantraniliprole is proved to have a low risk and acute toxicity when applied for pest management in okra. The residue levels of chlorantraniliprole quantified in the okra samples were below the corresponding EU–MRL after 1.10 days of the final spraying and dietary exposures of the residues were less than the MPI on all the sampling days. Therefore, this insecticide can safely be used on okra as it does not seem to pose any problem to the health of man and environment.

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

Identification of potential insect parasitoids of major lepidopteran insect pests infesting vegetable crops

Potential hymenopteran parasitoids of major lepidopteran pests infesting different vegetable crops were collected from IIVR experimental farm. Total five larval parasitoids, one pupal parasitoid and one hyperparasitoid were identified. The larval parasitoids were identified as *Microplitis manila* Ashmead (larval endoparasitoid of *Spodoptera litura; Elasmus johnstoni* Ferrière, *Apanteles taragamae* (larval parasitoids of *Diaphania indica*); *Apanteles mamitus* Nixon, *Elasmus* spp. (larval parasitoids of *Spoladea recurvalis*). *Tetrastichus* spp. was identified as a pupal parasitoid of

Spoladea recurvalis whereas and *Mesochorus* spp. identified as hyperparasitoid of braconids and ichneumonids.

***Microplitis manila* Ashmead (Hymenoptera: Braconidae)**

***Apanteles taragamae* Viereck (Hymenoptera: Braconidae)**

***Apanteles mamitus* Nixon (Hymenoptera: Braconidae)**

***Tetrastichus* spp. (Hymenoptera: Eulophidae)**

***Mesochorus* spp. (Hymenoptera: Ichneumonidae)**

***Elasmus* spp. (Hymenoptera: Eulophidae)**

Bio-efficacy of different entomopathogens & botanicals against sucking pests of brinjal: Bio-efficacy of different entomopathogenic fungi (EPF) alone and their 1:1 combination with neem oil (0.5%) at half of their recommended doses were evaluated against brinjal jassids (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*) during *Kharif* season 2020 under field conditions. Amongst the three EPF tested, *Lecanicillium lecanii* @ 5 g/lit was found most promising against jassids and whiteflies with maximum per cent reduction over control (PROC) 40.40 and 26.94, respectively. When these EPF and neem oil were blended at half of their recommended doses were found compatible. Combination of *L. lecanii* and neem oil at 1:1 ratio treated plots showed lowest jassid (1.32) and whitefly (0.96) population per leaf and there by having maximum PROC (55.56 and 50.26, respectively). Interestingly, all the biopesticides treated plots harbored higher spiders' population per plant as compared to the Imidacloprid treated plots (Table 11).

Bio-efficacy of different entomopathogenic fungi and neem oil alone and their combinations against sucking of okra: Bio-efficacy of different entomopathogenic fungi (EPF) alone and their 1:1 combination with neem oil (0.5%) at half of their recommended doses were evaluated against brinjal jassids (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*) during *Kharif* season 2020 under field conditions. Amongst the three EPF tested *Lecanicillium lecanii* @ 5 g/lit was found most promising against jassids and whiteflies with maximum per cent reduction over control (PROC) 59.52 and 49.61, respectively. When these EPF and neem oil were blended at half of their recommended doses were found compatible. Combination of *L. lecanii* and neem oil at 1:1 ratio treated plots showed lowest jassid (1.39) and whitefly (0.60) population per leaf and there by having maximum PROC (63.73 and 53.49, respectively). Interestingly, all the biopesticides treated plots harboured higher spiders' population per plant as compared to the Imidacloprid treated plots (Table 12).

Table 11: Effect of different EPF and neem oil alone and their 1:1 combination against major sucking pests of brinjal

Treatments	Jassids/ leaf			Whiteflies/ leaf			Spiders/ plant	Beetles / plant
	Before spray	After spray	PROC	Before spray	After spray	PROC		
T1 = *Beauveria bassiana*	3.43	1.89	36.36	2.91	1.47	23.84	4.94	1.85
T2 = *Metarhizium anisopliae*	3.52	1.93	35.02	2.60	1.52	21.24	4.21	1.55
T3 = *Lecanicillium lecanii*	3.29	1.77	40.40	2.57	1.41	26.94	4.03	1.93
T4 = *B.bassiana* + Neem oil	3.55	1.47	50.51	2.72	1.11	42.49	4.21	1.71
T5 = *M. anisopliae* + Neem oil	3.29	1.62	45.46	2.91	1.27	34.20	4.85	1.81
T6 = *L. lecanii* + Neem oil	3.78	1.32	55.56	2.34	0.96	50.26	5.43	1.88
T7 = Imidacloprid	3.28	1.37	53.87	2.76	1.38	28.50	2.54	0.77
T8 = Control	3.66	2.97	--	2.89	1.93	--	5.99	2.35
SEm(±)	--	0.19	--	--	0.12	--	0.49	0.22
LSD (5%)	--	0.45	--	--	0.27	--	1.13	0.47

Table 12: Effect of different EPF and neem oil alone and their 1:1 combination against major sucking pests of okra

Treatments	Jassids/ leaf			Whiteflies/ leaf		
	Before spray	After spray	PROC	Before spray	After spray	PROC
T1 = *Beauveria bassiana*	4.11	1.91	49.34	1.54	0.86	33.33
T2 = *Metarhizium anisopliae*	3.47	1.99	47.22	1.69	0.97	24.81
T3 = *Lecanicillium lecanii*	3.84	1.68	59.52	1.51	0.65	49.61
T4 = *B. bassiana* + Neem oil	3.59	1.57	58.36	1.65	0.79	38.76
T5 = *M. anisopliae* + Neem oil	4.06	1.78	52.79	1.48	0.90	30.23
T6 = *L. lecanii* + Neem oil	3.57	1.39	63.73	1.62	0.60	53.49
T7 = Imidacloprid	3.98	1.63	56.76	1.57	0.88	31.78
T8 = Control	4.15	3.77	--	1.41	1.29	--
SEm(±)	--	0.24	--	--	0.11	--
LSD (5%)	--	0.53	--	--	0.25	--

Bionomics of *Cassida circumdata* under laboratory conditions: Biology and bionomics of tortoise beetle, *Cassida circumdata* Herbst, 1799 (Coleoptera: Chrysomelidae: Cassidinae) was studied under laboratory conditions. Nucleus culture of the test insect (tortoise beetle) was maintained in Entomology laboratory starting with the initial culture obtained from the nearby villages (Kushwah, Shahanshahpur and Kelabela). To determine the duration of the egg stage and their viability, newly emerged (up to 24 h old) tortoise beetle adult male and female (2:1 ratio) were placed on the twigs of water spinach and allowed them to lay eggs. The entire set was again put inside a cage under laboratory conditions at 28±2ºC, 70-80% relative humidity and a photoperiod of 13:11 (L:D) hour. Observations were made at regular intervals.

From the table 13 it is evident that *C. circumdata* had life cycle of 38.5 – 70.25 days. Gravid females laid eggs up to 241 eggs during her life-time with an average of 210 ± 20.02 eggs. The light green egg is covered by translucent parchment-like membrane. Egg viability ranged from 83–95 per cent. The incubation period varied from 2.5 to 6 days with an average of 4.25±1.25 days. There are five larval instars. The first, second, third, fourth and fifth instar larval period ranged from 2.75 to 3.50, 2.75 to 4, 2.50 to 3.25, 2.50 to 3.50 and 4 to 5 days, respectively. Duration of the total larval period ranged from 14.50 to 19.25 days. Late instars changed colour from green to yellowish green, becoming more yellow near pupation. Pupae were oval, flattened with prominent prothoracic shield. The pupal period ranged from 5 to 7.25 days with an average of 6.40 days ranging (table 13). The adult was a small tortoise beetle with metallic greenish yellow body. Adults were survived for 15 to 33 days with an average of 23.20±7.69 days.

Biology and bionomics of tortoise beetle, *Cassida circumdata* Herbst, 1799 (Coleoptera: Chrysomelidae: Cassidinae) was studied under laboratory conditions. Nucleus culture of the test insect (tortoise beetle) was maintained in Entomology laboratory starting with the initial

Table 13: Biological events in life-cycle of *C. circumdata* under laboratory conditions

Biological parameters	Minimum	Maximum	Mean* ± SD
Fecundity (Nos.)	197	241	210±20.02
Egg viability (%)	83	95	88±4.69
Incubation period (days)	2.5	6	4.25±1.25
Larval duration (days)			
First instar	2.75	3.50	3.05±0.23
Second instar	2.75	4.00	3.40±0.52
Third instar	2.50	3.25	3.00±0.41
Fourth instar	2.50	3.50	2.95±.037
Fifth instar	4.00	5.00	4.30±0.28
Total larval period	14.5	19.25	16.50±1.25
Pre-pupal period (days)	1.50	4.75	3.80±1.39
Pupal period (days)	5.00	7.25	6.40±1.15
Adult longevity (days)	15	33	23.20±7.69

SD= Standard Deviation
*Means are based on ten replications

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

Evaluation of different modules for management of fungal diseases of tomato

The nursery part of this experiment was reported in last year and remaining field experiment was completed in

2020 and accordingly the finding reported. Five following module interventions applied after transplanting.

T1 (Chemical module): One spray of copper oxychloride @0.3% after 30 days of transplanting DAT. Drenching of carbendazim @0.1% at root rot/wilt/collar rot incidence. One spray of mancozeb @0.25% and one spray of cymoxanil 8% + mancozeb 64% @0.2.5% on late blight appearance.

T2 (Biological module): Soil solarization on nursery beds, Nylon net 40 mesh covering of nursery beds Seed treatment by *Trichoderma* sp. (BATF-43-1) @1%. Drenching by BATF-43-1 @1% thrice at 25 days interval.

T3 (Good Agricultural Practices (GAP) module): Spot use of vermicompost @50g/plant thrice at 25 days interval. Proper fertilization by micronutrient @0.2% as foliar spray. Neem oil sprays @0.3% thrice at 10 days interval. Proper field sanitation for inoculum reduction particularly Sclerotinia, fruit rots and wilt diseases.

T4 (Integrated module): One spray of copper oxychloride @0.3% after 30 days of transplanting. One spray of mancozeb @0.2.5% at flowering to fruit setting stage. One spray of cymoxanil 8% + mancozeb 64% @0.2.5% on late blight appearance.

T5 (Research gap module): Drenching of CRB7 @1% +TRB17 @1% thrice at 25 days interval started 30 DAT. Foliar spray of BS2 @1% thrice at 25 days interval after 30 DAT. One each spray of azoxystrobin @0.05% alternated by mancozeb @0.2% at 8-day interval on early blight appearance.

T6 (Control): The significantly lowest late blight severity was 65.97% in integrated module (T4) comprising one spray of copper oxychloride @0.3% after 30 days of transplanting + one spray of mancozeb @0.2.5% at flowering to fruit setting stage + one spray of cymoxanil 8% + mancozeb 64% @0.2.5% on late blight appearance. Late blight incidence was almost same in Chemical, Biological and Good Agricultural Practices (GAP) module where PDI was significantly at par to each other 78.0-79.1%. The late blight was significantly very high (90.0%) in control in variety Kashi Aman. Similarly, the Phytophthora rotted fruits were minimum 78.7% in the same module i.e. in integrated module (T4) in comparison to control 93.2%. During cropping season 2019-20 late blight incidence was very high in this area and could not managed effectively by any of the module due to congenial weather for the disease. As far as yield is concern, the highest total yield (347.23q/ha) as well as total marketable yield (233.47 q/ha was recorded in biological module (T2) in comparison to control 244.79 & 156.53 respectively (Table-14).

Artificial screening of tomato germplasm lines/ advanced lines against Fusarium wilt: A total of 34 lines of tomato seedlings of about 50 days old were received for artificial screening. The fine root was trimmed completely along with few portions of main root and it was dipped for one hour in spore suspension of pure culture of *Fusarium oxysporum* f.sp. *lycopersici* and the old isolates FWT-67 and FWT-71 stored in sterile water was used for inoculation in autoclaved soil under pot conditions in net house. Observation was recorded after about three months of inoculation on uprooting the plants and the vascular browning vertical progress in the pith. Among all these lines few lines like VRT-02(PC), VRTH-H-5, VRTH-16-74, and 17-163 were found resistance with PDI value between 4 to 10 %

Table 14: Effect of different management modules on yield and late blight in tomato

Treatments	Late blight PDI	Marketable yield kg/plot	Unmarketable yield kg/plot	Marketable yield (q/ha)	Unmarketable yield (q/ha)	Total yield (q/ha)	Phytopthora rotted fruits % 5th harvest
T1- Chemical module	78.0	49.26	21.62	164.20	72.06	236.26	90.0
T2-Biological module	77.9	70.04	34.13	233.47	113.76	347.23	90.5
T3- GAP module	79.1	45.04	21.80	150.13	72.67	222.8	83.3
T4-Integrated module	65.9	52.92	23.87	176.40	79.57	255.97	78.7
T5-Research gap module	83.0	52.71	25.86	175.57	86.20	261.83	88.3
T6- Control	90.0	46.96	26.48	156.53	88.26	244.79	93.2
S. Em	6.67	8.82	2.82	-	-	-	-
SE(d)	9.43	12.48	3.99	-	-	-	-
CV	16.89	33.42	22.39	-	-	-	-

only. However, this screening needs further screening with optimum stage of seedling because the seedling was very old which was not desirable for artificial screening.

Rating scale and scoring for screening

Fig. 3: *F. oxysporum* f.sp. *lycopersici* inoculated seedling in moderately resistant lines

A total of 20 lines of tomato seedlings of about 24 days old were used for artificial screening. The fine root was trimmed along with few portions of main root. It was dipped for half an hour in spore suspension of pure culture of *Fusarium oxysporum* f.sp. *lycopersici* and screened by root dip method under laboratory condition during November 2020 (Fig 3). Observations was recorded subsequently at different intervals at ambient condition. Foliage yellowing and collar region stem/root browning was recorded after 4 and 7 days of inoculation on 0-5point rating scale. Among 20 advanced lines and hybrids, VRTH16-75 (15%) and Kashi Chayan (25%) were found moderately resistant. Initially VRTH-16-75 showed resistant (6.67%) and Kashi Chayan moderately resistant (13.33%) reaction at 5 ml inoculum having concentration of $1.3x10^7$ cfu/ml but repeated inoculation with 10 ml inoculum resulted increased PDI on foliage as well as stem and both lines become moderately resistant.

Potentiality and quality status of resident bioagents: Different biocontrol agents were prepared in Plant Pathology laboratory for experimental as well as limited distribution to scientists and farmers in two different batch. TCV-1 and TBG-V clearly diffused yellow pigmentation of culture media. Among seven *Trichoderma* sp. three i.e. *Trichoderma asperllum*, TCV-2, TTV-2 were most potential under *in vitro* dual culture antagonism against *Sclerotium rolfsii, Phythium apanidermatum, Fusarium oxysporum, Macrophomina phaseolina* and *Rhizoctonia solani* therefore, talc-based formulation of these potential bioagents were sent to 16 different AICRP centers for multilocation evaluations. The viable spore of fungal bioagents count was recorded in peptone dextrose rose bengal agar medium, bacterial bioagents on nutrient agar and N.1-2 on actinomyces selective medium. All the talcum based bioagents were stored at refrigerated conditions and CFU was recorded within one month of preparation. The viable spore of *Trichoderma asperllum* varied from $1.3x10^7$ to $1.9x10^8$ CFU/gram while CRB-7 count was $1.47x10^8$ to $1.0x10^9$ CFU/gram of formulation. Viable colony forming unit in fungal bioagents were in the range of minimum$1.2x10^6$ to maximum $2.6x10^8$, bacterial bioagents CFU count was in the range of $1.05x10^8$ to $1.0x10^9$ which was more than sufficient in the formulations (Table-15 & 16).

Fig. 4: Mass multiplication of talc-based *Trichoderma asperellum*

Development and evaluation of different management module/package for fungal diseases of brinjal and chilli: Eight management modules based on biological and integrated components against fungal diseases of brinjal while ten modules for chilli fungal diseases are being tested considering major prevalent diseases from nursery stage to maturity of crop. Variety Kashi Uttam of brinjal and Kashi Gaurav of chilli was used for the experimentation. Soil solarization on nursery beds, Nylon net with 40 mesh covering of nursery beds and Green manuring in main field are common for all the treatments. The *in vitro* average seed germination was 63% of Kashi Uttam while96% of Kashi Gaurav. Brinjal seed sowing was carried out on 3rd July and transplanted on 30th July while chill seed sown on 12 August and transplanted on 19 September 2020. Three spray schedules in brinjal and two in chilli has completed and remaining will continue in due course of time.

Table 15: Potential biocontrol of institute with properties and CFU

Sl. No.	Bioagents	Property	CFU/gram
1.	*Trichoderma asperellum*	Antagonist + Growth promoter	1.13 x 10^6, 1.2x10^7 1.9 x 10^8
2.	TTV-2 (*Trichoderma* sp.)	Antagonist + Growth promoter	1.6 x 10^7
3.	TCV-2 (*Trichoderma* sp.)	Antagonist + Growth promoter	1.9 x 10^7
4.	TCV-1 (*Trichoderma* sp.)	Antagonist + Growth promoter	3.3 x 10^6
5.	TBG-V (*Trichoderma* sp.)	Antagonist + Growth promoter	1.2 x 10^6
6.	BATF -43-1 (*Trichoderma* sp.)	Antagonist	2.6 x 10^8
7.	CRB-7 (*Bacillus subtilis*)	Antifungal + Anti-nematode + Growth promoter	1.0 x10^9, 1.47 x 10^8, 9.8 x1 0^8
8	BS-2 (*Bacillus subtilis*)	Antagonist + Growth promoter	1.96 x 10^9
9.	TRB-17 (*Stenotrophomonas maltophila*)	*F. oxysporum* inhibitor, Anti-nematode	1.05 x 10^8
10.	N.1-2 (Actinomyces)	Antifungal + Growth promoter	2.3 x 10^9

Table 15: Potential biocontrol of institute with properties and CFU

Bioagent isolate	Broth Inoculation	Incubation period (days)	Both quantity (ml)	Product weight (kg)	CFU/gram
T. asperellum	27.6.2020	7.7.2020 10 days	450.0ml/kg	2.0	1.13x10^6
TBG-V	27.6.2020	10.7.2020 10 days	533.3ml/kg	1.5	1.2x10^6
TCV-1	27.6.2020	13.7.2020 13 days	333.3 ml/kg	1.5	3.33x10^6
CRB-7	1.7.2020	8.7.2020 7 days	466.7 ml/kg	1.5	1.47x10^8
CRB-7	09.11.2020	21..11.2020 11 days	375ml/kg	4.0	1.8x10^9

Fig. 5: Seed and seedling status of brinjal and chilli at nursery experimentation

Emerging diseases of vegetable crops in this region

Chilli crop was severely infected by apical blight followed by dieback disease appeared in first week of September and prevalent upto first week of November in most of the varieties and hybrids grown in this region. High temperature with high humidity was congenial for the disease development. weather was to October. Pathogen was reported as *Choanephora cucurbitarum* in most of the literature. However, the cross infectivity with sporangial suspension of chilli isolate did not infect cucurbits like pumpkin and sponge gourd hence the species is specific to chilli and may be considered as *Chanephora capsici.*

The detail species level identification and confirmation to be done. Green chilli fruit rotting was observed at farmers' field. Infection initiates as wet sunken lesions on fruits which later engulfing entire green fruits and fall down after rotting. The pathogen was isolated and identified on the basis of colony characters and microscopic observations as *Colletotrichum acutatum*. The pathogen is seed borne and spreading in chilli growing area of this region.

Choanephora blight **Anthracnose** **Pure culture**

Fig. 6 : Emerging diseases of vegetable crops

Project 6.5: Bio-prospecting of Microorganisms Associated with Vegetables against Plant Pathogens

Development of talc based bioformulation of bioagents

Talc based bioformulation of *Actinomyces* sp. (IIVR-N1.2), *Bacillus subtilis* (IIVR- CRB7) and *Trichoderma*

asperellum (IIVR) were prepared. In order to increase the colony forming unit (cfu) count a re-standardized protocol was developed by mixing each kilogram of the autoclaved talcum powder with 48 hours old 1.5 l of nutrient broth culture of *Actinomyces* sp. (IIVR-N1.2) along with carboxymethyl cellulose (5 gram). The components were mixed well and left for drying at room temperature for 2 days, finally packed and kept in the cold laboratory. Colony forming unit of the Actinomyces sp. (IIVR-N1.2) was now increased from 5.30 x 10^6 cfu/g to 2.3 X 10^9 cfu/g of the talc bioformulation. Total 20 kilogram of the bioformulation was developed in our laboratory and was distributed to the different centers under AICRP trails. Pot and field experiments using formulations of *Actinomyces* sp. (IIVR-N1.2), *Bacillus subtilis* (IIVR- CRB7) and *Trichoderma asperellum* (IIVR) are under progress.

Evaluation of bioagents against nursery diseases

Talc based formulation of bioagents *Bacillus subtillis* (IIVR-BS2, 2.5×10^8 cfu/g), *B. subtillis* (IIVR-CRB7, 2.5×10^{11} cfu/g), *Trichoderma asperellum* (IIVR-strain, 2×10^7 cfu/g), IIVR-TCV-1, *Actinomyces* N 1.2 (5.30 x 10^6 cfu/g) and Jaivshakti (10×10^{12}cfu/g) were applied as seed treatment @ 4g/kg and soil application with bioagents fortified vermicompost (1:150) @ 600g/m^2 in nursery bed of tomato (Kashi Aman), brinjal (Kashi Taru), chilli (Kashi Anmol), cabbage (cvs. Golden Acre and CAB-111) and cauliflower (Pusa snowball). All treated plots were found free from incidence of damping off and bacterial blight however 100 per cent incidence of damping off was recorded on farmers untreated chilli nursery plot.

Field evaluation of *Actinomyces* sp. strain N1.2 bioformulation using brinjal and chilli crops

Nursery raised seedlings of Brinjal (Kashi Taru), and Chilli (Kashi Anamol) were transplanted using seven treatments of Actinomyces sp. strain N1.2 talc based bioformulation (5.30 x 10^6 cfu/g) applied thrice at 20 days interval after15 days of transplantation. Treatment with spot/ring application of 3 gram/plant of N1.2 bioformulation, was reported to give the best fruit yield (8.22 t/h) with 57.47% increase over the control (5.22 t/h) in brinjal. While Percentage Disease Incidence (PDI) data of white rot (*Sclerotinia sclerotiorum*) in brinjal was inconclusive (Table 17). Similarly, in chilli treatment involved root dipping of the seedlings in 10 g/l and drenching with 10 g/l of N1.2 bioformulation was reported for the highest yield (3.71 t/h) with 47.80% increase over the control (2.51 t/h) as reflected in (Table 18, Fig. 7, 8 & 9).

Table 17: Effect of Actinomyces sp. N1.2 on brinjal (Kashi Taru) against white rot disease (*Sclerotinia sclerotiorum*) and yield

Sl. No.	Treatment details	Yield (t/ha)	Percentage Disease Incidence (PDI) of *Sclerotinia* rot
T1	Root dipping of the brinjal seedlings in 10 gram/liter of Actinomyces sp. strain N1.2 talc based bioformulation	7.77	52.78
T2	Spot/ring application of 3 gram/plant of N1.2 formulation, 15 days after transplantation, thrice at 20 days interval	8.22	37.50
T3	Drenching with 10 gram/liter water solution of N1.2 formulation, 15 days after transplantation, thrice at 20 days interval	5.77	34.72
T4	Combined application of T1 and T2	6.83	41.67
T5	Combined application of T1 and T3	7.77	40.28
T6	Combined application of T2 and T3	7.73	56.94
T7	Control	5.22	38.89
	CV	0.16	0.19

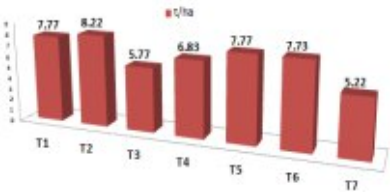


Fig. 8: Brinjal fruit yeild

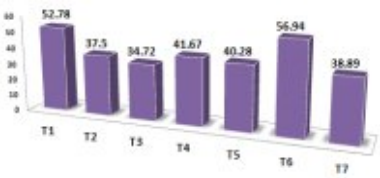


Fig. 9: White rot incidence in brinjal

Table 18: Effect of talc based bioformulation of Actinomyces sp. N1.2 on yield in Chilli (Kashi Anamol)

Treatments	Treatment details	Yield (t/ha)
T1	Root dipping of the brinja l seedlings in 10 gram/liter of Actinomyces sp. strain N1.2 talc based bioformulation	2.87
T2	Spot/ring application of 3 gram/plant of N1.2 formulation, 15 days after transplantation, thrice at 20 days interval	3.24
T3	Drenching with 10 gram/liter water solution of N1.2 formulation, 15 days after transplantation, thrice at 20 days interval	2.95
T4	Combined application of T1 and T2	2.48
T5	Combined application of T1 and T3	3.71
T6	Combined application of T2 and T3	3.12
T7	Control	2.51
	CV	0.14

Screening and scoring of brinjal germplasm against *Phomopsis* blight/fruit rot in brinjal crossing block: 91 Varieties/advanced breeding line/germplasm/hybrids and 28 varieties/hybrids of brinjal from multinational seed companies were screened and scored against phomopsis fruit rot/blight. *Phomopsis vexans* fruit blight incidence recorded 0 - 37.66% with 0% severity on brinjal germplasm/varieties (IVBR-20-81-6 and IVBR-20-B2-34) however higher *Phomopsis* incidence (56.33%) recorded on varieties obtained from Multinational Companies.

Fig. 7: Field view of brinjal crop treated with *Actinomyces* sp. N1.2.

Pathogenicity test of isolates of *P. vexans* were performed and lesion size (6.2-8.8 x 3.1-6.2 mm) were recorded under detached fruit method. Germplasm/variety viz. Ram Nagar Giant, BR-14, 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 subjected for pathogenicity test and disease reaction on detached fruit. Among tested germplasm/varieties IVBR-20, IVBHL-23 and IVBL-28 were found resistant against *Phomopsis* fruit rot (Table 19 and Fig. 10,11,12, 13 & 14).

Table 19: Pathogenicity test on detached fruit of brinjal

Germplasm/ variety	Disease reaction	Germplasm/variety	Disease reaction
Ram Nagar Giant	+	IVBL-28	+
BR-14	+	IVBHL-20	+
IVBHL-23	-	IVBHL-21	+
PR-5	+	IVBHL-22	+
Kashi Sandesh	+	IVBHR-16	+
IVBL-23	+	IVBHR-17	+
IVBR-17	+	IVBHR-18	+
IVBR-18	+	IVBHR-19	+
IVBR-19	+	Kashi Prakash	+
IVBR-20	-	Kashi Taru	+
IVBHR-19	+	Kashi Komal	+
IVBL-24	+	IVBL-28	-
IVBL-25	+	IVBHL-20	+
IVBL-26	+	IVBHL-21	+
IVBL-27	+	IVBHL-22	+

Fig. 10: Phomopsis fruit blight

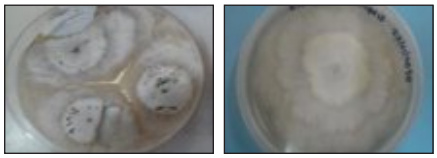


Fig. 11: PDA plate of Phomopsis vexans

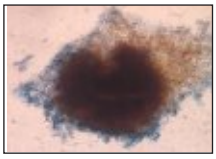


Fig. 12: Pycnidia of Phomopsis vexans

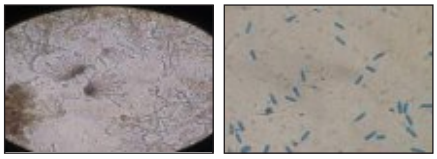


Fig 13: Conidia of Phomopsis vexans

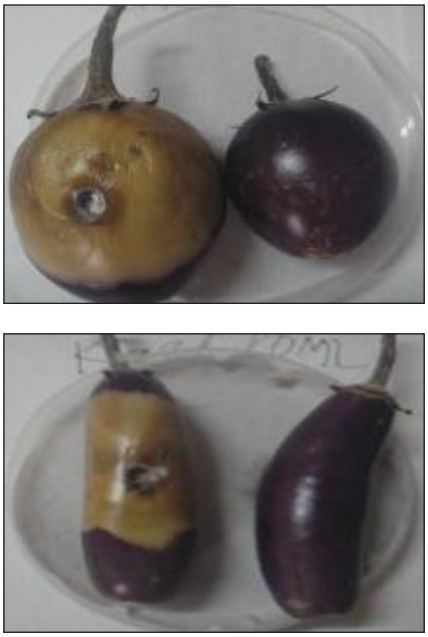
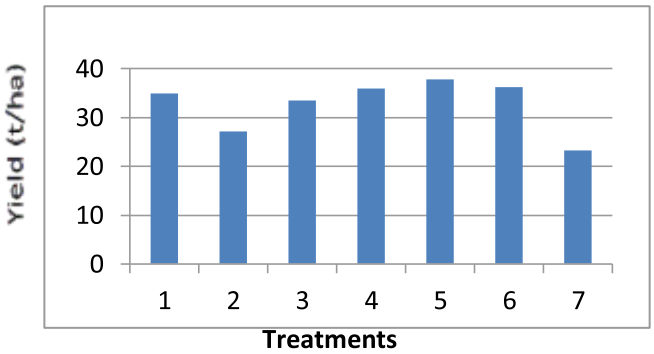


Fig 14: Pathogenicity test on detached fruit

Screening and scoring of brinjal germplasm against *Sclerotinia* blight in brinjal crossing block: 119 Varieties/advanced breeding line/germplasm/hybrids including varieties of Multinational Companies of brinjal were screened and scored against *Sclerotinia sclerotiorum* blight. *Sclerotinia* rot incidence 0 to 4.66% in brinjal germplasm/varieties were recorded. Out of which 25 Germplasm/variety viz. VBVR-20-81-6, IVBR-21-B1-7, IVBL-29-B1-16, IVBHL-20-B1-17, IVBHL-21-B1-18,IVBL-23-B2-22, IVBL-25-B2-23,IVBL-27-B2-25, IVBL-28-B2-26,IVBHR-B3-44,47,48,49,51,52, IVBHL-B3-59,62,6365,67, IVBHR-B2-36, IVBHL-B4, 81,84,86 and 87 were found free from *Sclerotinia* rot .



Recording of incidence of late blight on organic tomato production block: Among tomato organic block-1 (treatment T1- FYM @ 15t/ha , T2- FYM @ 20t/ha, T3- FYM @ 25t/ha, T4- Control@ 100% RDF); organic block-2 (treatment T1- Vermicompost @5t/ha, T2-Vermicompost @7.5t/ha, T3-Vermicompost @10t/ha, T4- Control (no manure); Organic block -3 (T1- NADEP @ 15t/ha, T2- NADEP + FYM @ 20t/ha, T3- FYM @ 25t/ha, T4- Control@ 100% RDF) and organic block -4 (T1- 50% NYFM + 50% NADEP,T2-50% NNADEP+ 50% NVC, T3- 50% NYFM + 50%NVC, T4- Control without manure)- lowest incidence of late blight (63%) in comparison to control (90%) on tomato was recorded with treatment T1-Vermicompost in organic tomato production in block –II (Table 20).

Table 20: Incidence of late blight in organic tomato blocks

Treatments	PDI (Late blight)
Organic block -1	
T1- FYM @ 15t/ha	83.33
T2- FYM @ 20t/ha	85.00
T3- FYM @ 25t/ha	83.00
T4- Control@ 100% RDF	75.00
Organic block -2	
T1- Vermicompost @5t/ha	63.00
T2-Vermicompost @7.5t/ha	63.00
T3-Vermicompost @10t/ha	63.00
T4- Control (no manure)	90.00
Organic block -3	
T1- NADEP @ 15t/ha	92.50
T2- NADEP + FYM @ 20t/ha	90.00
T3- FYM @ 25t/ha	95.00
T4- Control@ 100% RDF	100.00
Organic block -4	
T1- 50% NYFM + 50% NADEP	93.33
T2-50% NNADEP+ 50% NVC	81.66
T3- 50% NYFM + 50%NVC	71.66
T4- Control (no manure)	90.00

Project 6.6: Management of Important Bacterial Diseases of Vegetable Crops

Evaluation of different management modules against major bacterial disease of tomato and yield: Among different modules, chemical & Botanical module comprises foliar spray of I- copper oxychloride 50 WP @ 0.3%, II- azadirachtin 0.03% @ 0.3%, III- copper hydroxide 53.8 DF @ 0.2%; IV- streptocycline (9:1) @ 150 ppm applied at 20 days after transplanting, 4 Subsequent sprays done at 20 days interval which recorded highest yield (37.85 t/ha) as compare to control (23.20 t/ ha). The lowest late blight (*Phytophthora infestans)*, percent Disease Index (57.66) recorded with chemical module in tomato (Cv. Kashi Aman) however all treatments including control were found free from bacterial blight (Table 21 & Fig. 15).

Table 21: Evaluation of different management modules against disease of tomato and yield

Treatment	Yield (kg/plot size 21 sq m) (Marketable fruit)	Late blight infected fruit yield (kg/plot) size 21 sq m)	Yield (t/ha) (Marketable fruit)	PDI (Late Blight)	Bacterial blight
T1–Biological module: Spray of *B. subtilis* (BS2) talc -based formulation @ 1% (10 g/l), II spray *P. fluorescens* talc- based formulation @ 1% (10 g/l), III spray Actinomycetes N.1.2 talc - based formulation @ 1% (10 g/l), IV Spray of CRB 7 @ 1% (10 g/l);	73.42	4.09	34.96	66.00	-
T2-Botanical module: I, II, III, IV spray with Azadirachtin 0.03% @ 0.3% (3 ml/l)	57.06	3.68	27.17	67.66	-
T3- Chemical module: I spray of copper oxychloride 50 WP @ 0.3% (3 g/l); II spray streptocycline (9:1) @ 150 ppm (150 mg/l), III spray copper hydroxide 53.8 DF @ 2 g/l, IV Azoxystrobin 23 SC @ 0.1% (1 ml/l)	70.33	4.44	33.49	57.66	
T4-Chemical & Biological: I Spray of copper oxychloride 2.5 g/l; II BE – IIVR Strain (Bacterial endophyte -IIVR Strain) talc -based formulation @ 1% (10 g/l); III Spray Actinomycetes N.1.2 talc -based formulation @ 1% (10 g/l); IV S pray streptocycline (9:1) @ 150 ppm (150 mg/l),	75.49	5.13	35.94	63.00	-
T5-Chemical & Botanical: I Spray of copper oxychloride 50 WP @ 0.3% (3 g/l), II Spray with Azadirachtin 0.03% @ 0.3% (3 ml/l), III Spray copper hydroxide @ 2g/l; IV Spray streptocycline (9:1) @ 150 ppm (150 mg/l)	79.56	5.70	37.85	58.33	-
T6- IDM module I Spray of copper oxychloride 0.3% (3 g/l); II BE–IIVR strain (Bacterial endophyte -IIVR Strain) talc -based formulation @ 1% (10 g/l); III Spray of *P. fluorescens* talc-based formulati on @ 1% (10 g/l); IV Spray streptocycline (9:1) @ 100 ppm mix with Azadirachtin 0.03% @ 0.3% (3 ml/l);	76.03	4.10	36.20	58.66	-
T7-Untreated Control	48.72	6.36	23.20	71.66	-
C.D.	17.47	NS	-		
C.V.	14.14	23.04	-		

Effectiveness of bacterial bio-agents, fungicides and bactericides against bacterial diseases on cabbage and yield: Experiment was conducted using variety CAB-111 without seed treatment in randomized block design and maintaining plant to plant distance of 50cm and row to row distance 100 cm in three repklications. The highest cabbage (cv. CAB -111) yield (17.85 t/ha) recorded with chemical module- I- copper oxychloride 50 WP @ 0.3%; II-spray streptocycline (9:1) @ 150 ppm, III-copper hydroxide 53.8 DF @ 0.2%, IV-azoxystrobin 23 SC @ 0.1% applied at 20 DAT and 4 subsequent spray done after 20 days of interval from first spray however all treatments including control were found free from bacterial black rot. The lowest percent disease incidence of *Alternaria* blight on cabbage recorded with chemical module (54.66) in comparison to control (Table 22 and Fig 16).

Table 22: Effectiveness of bacterial bio-agents, fungicides and bactericides against bacterial diseases on cabbage and yield

Treatment	Yield (kg/plot size 12 sq m)	Yield (t/ha)	PDI (*Alternaria brassicae* blight)	Bacterial blight
T1–Biological module: Spray of B. subtilis (BS2) talc -based formulation @ 1% (10 g/l), II spray P. fluorescenstalc based formulation @ 1% (10 g/l), III spray Actinomycetes N.1.2 talc-based formulation @ 1% (10 g/l), IV Spray of CRB 7 @ 1% (10 g/l);	19.85	16.54	64.33	-
T2-Botanical module:I, II, III, IV spray with Azadirachtin 0.03% @ 0.3% (3 ml/l)	21.34	17.78	64.33	-
T3- Chemical module:I spray of copper oxychloride 50 WP @ 0.3% (3 g/l); II spray streptocycline (9:1) @ 150 ppm (150 mg/l), III spray copper hydroxide 53.8 DF @ 2 g/l, IV Azoxystrobin 23 SC @ 0.1% (1 ml/l)	21.43	17.85	54.66	-
T4-Chemical & Biological:I Spray of copper oxychloride 2.5 g/l; II BE – IIVR Strain (Bacterial endophyte -IIVR Strain) talc -based formulation @ 1% (10 g/l); III Spray Actinomycetes N.1.2 talc -based formulation @ 1% (10 g/l); IV Spray streptocycline (9:1) @ 150 ppm (150 mg/l),	21.36	17.80	61.00	-
T5-Chemical & Botanical: I Spray of copper oxychloride 50 WP @ 0.3% (3 g/l), II Spray with Azadirachtin 0.03% @ 0.3% (3 ml/l), III Spray copper hydroxide @ 2g/l; IV Spray streptocycline (9:1) @ 150 ppm (150 mg/l)	17.46	14.55	59.66	-
T6- IDM module I Spray of copper oxychloride 0.3% (3 g/l); II BE –IIVR strain (Bacterial endophyte -IIVR Strain) talcbased formulation @ 1% (10 g/l); III Spray of P. fluorescens talc -based formulation @ 1% (10 g/l); IV Spray streptocycline (9:1) @ 100 ppm mix with Azadirachtin 0.03% @ 0.3% (3 ml/l);	15.85	13.19	59.00	-
T7-Untreated Control	14.34	11.95	68.00	-
C.D.	NS			
C.V.	23.77			

Isolation and confirmation of bacterial diseases from different host: Bacterial blight pathogen, *Xanthomonas compestris* pv *vesictoria* (*X. euvesictoria*), bacterial wilt (*R. Solanacearum*) and *Erwinia* soft rot pathogen isolated from tomato and followed by EPPO standard for their identification (Fig. 17-20). During winter season, Bacterial wilt pathogen isolated from wilted summer squash plants on nutrient agar and pathogen identified as *Erwinia* sp. Soft rot incidence was recorded on crossing block of summer squash varieties viz. cvs. VRSS6566 (5.0%), VRSS65 (1.6%), Kashi Subhangi (3.3%) and Seven Star (20%). Morphological and cultural variability and biochemical test of EPPO standard were performed for confirmation and identification of the isolated bacterial pathogen.

Fig.17: NA plate of *Xanthomonas axenopodis* pv *euvesictotia*

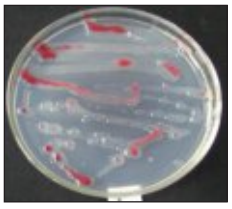


Fig.18: TZCA plate of *Ralstonia solanacearum*

Fig.19: Erwinia soft rot on summar squash

Fig.20: NA plate of Erwinia spp

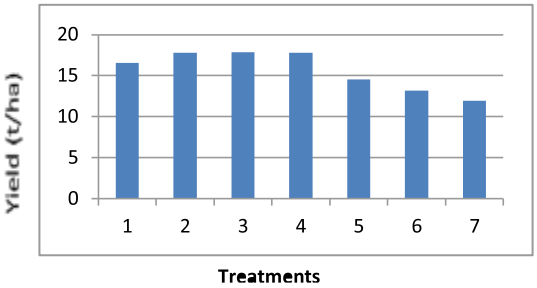


Fig. 16: Cabbage fruit yield

Evaluation of seed health and detection of seed borne pathogens in seeds of vegetable crop

Seed health status of 210 seed samples of conserved/stored seed of brinjal (94 samples), chilli (10 samples), tomato and cluster bean (4 samples each), winged bean (90 samples), dolichos bean, French bean, cowpea, pea, cabbage, bottle gourd, ash gourd, sponge gourd of vegetable crops were subjected for evaluation

of seed health under incubation and semi selective agar method. Seeds are sterilized with sodium hypochlorite (1.0%) for one minute and rinse with sterilized water. Surface sterilized seeds were plated @ 10 seeds per Petri plates and incubated at 24±2 °C for 7 days. Pure cultures of pathogens were established for further microscopic identification. Important seed borne fungal genera namely *Alternaria, Colletotrichum, Sclerotinia, Macrophomina, Phoma, Phomopsis* and bacterial genera *Pseudomonas, Xanthomonas* were recorded.

***In-vitro* evaluation of bacterial newly isolated microbes and available *Trichoderma* sp. against vegetable pathogens**

All the 13 rhizobacterial cultures isolated were screened against the pure cultures of *Alternaria solani* and *Fusarium oxysporum* f.sp *lycopersici* (*FOL*) infecting tomato in-vitro. Results showed rhizobacterial cultures were not effective in controlling the pathogen growth. Hence the rhizobacterial cultures were discarded. In addition, newly isolated Trichoderma culture was also tested for biocontrol potential against the soil borne pathogenic fungi such as *Sclerotinia sclerotiorum*, *Sclerotium rolfsii* and *Macrophomina phaseolina* Including *Fusarium* sp. by dual culture technique. The result revealed that there was a significant reduction (86.67%) in mycelium growth of *FOL* (Fig 21 and Table 23) whereas, it was not able to reduce the mycelial growth of other tested pathogenic fungi. Therefore, among these tested pathogens, Trichoderma species seemed to be effective biocontrol activity against *F. oxysporum.*

Table 23: *In vitro* screening of *Trichoderma* species against major soil borne fungus of vegetable crops

Pathogens	Mycelial growth (mm)	% reduction over control
Fusarium oxysporum f.sp lycopersici	12^{b}	86.67
Sclerotinia sclerotiorum	90^{a}	-
Sclerotium rolfsii	90^{a}	-
Macrophomina phaseolina	90^{a}	-
Control	90^{a}	-

Note: Means followed by same letters are not significantly different according to Duncan's multiple range test (DMRT) at 5% level.

Pure culture of *Alternaria solani* | Pure culture of *Fusarium oxysporum* f.sp *lycopersici* | *In vitro* dual culture assay showing Trichoderma culture reducing mycelial growth of FOL

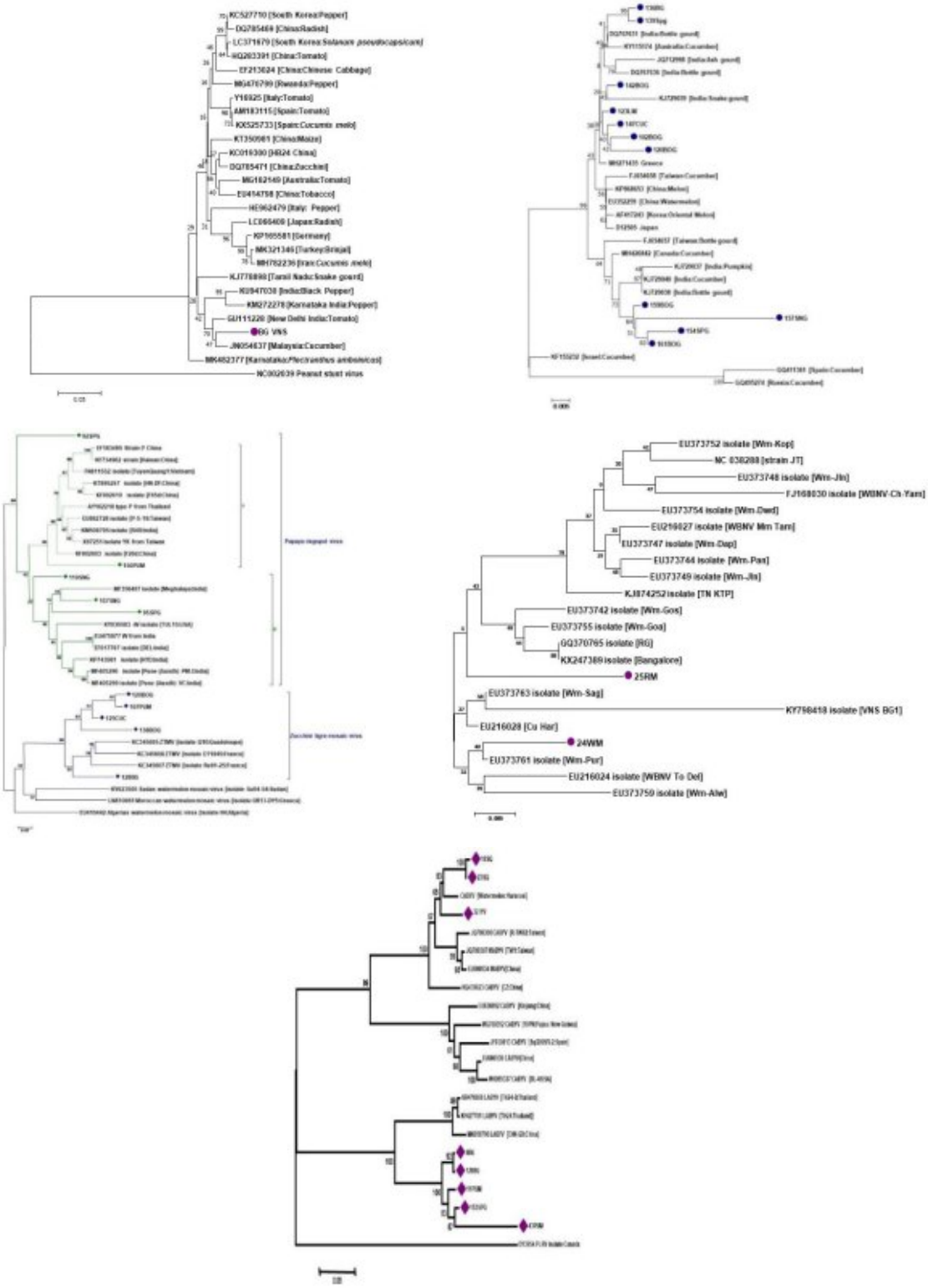
Fig. 21: Cultures used in Dual culture assay

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

Phylogenetic analysis of viruses infecting cucurbit crops: Field surveys were conducted during the cropping seasons in 2018 to detect and determine the virus prevalence in the major cucurbit-growing areas of all nine agro-climatic zones of Uttar Pradesh, India. All collected samples were tested through RT-PCR and PCR assay against 9 viruses. The result showed that presence of Cucumovirus, Potyvirus, Polerovirus Tobamovirus, Orthotospovirus and Begomovirus. In order to characterize the viruses at the nucleotide level, only representative samples were cloned and sequenced. The phylogenetic tree was constructed for the nucleotide sequences of the 5 viruses (CMV, CGMMV, Potyvirus, Tospovirus and polerovirus) using Neighbour joining tree method, bootstrapped with 1000 replication using MEGA 7.0.

Phylogenetic analysis based on the nucleotide sequence of the 2a fragment showed that a CMV isolate infecting cucurbits shared ancestry with the CMV reported on tomato, snake gourd, bottle gourd, pepper and banana from India. Similarly, sequence analysis based on the coat protein gene of the CGMMV isolates (Bottle gourd, bitter gourd, sponge gourd, snake gourd, long melon and cucumber) revealed prevalence of two distinct groups in India. The first group forms a cluster with isolates reported from China, France, Canada and India while the second group comprises only Indian isolates. In the case of PRSV and ZTMV (potyviruses), based on the NIb region, PRSV and ZTMV isolates grouped under two separate clades. Within PRSV isolates, two distinct clades were observed. One clade shared ancestry with the PRSV strains reported from different countries other than India and the second clade clustered particularly with Indian isolates. The first one comprised isolate reported from different countries including India whereas the second formed a group with non-Indian isolates. Being a new virus to India, ZTMV isolates were found to have a close relationship with France isolates.

Similar analysis of WBNV isolates infecting round melon and watermelon typically displayed the same center of origin with other Indian isolates reported earlier. Phylogenetic analysis of polerovirus sequence showed 2 distinct clades of poleroviruses, one comprising CABYV and MABYV and the other comprising LABYV.



Cloning of coat protein gene of WBNV and CABYV in expression vector for antiserum development: Complete coat protein gene of Watermelon bud necrosis virus (WBNV) and Cucurbit aphid-borne yellow virus isolates infecting round melon plants (clone MH717083) and watermelon (MN688220) respectively, have been amplified using newly designed primer pair (Table 24). The amplified product of 900 bp and 600 bp corresponding to CP region of WBNV and CABYV respectively, were then cloned into pTZ57r/T vector system (Thermo Scientific) and transformed into *E.coli* DH10β (Fig. 22). The insert was further subcloned in pET28a(+) vector (5369 bp) and transformed into *E. coli* BL21 (DE3) for expression of protein. The positive clones were identified for both WBNV and CABYV by colony PCR, subjected to restriction digestion with same enzymes for further confirmation. Expression studies are under progress.

Table 24: Detail of primers used in this study

Primer ID	Sequence (5'-3')	Added with restriction enzymes
KN WBNV F	GCTCTCTAGAATGTCTAC CGTTAAGCAACTC	BamHI
KN WBNVR	GGTGGATCCTTACAATTC CACCGAAG	XbaI
KN POL F	TACGAGCTCATGAATAC GGTCGTGGCTAG	SacI
KN POLR	ATTCTCGAGCTATTTTGG GTTCTGGACCTG	XhoI

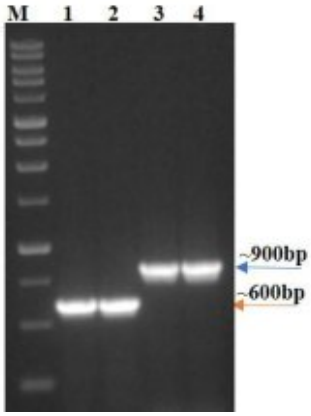


Fig. 22: RT-PCR detection of WBNV and CABYV using newly designed primer pairs

New report of virus disease: During 2020 (August-September), nearly 80% of satputia (*Luffa hermaphrodita*) plants with symptoms resembling virus infection, such as yellowing and mild downward rolling of leaves, were observed in ICAR-IIVR research farm, Varanasi (Fig 23a). To confirm the presence of polerovirus, total RNA was extracted from symptomatic plants and were subjected to reverse transcription polymerase chain reaction (RT-PCR) using universal polerovirus primer pair. Assay showed the presence of polerovirus only with the symptomatic samples. Amplicons of ~600 bp were obtained from symptomatic plants and sequenced directly (Fig 23b). Sequence analysis revealed 99% identity with luffa aphid-borne yellow mosaic virus isolates reported earlier from different part of the world. This is the first confirmed report for the infection of polerovirus in satputia from India.

During 2020, datura (*Datura innoxia*) plants manifesting symptoms of chlorotic and necrotic spots on leaves, were collected from ICAR-IIVR research farm, Varanasi (Fig 24a). Preliminary detection of tospovirus was assayed serologically through DAC-ELISA using polyclonal antibodies of *Groundnut bud necrosis virus* (GBNV). In order to identify the tospovirus species associated, samples were tested through RT-PCR assay using universal tospovirus primer pair as well as species specific primer pairs of GBNV, WBNV and CaCV spanning complete N gene. Upon testing with RT-PCR, samples were found to be positive for CaCV by yielding and expected amplicon size of 1237 bp, respectively (Fig. 24b). This is the first report for the association of CaCV with the Datura plants from India.

Fig. 23a: Yellowing and downward rolling of leaves

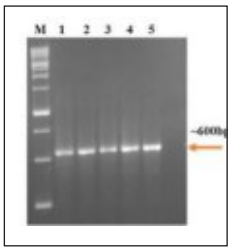


Fig. 23b: RT-PCR detection of polerovirus using universal primer

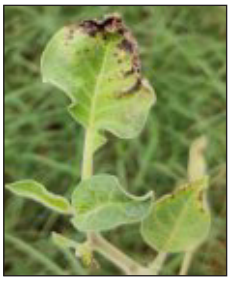


Fig. 24a: Chlorotic and necrotic spots on leaves

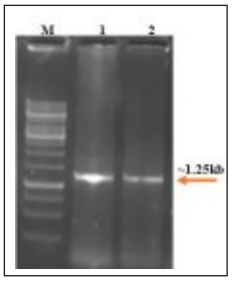


Fig. 24b: RT-PCR detection of CaCV

Management of viral diseases in tomato

During 2019, In tomato (cv. Kashi Amrit) for the management of viral diseases, five different modules were imposed with its following details:

1. Chemical module (T1): Seed treatment with imidacloprid @1ml/l, rotational spray with imidacloprid (0.3ml/l), thiomethoxam 25%WG (0.35g/l), dimethoate 30 EC (1ml/l) and lambda cyhalothrin 9.5%ZC+thiomethoxam 12.6% (0.25ml/l) at 10 days interval.

2. Chemical module 2(T2): Seed treatment with thiomethoxam Rotational spray with dimethoate 30 EC(1ml/l)), cyantraniliprole (1.8ml/l), spiromesifen (1.25ml/l) and thiomethoxam 17.5% w/w SC+ chlorantraniliprole 8.8% w/w (0.3ml/l) at 10 days interval.

3. Biological module (T3): Seed treatment with CRB-7, seedling root dip in talc based CRB-7 @ 1% for 30 minutes after 21 days after sowing; soil drenching with humic acid @ 5ml/l at 25 DAT; followed by rotational foliar spray with *Lecanicillium lecanii*, *Beauveria bassiana* and *Metarhizium anisopliae* @ 5g/l at 10 days interval; neem oil spray @ 0.3% twice at 20 days interval.

4. Integrated disease management module (T4): Seed treatment with tihiomethoxam @ 7ml/l; seedling root dip in talc based CRB-7 @ 1% for 30 minutes after 21 days after sowing; black silver mulching; border cropping with bajra; soil drenching with humic acid @ 5ml/l at 25 DAT; installation of yellow sticky traps; foliar sprays of micronutrient @ 0.3% twice at 30 days interval; rotational foliar spray of *Beauveria bassiana* (5g/l), cyantriliprole (1.8ml/l), spiromesifen (1.25ml/l), salicylic acid (2mM), thiomethoxam (0.35g/l), neem oil (0.3%), thiomethoxam + lambda cyhalothrin (0.25ml/l) and chlorantraniliprole+thiomethoxam (0.3ml/l) at 10 days interval. Among the tested modules, Integrated module (T4) was found effective in reducing tomato leaf curl disease incidence and improving yield as compared to control (Table 25 & Fig. 25). Trial is under progress for the period of 2020.

Table 25: Effect of different modules on viral disease incidence and yield in tomato

Modules	Average disease incidence	% reduction of disease over control	Yield (q/ha)
T1	28.62	14.02	243.25
T2	28.05	15.72	262.5
T3	18.56	44.25	268.25
T4	11.35	65.90	315.75
T5	33.28	-	203.5
CD (0.05)	6.49	-	54.24
CV (%)	17.39	-	13.46

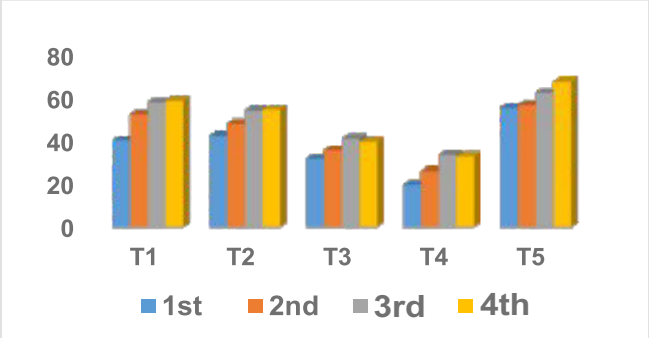


Fig. 25: Percent disease incidence of leaf curl disease on tomato over different intervals

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

Population dynamics of major insect pests of different cucurbitaceous vegetables during kharif 2019

A field study on the population dynamics of major insect pests of different cucurbitaceous vegetables was carried out during kharif, 2019 at IIVR farm, Varanasi, Uttar Pradesh, India. During the study period maximum incidence of red pumpkin beetle, *Diaphania indica* and melon weevil was observed on different cucurbit vegetable crops. The highest incidence of red pumpkin beetle was observed on bottle gourd during 46th SMW (55.53/plant/week) followed by pumpkin during 48th SMW (45.93/plant/week) (Figure 1A). The maximum incidence of *D. indica* was observed on cucumber (4.20/plant/week) and long melon (3.13/plant/week) during 43rd SMW followed by ash gourd during 44th SMW (3.07/plant/week) (Figure 1B). Sponge gourd (4.33/plant/week) and ash gourd (2.13/plant/week) recorded peak incidence of melon weevil during 48th SMW (Fig. 26).

Population dynamics and relative host preference of major insect pests on different cucurbitaceous vegetable crops during summer and kharif, 2020

A field study on the population dynamics and host preference of major insect pests of different

cucurbitaceous vegetables was carried out during summer, 2020 at IIVR farm, Varanasi, Uttar Pradesh, India. During the study period maximum incidence of red pumpkin beetle, pumpkin caterpillar (*Diaphania indica*), melon weevil, thrips, whiteflies and fruit damage by cucurbit fruit fly was observed. The highest incidence of red pumpkin beetle was observed on pumpkin during 20th SMW (9.2/plant/week). The maximum incidence of *D. indica* was observed on long melon (3.13/plant/week) during 24th SMW. Bitter gourd and sponge gourd recorded peak incidence of thrips and melon weevil during 20th SMW (9.13/3 leaves/plant) and 21st SMW (2.8/plant/week) (Table 26 & Fig. 27).

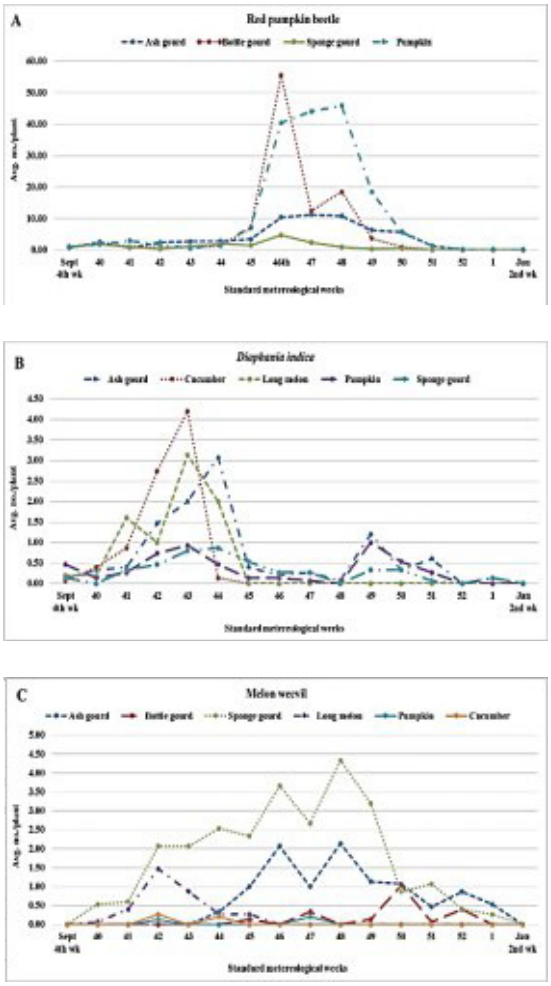


Fig. 26: Population dynamics of red pumpkin beetle (A), Pumpkin caterpillar *Diaphania indica* (B) and Melon weevil (C) on different cucurbitaceous vegetable crops during kharif 2019.

Maximum incidence of major insect pests such as red pumpkin beetle on bottle gourd (3.28) and pumpkin (5.55), *D. indica* larvae on long melon (0.67), cucumber (0.67) and ash gourd (1.63), Melon weevil on sponge gourd (1.24 in summer and 1.34 in kharif) and fruit fly damage on pumpkin (27.71 %) and bitter gourd (28.04 %) was recorded during summer and kharif season in the year 2020, respectively (Fig. 28). Furthermore, sucking pests such as thrips and whiteflies incidence was highest on bitter gourd (3.37) and sponge gourd (1.47), respectively during summer 2020, whereas maximum incidence of thrips was recorded on ash gourd (4.14) during kharif 2020 (Fig. 29). Long melon (60.01mites/3 leaves/plant) was severely infested with red mites during summer. The relative host preference of major insect pests including sucking pests on different cucurbitaceous host plants.

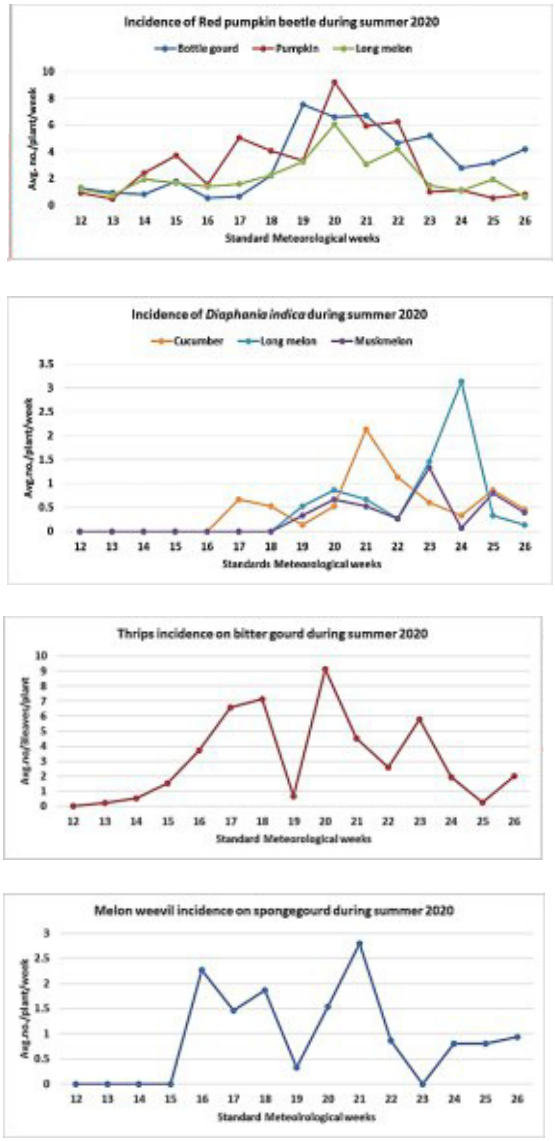


Fig 27: Population dynamics of major insect pests of cucurbitaceous vegetable crops during summer 2020.

Table 26: Preferences of all the insect pests of cucurbits

Red Pumpkin Beetle	Summer 2020	Bottle gourd > pumpkin > long melon > musk melon > cucumber and round melon
	Kharif 2020	Pumpkin > ash gourd > bottle gourd > sponge gourd > long melon > cucumber
Diaphania indica	Summer 2020	Cucumber and long melon > musk melon > bottle gourd > pumpkin
	Kharif 2020	Ash gourd > pumpkin > cucumber > bitter gourd > sponge gourd > long melon > musk melon
Melon weevil	Summer 2020	Sponge gourd
	Kharif 2020	Sponge gourd > Ash gourd
Fruit fly damage	Summer 2020	Pumpkin > cucumber and long melon > musk melon > bitter gourd
	Kharif 2020	Bitter gourd > pumpkin > sponge gourd > ash gourd > musk melon > bottle gourd
Thrips	Summer 2020	Bitter gourd > ash gourd > water melon > musk melon > round melon
	Kharif 2020	Ash gourd > bitter gourd > water melon > musk melon > round melon > cucumber
Whiteflies	Summer 2020	Sponge gourd > ash gourd and bitter gourd > water melon > round melon
	Kharif 2020	Cucumber > pumpkin > ash gourd > sponge gourd > bitter gourd > bottle gourd
Mites	Summer 2020	Long melon > Pumpkin > cucumber and round melon > ash gourd

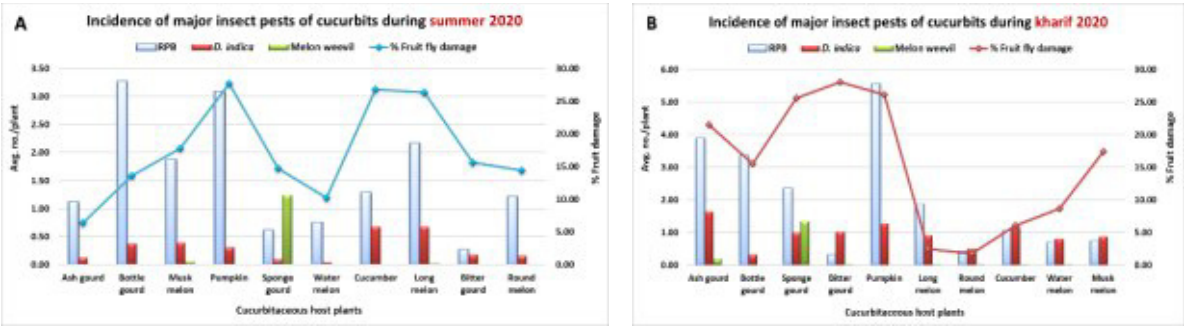


Fig. 28: Relative host preference and incidence of major insect pests on different cucurbitaceous vegetable crops during summer and kharif 2020.

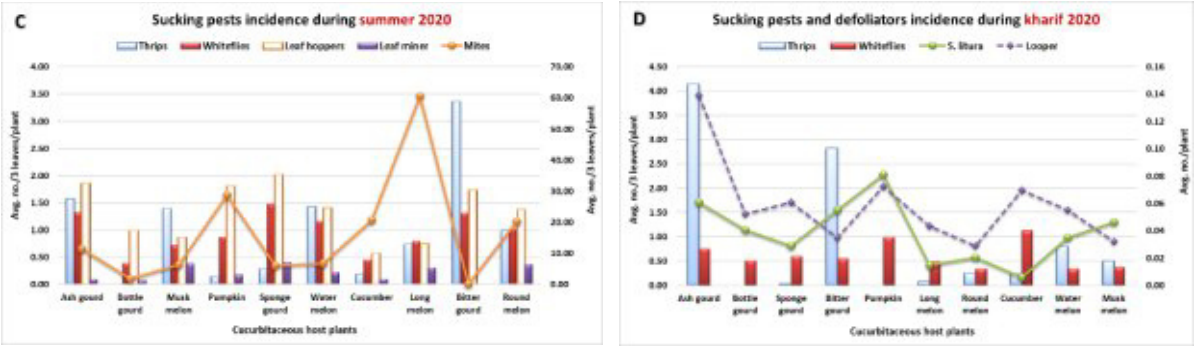


Fig. 29: Relative host preference and incidence of sucking pests and defoliators on different cucurbitaceous vegetable crops during summer and kharif 2020.

Incidence of *Leucinodes orbonalis* during the year 2020: The dynamics of brinjal shoot and fruit borer (BSFB), *L. orbonalis* in brinjal was recorded by installing sex pheromone traps. Incidence of BSFB was recorded throughout the year during 2020 at IIVR farm, Varanasi, Uttar Pradesh, India. Large fluctuation in the incidence of *L. orbonalis* population in brinjal was observed with maximum moth catches were noted from

9th SMW to 20th SMW. The first peak of moth catches (39.22 moths/trap) was recorded during 10th SMW (1st week of March, 2020). The highest moth catches in the pheromone traps were recorded during 16th SMW (59.89 moths/trap, 3rd week of April, 2020) and no or less moth activity was observed from 21st to 40th SMW (Fig. 30 & 31).

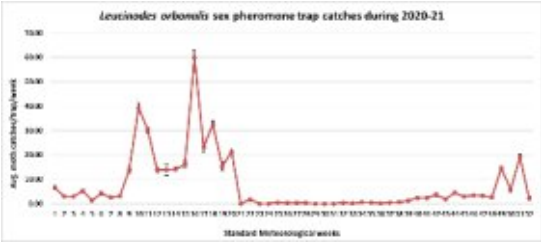


Fig 30: Dynamics of *L. orbonalis* moth population in 2020

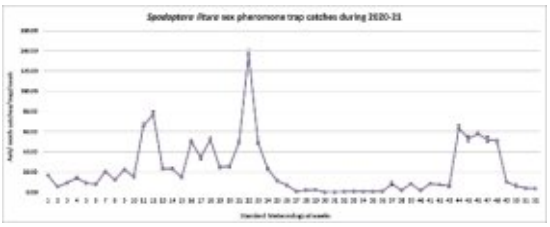


Fig 31: Dynamics of *S litura* moth population in 2020

Incidence of *Spodoptera litura* during the year 2020: Population dynamics of *S. litura* majorly infesting tomato, cabbage and cauliflower was studied by installing the sex pheromone traps. The incidence of *S. litura* was recorded throughout the year from January 2020 to December 2020 at IIVR farm, Varanasi, Uttar Pradesh, India. A considerable fluctuation in the moth catches in the pheromone trap was observed during the study period 1st to 26th SMW and 44th to 49th SMW. The first peak of moth catches (77.29 moths/trap) was recorded during 12th SMW (3rd week of March, 2020). The highest trap catches were recorded during 22nd SMW (137 moths/trap, 4th week of May, 2020) and no moth activity was observed from 27th to 36th SMW.

Feeding preference of diamond back moth, *Plutella xylostella* and *Spodoptera litura* on different Kale germplasms: Laboratory bioassay on three kale germplasms with different densities of trichomes on the leaf surface such as Kale-1 (without trichomes, WOT), Kale-9 (with trichomes, WT) and F1 hybrid (sparse/less trichomes, ST) was conducted to study the feeding preference of 3rd instar larvae of diamond back moth, *Plutella xylostella* and *Spodoptera litura*. In choice experiment, the results showed that DBM larvae preferred to feed more on young leaves of F1 hybrid (35 %, ST) and Kale-1 (34 %, WOT) as compared to the Kale-9 (31 %, WT). In case of middle/lower leaves, no difference was observed in the feeding preference of DBM larvae. Whereas, *S. litura* larvae showed more preference for feeding on young leaves of Kale-1 (48 %, WOT) and middle/lower leaves of F1 hybrid (41 %, ST) as compared to the Kale-9 (27 % and 29 %, WT) (Fig. 32). In no-choice experiment, it was observed that *P. xylostella* larvae fed more on leaves of Kale-9 (36 %, WT) germplasm irrespective of leaf types as compared to Kale-1 (WOT) and F1 hybrid (ST). Whereas, larvae of *S. litura* fed more on young and middle/lower leaves of F1 hybrid (39 % and 48 %, ST) as compared Kale-1 (27 % and 26 %, WOT) and Kale-9 (34 and 26 %, WT) germplasms, respectively (Fig. 33).

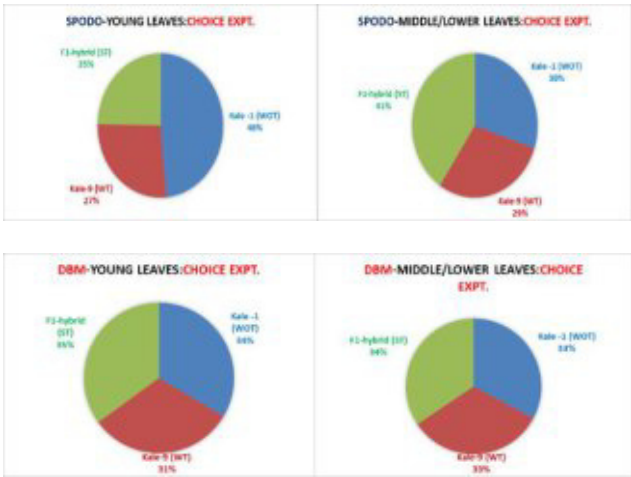


Fig. 32: *P. xylostella* and *S. litura* larval preference for leaf consumption in choice experiment

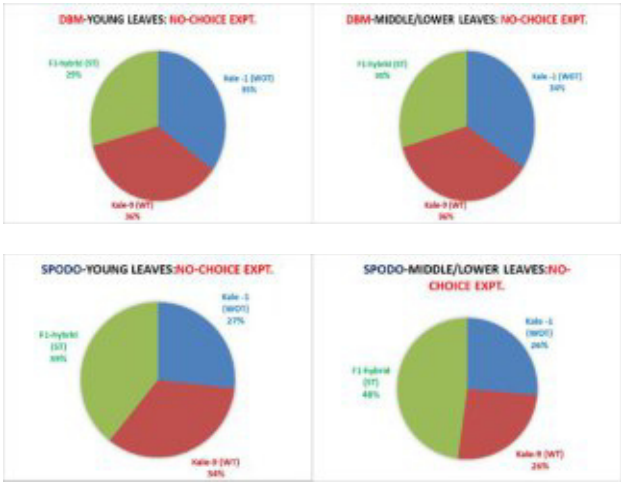


Fig. 33: *P. xylostella* and *S. litura* larval preference for leaf consumption in No-choice experiment.

Seasonal incidence of insect pests of cowpea

Seasonal incidence of various insect pests of cowpea was studied at RRS, Sargatia during Kharif 2019. The first incidence of cowpea aphid was observed in 33rd SMW and the highest incidence was observed in 40th SMW. Jassid incidence was observed in 34th SMW and its peak incidence was recorded in 36th SMW. Hadda beetle incidence was recorded in 33rd SMW and its highest incidence was recorded in 35th SMW. Cowpea pod borer incidence was observed in 35th SMW onwards till pod harvest and the peak incidence was observed at 40th SMW. Blister beetle incidence was recorded from 41st to 43rd SMW (Fig. 34).

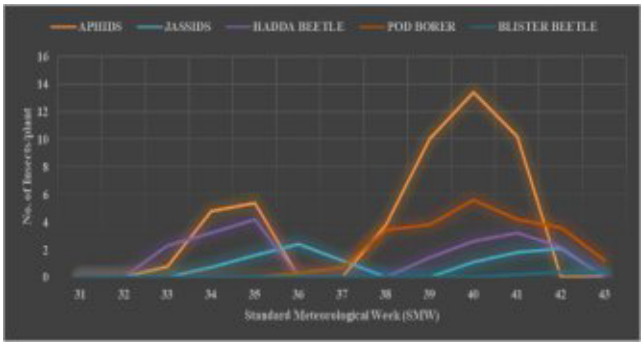


Fig. 34: Seasonal incidence of insect pests of cowpea.

Project 6.11: Mapping and Characterization of Phytoplasma Infecting Vegetable Crops and its Management

Collection of little leaf infected brinjal samples from different parts of India

Samples of brinjal showed phytoplasma suspected symptoms of little leaf, proliferated shoots, stunted growth and phyllody were collected from Rajasthan, Andhra Pradesh, Tamil Nadu, Punjab, Maharashtra and Uttar Pradesh. To confirm the presence of phytoplasma, total genomic DNA was extracted from symptomatic and asymptomatic plants by following CTAB method. Nested PCR assay was performed with phytoplasma universal primer pairs P1/P7 (Deng and Hiruki 1991) followed by nested primer pairs 3Fwd/ 3Rev (Manimekalai *et al*., 2010) targeting 16SrDNA region and yielded approximately ~1.8 and ~1.25 kb amplicons in direct and nested PCR assays, respectively (Fig. 35). However, no DNA amplification was observed with any of asymptomatic samples. Sequencing of amplicons are under progress to study the diversity of phytoplasma group associated with BLL.

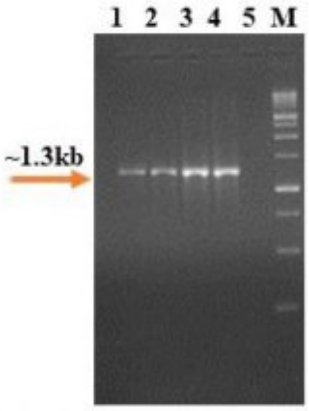


Fig 35. Nested PCR amplification of 16S rDNA region of phytoplasma using universal primer

Evaluation of entomopathogenic fungus and growth regulator on the little leaf disease of brinjal: In brinjal (cv. Kashi Taru) for the management of little leaf disease, different treatments comprising of different entomopathogenic fungi (EPF) alone and their 1:1combination with imidacloprid at half of their recommended doses were evaluated under field condition. Though there is no significant difference in yield between plots, maximum yield was observed in the combined treatments of T4 and T8 compared to growth regulator treatments and chemical treatment applied alone. Due to low incidence of disease under natural field conditions, effect of treatments on disease could not able to derive. But the treatment with bio-agents had improved the yield than chemical, control and growth regulators. Since disease incidence was too low, effect of growth regulator was not clear. Same experiment is repeated for the second year (2020-21) to observe the performance (Table 27).

Table 27: Effect of different modules on brinjal little leaf disease incidence and yield

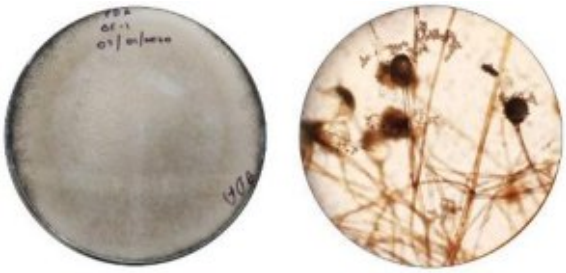
Treatments	% Disease incidence*	Total yield (q/ha)
T1 (*Lecanicillium lechanii* @5ml/l	2.85	416
T2 (*Beauveria bassiana*) @5g/l	5.59	439
T3 (*Metarhizium anisopliae*) @5ml/l	3.25	440
T4 (T1+T2+T3)	2.20	465
T5 (*Lecanicillium lechanii* + imidacloprid)	3.15	423
T6 (*Beauveria bassiana* + imidacloprid)	3.35	454
T7 (*Metarhizium anisopliae* + imidacloprid)	4.84	459

T8 (T5+T6+T7)	2.51	467
T9 (Chemical control)	5.12	405
T10 (Salicylic acid@2mM)	2.29	424
T11 (gibberellic acid @10ppm)	5.85	414
T12 (indole acetic acid@10 ppm)	3.35	405
T13 (T10+T11+T12)	2.63	415
T14 (Control)	6.34	395
C.D.	NS	NS
C.V.	26.08	9.97

Note: * Arcsine transformed values

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

Isolation of postharvest pathogen from brinjal-Rhizopus, and BF1A: Isolation of postharvest pathogens were carried out from unhealthy brinjal fruit collected from the market. Fruits were surface sterilized and small plug of rotten fruit was carefully inoculated on potato dextrose agar (PDA) medium and incubated for 3-4 days at 30±2℃ temperature. Fungal colonies were carefully picked and re-inoculated on PDA to obtain pure colonies of the fungal pathogen. One of the fungal pathogen was identified to be member of the genus *Rhizopus* based on the colony morphology. *Rhizopus* colonies grew rapidly on PDA medium and produced white cottony growth and black spores at later stage. The mycelium was observed under microscope and seen to possess numerous coenocytic aerial mycelium. Apically produced sporangium on the top of columella with small spherical, hyaline numerous sporangiospores could be seen (Fig. 36). Sporangiophores arise vertically from root like rhizoids. Based on the colony morphology and microscopic examination the pathogen was identified to be *Rhizopus stolonifer*.



a b

Fig. 36: (a) Colony morphology of *Rhizopus* on PDA medium with black spores at the periphery (b) *Rhizopus* showing sporangium with numerous sporangiospores as observed under light microscope at 10X magnification

Two pathogenic strains of brinjal were isolated viz. BF1A and BF1B with similar colony morphology of which BF1A was found to be more virulent. BF1A produced white cottony septate mycelium that later turned dark grey to black on PDA medium. No spore forming structures were formed till 12 days of incubation. Further incubation of 30 days led to production of terminal chlamydospores with acropetal succession as shown in Fig. 37.

a b

Fig. 37: (a) Colony morphology of BF1A on PDA medium (b) BF1A pathogen producing chlamydospores as observed under light microscope at 40X magnification

Pure colonies of the fungal pathogens were inoculated in surface sterilized brinjal and incubated for 3 to 4 days at 30±2℃ to confirm its pathogenicity as shown in Fig. 38. The isolated fungal pathogen culture could produce disease symptoms in the healthy surface sterilized brinjal fruit.

Fig. 38: Pathogenicity test of the isolated fungal pathogen *Rhizopus*, BF1A, and BF1B

Screening of potential biocontrol agents against fungal pathogen Rhizopus

Postharvest fungal pathogen *Rhizopus* were tested against already available potential biocontrol agents (BCA) in dual culture plate assay (Fig. 39). 12 bacterial and 7 fungal BCA of the genus *Trichoderma* were tested against *Rhizopus*.

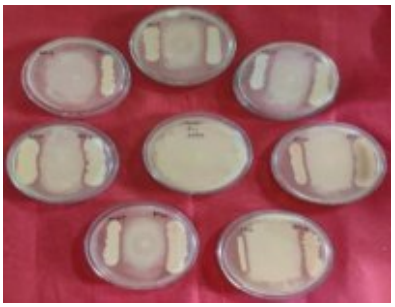


Fig. 39: Anti-microbial property of bacterial BCA against *Rhizopus* in dual culture

Fungal biocontrol agents of the genus *Trichoderma* were found to be more effective against the fungal pathogen *Rhizopus*. Tasp1 was most effective and could inhibit mycelial growth of *Rhizopus* by 98.50% followed by TCV2 (87.51%) and TTV2 (83.51%). Whereas BATF was least effective with percent mycelial inhibition of 44.03%. Bacterial isolates could cause significant reduction from 73.33 to 81.11% in the mycelial growth. Isolate AB16 and AD28 performed better against *Rhizopus* as compared to other bacterial BCA with percent mycelial inhibition of 81.11% and 79.63%, respectively (Fig. 40).

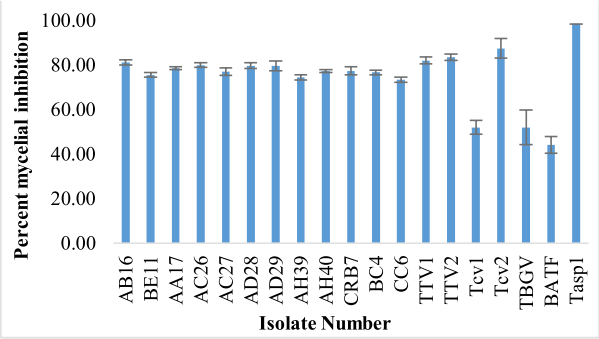


Fig. 40: Efficacy of bacterial and fungal BCA against postharvest pathogen *Rhizopus* in dual culture plate assay

Screening of *Trichoderma* against major plant pathogens: *Trichoderma* are well known for their biocontrol properties. Six *Trichoderma* isolates were tested against five major pathogen of vegetable crops (Fig. 41). Isolate TCV2 was found to be the most effective against all the fungus pathogen with percent mycelial inhibition of 59.30, 76.38, 73.75, 45.03, and 40.00% in *Macrophomina, Pythium, Sclerotium rolfsii, Rhizoctonia solani,* and *Fusarium* (Table 28). The *Trichoderma* based biocontrol agent (BCA) could successfully suppress formation of sclerotia called resting structures in *Sclerotium rolfsii* even after 20 days of incubation.

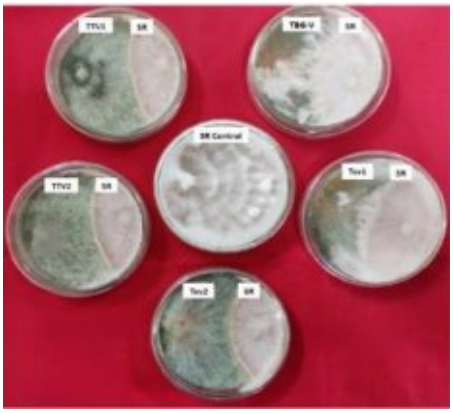


Fig. 41: Antagonistic property of *Trichoderma* against *Sclerotium rolfsii* in dual culture plate assay

The other isolates were not as effective as TCV2 but still could cause significant reduction in the growth of the fungal mycelium. The biocontrol agents were more effective against the *Pythium* and *Sclerotium rolfsii* as compared to the other plant pathogens as it showed significantly higher mycelial inhibition in dual culture plate assay. *Trichoderma* isolate TCV2 can be tested against these plant pathogens under the field condition for effective disease management.

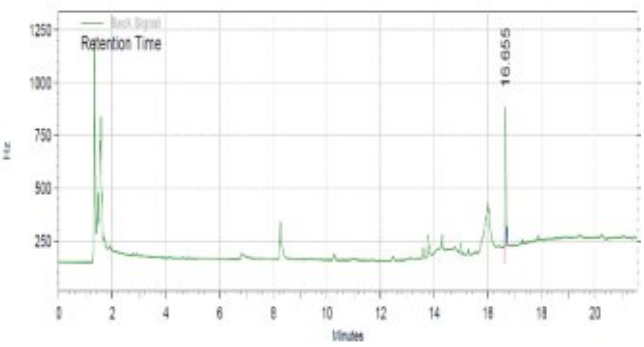
Table 28: Percent mycelial inhibition by *Trichoderma* based biocontrol agents against major plant pathogens

Biocontrol Agent	Percent mycelial inhibition				
	Macrophomina	*Pythium*	*Sclerotium rolfsii*	*Rhizoctonia solani*	*Fusarium*
TTV1	41.05±7.29	66.93±1.57	72.50±2.50	40.94±6.16	16.00±6.93
TTV2	53.68±4.21	75.33±6.36	71.25±1.25	36.84±1.75	40.00±0
TCV1	48.77±1.22	55.91±3.15	54.17±3.61	26.32±3.51	32.00±10.58
TCV2	59.30±2.43	76.38±2.73	73.75±2.17	45.03±2.68	40.00±0
TBGV	55.79±5.57	62.73±5.53	58.33±3.61	34.50±4.42	38.67±6.11
BATF43-1	50.88±6.08	65.35±0	67.08±4.02	41.52±5.06	32.00±4.00
CD (5%)	8.78	6.91	5.37	7.47	10.61

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

A simple method for the estimation of chlorantraniliprole by GC-µECD, ^{63}Ni

Chlorantraniliprole, a new systemic insecticide of anthranilic diamide class gaining popularity among farmers for its effective control of Lepidoptera pest particularly in vegetables. Thus, monitoring of chlorantraniliprole leftover in vegetables is required and to this end eco-friendly, cost effective, selective and accurate method was developed and validated for quantification of its left over in vegetable. Gas chromatography equipped with an autosampler and microelectron capture detector (µECD, ^{63}Ni) were used for the detection of chlorantraniliprole. 1 µL of samples extract/ standatd was injected in GC–µECD in split injection mode with split ratio of 10:1 to detect and quantify the residues. A HP-5 capillary column (30 m length, 320 µm id, 0.25 µm film thickness with nitrogen gas flowing at 2 mL/min) was used for separation. The detector was maintained at 300ºC with makeup gas (N_2) flowing at 45 mL/min. The oven temperature was set to 150ºC for 4 min, ramped to 190ºC at 10ºC /min, and held for 4 min, ramped to 290ºC at 18ºC /min, and held for 4 min. Chlorantraniliprole appeared at retention time (RT) of 16.655 min (Fig. 42). The total run time was around 21.56 min.



Retention time (min)

Fig. 42: Chromatogram for Chlorantraniliprole

The residues were estimated by comparing the peak area of the standards with that of the unknown or spiked sample, run under identical experimental conditions.

Residue dissipation of chlorantraniliprole (18.50% SC) in brinjal fruits

After the last spray the initial (2 h after application) residues were found to be 0.03, 0.25 and 0.33 mgkg^{-1} for half of the recommended dose (RD half), recommended dose (RD) and double of the recommended dose (DD) respectively (Table 29). The degraded was faster up to 5 days after application (DAA) in all the doses and on 10 DDA residues became below detectable limit (BDL) in RD half and RD. The decline of pesticide residues due to primarily to plant growth dilution and fruits maturity between application and sampling time, as well as volatilization that occurs during the first days of following pesticide application, removal by weathering, heat decomposition, microbial degradation, plant enzyme, sunlight etc. The dissipation behaviour was initially faster and slow down over time. This indicated an exponential pattern of degradation and implied that it follows simple first-order kinetics that is adequate to explain the dissipation behaviour of the residues with R^2 value of 0.986, 0.990 and 0.909 for RD half, RD and DD respectively. The Regression equation equations are $y = 0.0277e^{-0.381x}$, $y = 0.248e^{-0.494x}$ and $y = 0.2214e^{-0.249x}$ for RD half, RD and DD respectively. The half-lives of chlorantraniliprole residue in brinjal fruits were estimated 1.82 days, 1.40 days and 2.78 for RD half, RD and DD respectively. Thus, the present study can assess the residue dynamics of chlorantraniliprole in brijal fruits with a holistic approach and the half-life values will help manage the residue of in brinjal ecosystem.

Table 29: Percentage reduction of chlorantraniliprole residue on a different day of sampling of brinjal fruits

Days after spray	Half of the recommended dose (RD half)		Recommended dose (RD)		Double the recommended dose (DD)	
	Residues (mg kg-1)	% decrease in residue	Residues (mg kg-1)	% decrease in residue	Residues (mg kg-1)	% decrease in residue
0	0.03	0.00	0.25	0.00	0.33	0.00
1	0.02	31.72	0.16	36.85	0.26	20.75
3	0.01	71.33	0.06	75.99	0.18	45.73
5	0.00	100.00	0.02	93.38	0.09	71.54
7	0.00	100.00	0.01	96.43	0.03	90.34
10	0.00	100.00	0.00	100.00	0.02	95.22
15	0.00	100.00	0.00	100.00	0.01	97.55

Externally Funded Projects

Project 1: National Innovations in Climate Resilient Agriculture (NICRA)

Development of F_1s for high temperature stress tolerance

48 new F_1s developed during rabi 2019–20 were transplanted in the field in Feb, 2020 (Fig. 1) along with private sector hybrids as check for evaluation of high temperature tolerance during summer 2020 (Mar–June, 2020). Out of 48 hybrids tested, 19 hybrids *viz*. VRNTH-20131, VRNTH-20122, VRNTH-20149, VRNTH-20133, VRNTH-20121, VRNTH-20148, VRNTH-20145, VRNTH-20145, VRNTH-20112, VRNTH-20143, VRNTH-20126, VRNTH-20146, VRNTH-20132, VRNTH-20114, VRNTH-20105, VRNTH-20109, VRNTH-20142, VRNTH-20117 and VRNTH-20120 were found superior over all the checks for their yield and fruit quality traits.

Earlier identified high temperature tolerance F_1s, developed during 2018–19 were evaluated in the field in Feb, 2020 along with private sector hybrids as check for high temperature tolerance. Among them, six hybrids *viz*. VRNTH 19095, VRNTH 19067, VRNTH 19091, VRNTH 19083, VRNTH 19088 and VRNTH 19089 were found superior over all the checks for their yield and fruit quality traits.

Development of F_1s tolerant to moisture deficit condition

Five earlier identified moisture deficit tolerant F_1s *viz.,* VRNTH-18-1, VRNTH-18-2, VRNTH-18-3, VRNTH-18-4 and VRNTH-18-5 along with 4 popular private sector hybrids as a check were evaluated for moisture deficit tolerance during October, 2019- February 2020 in field trial under moisture deficit condition as well as a control (without stress). Observations on yield and fruit quality traits were recorded. Analysis of data revealed that VRNTH-18-1 and VRNTH-18-2 were superior over popular private sector hybrids in the terms of yielding ability under both the conditions (control and moisture deficit).

Fig. 1: Tomato trial field during summer 2020

Evaluation and validation of exogenous application of salicylic acid and sodium nitro-prusside in mitigation of moisture-deficit condition

Five moisture deficit tolerant F_1s *viz.,* VRNTH-18-1, VRNTH-18-2, VRNTH-18-3, VRNTH-18-4 and VRNTH-18-5 along with three private sector hybrids were exposed to drought stress conditions for 21 days at vegetative and reproductive stage in net house condition. The plants were exposed to three distinct treatments: (1) salicylic acid (SA) foliar spray (0 and 250 µM); (2) sodium nitro-prusside (SNP) foliar spray (0 and 25 µM); and (3) the simultaneous addition of SNP and SA, under irrigation with two di erent conditions (control and moisture deficit). The samples were re-sprayed 3 days after the experiment initiation. The drought stress caused osmotic stress and increased the accumulation of reactive oxygen species (ROS). To overcome these conditions, the plants increased the osmolyte contents and antioxidant activities. The exogenous application of SA and SNP can trigger the rapid activation of non-enzymatic and enzymatic defense system accompanied by increased production of osmolytes, non-enzymatic scavengers and antioxidants. Analysis of data revealed that F_1s *viz.,* VRNTH-18-1 and VRNTH-18-2 were characterized by a relatively lesser H_2O_2 content, generation of O_2^-, electrolytic leakage and lipid peroxidation whereas higher content of both osmolytes and antioxidants recorded under moisture deficit as well as control conditions. The simultaneous or separate application of these signalling chemicals to plant under

normal growth conditions are not suggested as they will act as stress and impair growth productivity.

Development of mapping population and SNP genotyping for identification of QTLs linked to high temperature stress tolerance: $F_{2:3}$ populations were raised in field to get $F_{3:4}$ during October, 2020 to February 2021. Selfed seeds of 200 individual $F_{2:3}$ plants were harvested separately to get 200 $F_{3:4}$ progenies. $F_{2:3}$ populations (approx. 200 progeny rows) have been raised in field for phenotyping study under high temperature during summer 2021 (Feb–June, 2021). Illumina HiSeq 2000 platform was used for Next generation sequences. A total of 69880 million reads were generated in 200 genotypes of F_2 generation (H-88-78-1 x Punjab Chhuhara) along with its parents. Over 98.99 % of the reads had Phred-like quality scores at the Q30 level (error < 0.1%) and we obtained 69176 million clean reads with 36.81 % average GC content. Further, all clean reads with high-quality regions were assembled into 8.628 million SNP using SAM tools software and ANNOVAR analysis pipeline were used for the annotation of detected variations.

Validation and evaluation of brinjal rootstocks for waterlogging tolerance: Twelve graft combinations containing of 3 rootstocks (IC-354557, IC-111056 and Surya) and 4 scions (Kashi Aman, Kashi Adarsh, Kashi Chayan and Kashi Adbhut) along with non-grafted controls were exposed to waterlogging condition for 96h at vegetative stage in field during Sep-Oct, 2020. IC-111056 and IC-354557 showed better survival with all the four tomato scions, whereas more than 85% non-grafted plants could not survive under waterlogging conditions. The higher yield was recorded in all the grafts combination compare to non-grafted and the rootstock IC-111056 emerged as highest yielder with Kashi Adbhut followed by the combination of IC-111056 with Kashi Aman and IC-354557 with Kashi Chayan, respectively.

Dissemination of grafting technology to the farmers' field: A total of 1600 grafted tomato plants included nine graft combinations containing three rootstocks (IC-354557, IC-111056 and Surya) on three scions (Kashi Aman, Kashi Adarsh and Kashi Chayan) were distributed to farmer (Fig. 2) and awareness program on grafting technology for vegetable production was also organized. Observation was also recorded on performance of grafted plants at farmer's field and it was observed that Kashi Chayan scion on IC-354557 rootstock recorded highest yield followed by Kashi Chayan with IC-111056 combination.

Fig. 2: Distribution and performance of grafted plants at farmer's field

Project 2: CRP on Hybrid Technology (Tomato)

***Performance of tomato hybrids against tomato leaf curl virus (ToLCV) at IIVR*:** One hundred (100) hybrids developed from 2016-2018 were evaluated in year 2018-19, 2019-20 respectively to determine the yield of tomato hybrids with ToLCV tolerance and high TSS with respect to Abhilash (as check). On the basis of high yield with ToLCV tolerance in two consecutive years (2018-19 and 2019-20) and TSS, CRPVRTH-17-55 (Yield: 143.1 t/ha, TSS: 4.6) and CRPVRTH-18-38 (Yield: 155.4 t/ha, TSS: 4.8) were found to best performer than other tested hybrids. The yield of CRPVRTH-17-55 and CRPVRTH-18-38 increased by 33.6% and 38.9%, respectively as compared to check than rest of the hybrids (Table 1). These hybrids are ready for multi-location testing and commercial cultivation.

In addition to this, 91 new sets of F1s were also evaluated in terms of high yield and ToLCV tolerance with respect to check. CRPVRTH-19-24 (Yield: 125.3 t/ha) and CRPVRTH-19-32 (Yield: 118.3 t/ha) were found to be superior F_1's than others. 24.8% and 19.7% increase in yield was observed in CRPVRTH-19-24 and CRPVRTH-19-32, respectively in comparison to check (Table 2 and Fig. 3). These F_1's will again be tested in next year for further confirmation.

Table 1: Performance of ToLCV tolerant tomato hybrids (2018-19 and 2019-20)

Hybrids	Year wise Yield (t/ha)		Average	Fruit weight (g)	TSS	(%) increase in yield with check
	2018-2019	2019-2020				
CRPVRTH-17-55	**163.3**	**123.3**	**143.1**	**100-105**	**4.6**	**33.6**
CRPVRTH-17-49	146.6	111.3	128.9	70-80	3.5	26.3
CRPVRTH-17-33	136.9	99.5	117.7	65-70	4.2	19.3
CRPVRTH-17-20	131.6	120.6	126.1	70-80	4.7	24.7
CRPVRTH-17-183	129.9	85.9	107.9	70-75	3.4	11.9
CRPVRT-H-18-38	**163.3**	**147.5**	**155.4**	**80-85**	**4.8**	**38.9**
CRPVRTH-18-36	153.8	100.4	127.1	90-95	4.5	25.2
CRPVRTH-18-28	143.3	123.6	133.5	70-75	4.0	28.83
Abhilash (Check)	100.5	89.5	95.0	65-70	4.5	-

Table 2: Evaluation of new set of F_1s tolerant to ToLCV (2019-20)

Hybrids	Yield (t/ha)	Presence of Ty-3 genes	Fruit weight (g)	TSS	% increase in yield with check
CRPVRTH-18-80	77.7	+	75-80	4.6	-22.2
CRPVRTH-19-23	89.9	+	70-75	4.9	-5.7
CRPVRTH-19-24	**125.3**	**10%**	**75-80**	**4.6**	**24.8**
CRPVRTH-19-31	86.9	+	80-85	3.9	-9.3
CRPVRTH-19-32	**118.3**	**+**	**70-75**	**4.4**	**19.7**
CRPVRTH-19-37	84.9	10%	70-80	3.6	-11.9
CRPVRTH-19-5	76.9	+	65-70	4.0	-23.5
CRPVRTH-19-12	69.5	+	80-85	4.4	-36.7
CRPVRTH-19-14	59.3	+	70-75	4.0	-60.2
Abhilash	95.0	-	65-70	4.5	-

CRPVRTH-19-24

CRPVRTH-19-32

Fig. 3: Promising ToLCV tolerant tomato hybrids

Activity-2 Hybrids tolerant to abiotic stresses (high temperature, moisture deficit and salinity)

(a) ***Hybrids showing tolerance to high temperature*:** One hundred one (101) hybrids developed from 2016-2018 were evaluated in year 2018-19, 2019-20 respectively to determine the yield of tomato hybrids showing tolerance to high temperature with respect to Aryan-60 (as check). On the basis of high yield under high temperature in two consecutive years (2018-19 and 2019-20) and TSS, CRPVRTH-17-85 (Yield: 38.28 t/ha, TSS: 4.4) and CRPVRTH-17-163 (Yield: 32.67 t/ha, TSS: 4.8) were found to best performer than other tested hybrids. The yield of CRPVRTH-17-85 and CRPVRTH-17-163 were increased by 43.33% and 30.27% respectively as compare to Aryan-60 than rest of the hybrids (Table 3 and Fig. 4). These hybrids have been ready for multi-location testing and commercial cultivation.

In addition to this, forty five (45) new sets of F1,s were also evaluated in terms of high yield at high temperature with respect to check (Aryan-60). CRPVRTH-18-8 (Yield: 35.6 t/ha) and CRPVRTH-19-13 (Yield: 34.9 t/ha) were found to be superior F1's than others. 34.12% and 32.80% increase in yield was observed in CRPVRTH-18-8 and CRPVRTH-19-13 respectively in comparison to check (Table 4 and Fig. 5). These F_1's will again be tested in next year for further confirmation.

CRPVRTH-17-103

CRPVRTH-17-85

CRPVRTH-17-136 CRPVRTH-17-163

Fig. 4: Promising heat tolerant tomato hybrids

(IC) and moisture deficit (MD). On the basis of decrease in yield (%), CRPVRTH-16-3 was found to be superior hybrids than rest of tested hybrids. The decrease in yield was found to be lesser (25.29%) in CRPVRTH-16-3 than CRPVRTH-16-4 and CRPVRTH-16-5. Now, CRPVRTH-16-3 has been confirmed for MD condition and ready for multi-location testing (Table-5 and Fig. 6).

Table 3: Confirmation of high temperature tolerance tomato hybrids (2018-19 and 2019-20)

Hybrids	Yield in year wise (t/ha)		Average	Fruit weight (g)	TSS	(%) increase with check
	2018-2019	2019-2020				
CRPVRTH-17-103	31.6	28.6	30.10	50	4.2	27.94
CRPVRTH-17-85	**38.9**	**37.67**	**38.28**	**60.4**	**4.4**	**43.33**
CRPVRTH-17-136	21.0	24.4	22.70	34.5	4.9	4.40
CRPVRTH-17-163	**30.9**	**34.45**	**32.67**	**63.0**	**4.8**	**30.27**
CRPVRTH-17-157	28.6	31.56	30.08	64.0	4.2	27.89
Aryan-60 (Check)	19.94	23.45	21.69	63	4.9	-

Table 4: New set of tomato F_1's for high temperature tolerance (2019-20)

Hybrids	Yield (t/ha)	Fruit weight (g)	TSS	% increase in yield with check
CRPVRTH-18-8	**35.6**	**50.58**	**4.22**	**34.12**
CRPVRTH-18-7	30.9	65.0	4.32	24.11
CRPVRTH-18-90	32.1	46.0	4.13	26.94
CRPVRTH-19-25	32.9	52.5	3.98	28.72
CRPVRTH-19-41	33.5	54.0	4.7	30.0
CRPVRTH-19-27	31.6	57.0	3.80	25.79
CRPVRTH-19-33	32.3	50.0	5.03	27.39
CRPVRTH-19-13	**34.9**	**43.5**	**3.85**	**32.80**
Aryan-60 (Check)	23.45	63	4.9	----

CRPVRTH-18-8 CRPVRTH-18-7

Fig. 5: Promising high temperature tolerant tomato hybrids

(b) *Development of tomato hybrids for moisture deficit*: Hybrids namely CRPVRTH-16-3, CRPVRTH-16-4, CRPVRTH-16-5 were evaluated in terms of yield (t/ha) during 2018-19 and 2019-20 under irrigated condition

CRPVRTH-16-3 CRPVRTH-16-4 CRPVRTH-16-5

Fig. 6: Promising tomato hybrids tolerant to moisture deficit

Activity 3: Evaluation of nutritional rich tomato

Thirty two (32) F_1s developed in 2016-2019 were evaluated 2019-20 in terms of TSS, acidity, ascorbic acid, lycopene at IIVR. On the basis of evaluation F_1, s namely CRPVRTH-16-86 and CRPVRTH-17-163 were found to be superior in nutrition rich attributes than other tested hybrids.

Table 5: Tomato hybrids tolerant to moisture deficit (2018-19 and 2019-20)

Hybrids	Yield (t/ha) 2018-2019		Yield (t/ha) 2019-2020		Average Yield (t/ha)		% decrease in yield
	IC	MD	IC	MD	IC	MD	
CRPVRTH-16-3	74.9	49.0	88.8	73.3	81.85	61.15	-25.29
CRPVRTH-16-4	83.1	49.86	106.6	83.9	94.85	66.68	-29.64
CRPVRTH-16-5	64.4	55.6	95.3	59.1	79.85	57.35	-28.35

Table 6: Estimation of nutritional attributes in selected tomato hybrids

Hybrids	TSS (%)	Acidity	Ascorbic acid	Lycopene	Beta carotene
CRPVRTH-16-86	**4.02**	**.25**	**18.57**	**10.45**	**1.09**
CRPVRTH-17-163	**4.20**	**.40**	**24.29**	**10.12**	**0.92**
CRPVRTH-18-38	4.04	.32	21.14	8.08	.98
ToLCV-16	4.0	.28	24.05	10.34	1.10
CRPVRTH-16-90	3.42	0.34	21.26	9.50	.80

Note: TSS= Total soluble solids (%); Acidity= in %; Ascorbic acid= mg/100gFW; Lycopene=mg/100g FW; Beta carotene= mg/100g FW

Project 3: Network Project on Transgenic Crops (NPTC)

Fruit and shoot borer resistant transgenic brinjal –*Cry1Aa3* gene*:* Homozygous T8 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 T12generation. 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 T10 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 T10 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 andBcZAT12 transgenes were done by crossing both the transgenic lines in a reciprocal manner. The F5 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.

Project 4: CRP on Agrobiodiversity

Okra

Under CRP on Agro-biodiversity, during kharif season of 2020, 410 accessions of okra were screened for YVMV and ELCV diseases. Eighty eight accessions of *A. moschatus* ssp. *moschatus* were also evaluated for YVMV and ELCV disease resistance and 7 accessions (IC360655, IC284824, IC611595, IC620570, IC620571, IC611698, JBS/17-87-A) were validated for YVMV and ELCV disease resistance. Among 410 accessions evaluated, IC337410, IC747799, IC747819, IC 353323, IC372165 and IC419366 showed moderate resistance to YVMV. IC 419367, IC433485, IC433491, IC433507, IC433663, IC435688, IC469728, IC536695 and IC557103 exhibited moderate resistance to both YVMV and ELCV disease under field condition. Among the 88 *A. moschatus* ssp. *Moschatus* evaluated, all the accessions showed considerable variation for growth habit, leaf morphology and fruit morphology. All the accessions exhibited high degree of resistance to both the YVMV and ELCV diseases, except IC141068, EC361171 & EC361129 as they showed YVMV symptom. In validation of 7 accession, all the 7 acession showed moderate resistance to both the diseases.

Project 5: DUS Testing of Vegetable Crops

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

During the year, 06 variety of common knowledge of cucumber and one each in bitter gourd and bottle gourd were evaluated for DUS testing. In new variety category, 22 candidate varieties of tomato in 1st year and 06 candidate varieties in 2nd year evaluated. Because of Covid-19 pandemic, internal monitoring of crop was performed. No any candidate variety under Farmer's variety category was received.

Maintenance breeding was done to maintain the reference varieties. At present, a total of 415 varieties of cucumber (24), bitter gourd (30), bottle gourd (31), pumpkin (24), okra (42), brinjal (86), tomato (89), vegetable pea (42), French bean (26) and pointed gourd (21) were maintained as reference collection and are being used as reference during DUS testing of new, VCK and Farmers variety DUS testing.

Project 6: Agri-Business Incubator-IIVR, Varanasi

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.

The ABI unit organized a 21 days Entrepreneurship Development Programme entitled "*Gramin Yuvaon Ke Sashaktikaran Hetu Sabzee Ke Kshetra Mein Udyamita Vikas*" for young vegetable growers of east Champaran district of Bihar from 4 to 24 February, 2020 (Fig.7).

The programme was attended by 36 growers of east Champaran district of Bihar. The participants were trained on different technologies, which can be taken-up by them as future entrepreneurs. During the training program, there were lectures on improved vegetable varieties, their cultivation under field and protected conditions, marketing avenues and strategies, development of hybrid seeds in vegetable crops, seeds processing and storage, honey bee rearing, mushroom technology, organic farming, IPR issues in context of Indian Agriculture, and facilities at ICAR-IIVR, Varanasi for agri-business incubation. They were also provided with field exposure on different aspects through practical sessions as well as visits to different organizations working on these aspects.

Fig. 7: 21 days EDP entitled '*Gramin Yuvaon Ke Sashaktikaran Hetu Sabzee Ke Kshetra Mein Udyamita Vikas*' from 4 to 24 Feb. 2020

During the year 2020, sixteen technology commercialization license agreements were executed for commercialization of IIVR technologies as a result of the efforts undertaken in this direction by ABI unit.

Overall, a revenue of Rs.12.22 lakhs were generated through licensing and royalties during this year. Two entrepreneurs Indraprastham Agro Producer Company Ltd. and Mr. Atul Kumar Yadav got enrolled as an incubatee of the ABI unit, ICAR-IIVR, Varanasi during 2020.

Project 7: Zonal Technology Management Unit-IIVR, Varanasi

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 on a regular basis. The unit was instrumental in registration of three unique germplasms with NBPGR viz. Tropical Kale VRKALE-1 (Kashi Kale-1) and two CMS lines of radish VRRAD-201 & VRRAD-202. IC numbers of 71 genotypes were also obtained. Also 1027 accessions in 17 vegetable crops were provided to 40 organizations through MTA for use in research programs and evaluation.

A market sensitization programme for varieties/hybrids and promising lines of solanaceous vegetables (Tomato, Brinjal and Chilli) was organized on 18 January, 2020 (Fig.8) for promoting the commercialization of ICAR-IIVR technologies. The solanaceous day programme was attended by 35 representatives from of 19 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 different solanaceous vegetables. They expressed interest in many promising materials of tomato, brinjal and chilli.

Fig. 8: Solanaceous Day organized on 18th January, 2020 at ICAR-IIVR, Varanasi

The ZTMU organized a market sensitization programme for okra varieties/hybrids and promising lines on 28th October 2020 (Fig. 9) through online mode. The program was attended by 45 representatives from 29

private sector seed companies dealing in vegetable seeds. Firstly, the participants were apprised of different promising material at IIVR ready for commercialization through a PowerPoint presentation. Subsequently, the materials were shown to them in the field with the help of a camera in the field. The representatives expressed interest in many promising materials of okra, gave suggestions for further improvement and appreciated the efforts of IIVR to organize the event in this way in view of COVID-19 pandemic.

Fig. 9: Okra Field Day organized on 28th October, 2020 at ICAR-IIVR, Varanasi

Project 8: Cowpea Golden Mosaic Disease (CPGMD) Resistance: Agro-infectious Clone Development, Screening, Genetics of Inheritance, Molecular tagging and Mapping for CPGMD Resistant Gene(s) in Cowpea by using Linked Markers

Genetics of inheritance for cowpea golden mosaic disease

Based on field and in-house screening, three genotypes were found highly resistant to cowpea golden mosaic disease (CPGMD) *viz*., BC244002, EC528398 and IC202776 while VRCP-144-5 was identified as highly susceptible genotype. All the 3 genotypes were crossed with the susceptible genotype to develop F1, F2, BC1, BC2 for each cross combination. The field screening of all these populations for every cross combination showed 3:1 ratio for resistant to susceptible plants in F2 and 1:1 ratio in backcross (BC1) with susceptible parent VRCP-144-5. For the cross combination BC244002 × VRCP-144-5 using F2 population along with F1, BC1, BC2, P1 and P2 were grown in inhouse conditions also and screened using grafting technique also by using agroinfectoius clone. By using the grafting technique on 205 F2 plants, 57 plants were found susceptible to cowpea golden mosaic disease and remaining 148 plants were found resistant to disease. This also showed 3:1 segregation for resistant to susceptible plants for cowpea golden mosaic disease which shows that CPGMD is governed by single dominant gene.

Molecular tagging and mapping for CPGMD

DNA was collected from 10 cowpea golden mosaic disease resistant and 10 cowpea golden mosaic disease susceptible plants and two bulks were made viz., highly resistant bulk and highly susceptible bulk. After parental polymorphism SSR primers were run in the two bulks. Total 9 polymorphic SSR primers were identified by bulk segregant analysis out of 110 SSR primers. This shows that these primers were linked to CPGMD.

Fig. 10: F_2 population of the cross BC244002 × VRCP-144-5

Project 9: Monoecious Sex Expression in Muskmelon (*Cucumis melo* L.): Inheritance and Molecular Mapping of Monoecism using Linked Markers

DNA was isolated from andromonoecious genotype Kashi Madhu having round fruit and monoecious lines VRMM-170 with round fruit and B-159 with oblong fruit. 500 SSR primers covering twelve linkage group of *Cucumis melo* surveyed to identify the polymorphic SSR associated for monoecious vs andromonoecious sex expression and round vs oblong fruit. Among first 250 primers about 70 SSR primers found to be polymorphic for monoecious and andromonoecious sex expression; 56 primers are polymorphic for fruit shape and were subsequently validated for respective traits. Another 250 SSR primers also run to identify polymorphic SSR for sex expression and fruit shape and numbers of polymorphic SSR identified. For the development of mapping population, F_1s of andromonoecious (Kashi Madhu) and monoecious (VRMM-170 and B-159) were grown and self-pollination & back crossing was performed to harvest F_2, B_1 and B_2 seeds.

Project 10: Identification of Suitable Varieties/Hybrids of Cucurbitaceous Crops and Development of Production Protocol for Better Livelihood of River Bed (Diara Land) Farming Community

This project starred from September, 2021 with the objectives to standardize the river technology including identification of production problems and their management at riverbed condition. Based on the previous finding, the cucurbits varieties/hybrids were collected/procured includes bottle gourd (Kashi Ganga & Sarita), sponge gourd (Kashi jyoti & Alok), ridge gourd (Kashi Shivani), pumpkin (Kashi Harit, BSS-750 and Indrajeet), Watermelon (Max F_1), muskmelon (Kashi Madhu, Lyallpur-257), bitter gourd (Kashi Mayuri) and longmelon (Chandra Prabha). These varieties/hybrids were sown on 17th & 18th November, 2020. Besides cucurbits, possibilities of growing other crops were also explored and grafted tomato (Kashi Aman & NS-4266) was also transplanted. All released variety of muskmelon, watermelon, bottle gourd, pumpkin, bitter gourd, sponge gourd, ridge gourd, grafted tomato and long melon along with few advance lines will be collected or will be procured for evaluation. The observations on days taken to seed germination, days to 50 % female flower anthesis, days to first harvest, number of fruit per plant, average fruit weight, fruit length (cm), fruit diameter (cm), yield (kg), colour and shape of fruit are in progress.

Project 11: Efficient Water Management in Horticultural Crops

Effect of planting geometry and fertigation in chilli and baby corn

In this study, four planting geometry *i.e.* one, two, three or four plants (G1 to G4) adjusted to each dripper and four level of fertigation *i.e.* 140%, 120%, 100% and 80% recommended dose of NPK (F1 to F4) was compared with control (F5= conventional irrigation and soil application of 100% Rec. NPK).

In chilli (cv. Kashi Anmol) plant geometry and fertigation significantly influenced most of the parameters. Maximum number of fruits was recorded in G1F1 (160.6/ plant) followed by G1F2 (143.2 /plant) and G1F5 (140.8 /plant). Similarly, maximum individual plant yields were also registered with above treatment combinations i.e. G1F1 (498.08 g), G1F2 (438.18 g) and G1F5 (412.66 g), however the maximum chilli production per hectare was recorded under G4F1 (198.82 q) followed by G3F1 (175.61 q). These two treatment combinations have noticed 187.35% and 153.8% higher fruit yields, respectively over control (conventional irrigation and soil application of 100% Rec. NPK). Water use efficiency was also higher under G4F1 (7.70 q/ha/cm) and G3F1 (6.80 q/ha/cm), whereas fertilizer use efficiency was maximum in G4F5 (65.59 kg/ha/kg NPK) followed by G3F5 (62.44 kg/ha/kg NPK).

Planting geometry and drip fertigation study was conducted in baby corn (cv. Sweet Glory) during summer season in the same fashion as in chilli. The planting geometry and drip fertigation significantly influenced the yield of baby corn. Crop sown with 4-plant geometry and supplied with 140% NPK (G4F1) registered the maximum corn yield (54.94 q/ha) followed by G2F1 (51.55 q/ha) and G3F1 (46.43 q/ha). In baby corn production, maximum water and nutrient use efficiency was reported with G4F1 (214.62 kg/ha/cm water and 16.35 kg/ha/kg NPK) followed by G2F1 (201.35 kg/ha/cm water and 15.34 kg/ha/kg NPK). It was concluded from this study that the maximum baby

corn yield, WUE and NUE can be achieved by planting 2 or 4-plants with each emitter and drip fertigation @ 140% of rec. NPK.

Table 7: Effect of plant geometry and fertigation on yield attributes and resource use efficiency in Chilli and baby corn

Plant geometry & fertigation quantity	Chilli			Baby corn		
	Fruit yield (q/ha)	WUE (Q /ha/ cm)	FUE (Kg/ ha/ kg NPK)	Cob yield (q/ha)	WUE (Q /ha/ cm)	FUE (Kg/ ha/ kg NPK)
G1F1	105.91	4.10	31.52	22.63	88.39	6.73
G1F2	77.18	2.99	26.80	10.73	41.91	3.73
G1F3	54.91	2.13	22.88	11.70	45.71	4.88
G1F4	47.77	1.85	24.88	17.42	68.03	9.07
G1F5	69.19	2.68	28.83	15.93	36.87	6.64
G2F1	155.47	6.02	46.27	51.55	201.35	15.34
G2F2	117.98	4.57	40.97	27.67	108.07	9.61
G2F3	121.38	4.70	50.58	27.11	105.91	11.30
G2F4	67.83	2.63	35.33	13.43	52.47	7.00
G2F5	101.49	3.93	42.29	23.99	55.53	9.99
G3F1	175.61	6.80	52.26	46.43	181.37	13.82
G3F2	142.72	5.53	49.55	41.45	161.90	14.39
G3F3	123.42	4.78	51.43	28.27	110.43	11.78
G3F4	101.41	3.93	52.82	21.60	84.39	11.25
G3F5	149.86	5.80	62.44	36.77	85.12	15.32
G4F1	198.82	7.70	59.17	54.94	214.62	16.35
G4F2	158.10	6.12	54.90	36.32	141.89	12.61
G4F3	145.18	5.62	60.49	21.14	82.60	8.81
G4F4	89.51	3.47	46.62	20.51	80.11	10.68
G4F5	157.42	6.09	65.59	25.72	59.54	10.72
SeM±	**9.44**	-	-	**2.89**	-	-
CD (0.05)	**27.84**	-	-	**8.42**	-	-

Fig. 11: Chilli and baby corn production with 4-plant geometry and 140% of rec. NPK fertigation

Project 12: Development and Evaluation of Annual Moringa for Food Fodder and Nutrition Content in UP.

The project began in October-2020 and farm area to select to perform the experiment. Improved moringa varieties, i.e. PKM-1 from TNAU, Coimbatore, Konkan Ruchira from PDKV, Dapoli, Maharashtra, Bhagya from GKVK, Bengaluru, Karnataka and ODC-3 from, Odisha were acquired and planted in the main field. Moringa germplasm from various locations of Tamil Nadu will be collected during the upcoming exploration in February, 2021.

Project 13: ICAR-NASF project "Development and Validation of Need-Based Technology Delivery Model through Farmers Producer Organization for Eastern Region of India"

Efficient technology delivery model (TDM) enhances the meaningful sustained technology adoption. For improving the agricultural scenario in eastern region of India, an efficient TDM is highly required for both bringing green revolution in eastern India and doubling farmers' income. Keeping in mind these points, this multi-location project is operational in Uttar Pardesh, Bihar, Jharkhand and West Bengal. In Uttar Pardesh, ICAR-Indian Institute of Vegetable Research acting as cooperating centre and research is being carried out in the vicinity districts of Varanasi, Ghazipur and Sonbhadra. The work started by screening successful and working FPOs in the study area and two FPOs were screened each from Ghazipur (Shivans Farmers Producer Co. Ltd.) and Varanasi (Jaya Seeds Producer Co. Ltd.). A baseline survey of 100 farmers who are associated with FPO along with 100 non-FPO farmers were conducted to assess the socio-economic status and technology delivery system for both the categories. Need based technologies were delivered to the selected farmers of both the categories (FPO and Non-FPO) for assessing the technology dissemination pattern. Technologies were delivered through two methods: (i) Technology delivery through demonstration. (ii) Technology delivery through training. These two methods of technology delivery are very common and generally used by the extension agencies frequently. Improved vegetable seeds developed from ICAR-IIVR, Varanasi was demonstrated among FPO as well as Non-FPO group of farmers. The details of the demonstration are as follows:

Table 8: Technology demonstration in Kharif 2020

Sl.	Crop	Variety	Quantity (Kg)	Area covered (Acre)
1.	Tomato	Kashi Aman	0.50	3.08
2.	Brinjal	Kashi Sandesh	0.50	3.95
3.	Chilli	Kashi Anmol	0.50	3.08
4.	Radish	Kashi Swetha	0.75	0.25
5.	Palak	All Green	2.25	0.20
6.	Pumpkin	Kashi Harit	1.50	2.50
7.	Bottle gourd	Kashi Ganga	1.50	1.25
8.	Cowpea	Kashi Nidhi	15.00	1.85
9.	Okra	Kashi Kranti	15.00	2.50
10.	Sponge gourd	Kashi Divya	1.50	0.75

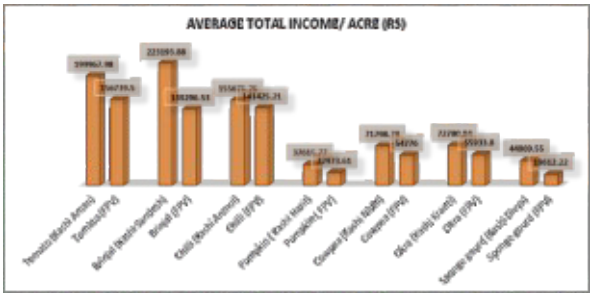


Fig. 12: Comparison of demonstrated vegetable varieties from IIVR with Farmer's preferred variety (FPV) on the basis of Average total income per Acre (Rs)

Fig. 13: Training on Scientific Mushroom Production

Fig. 14: Training on Scientific Beekeeping

Fig. 15: Training on Protected and Scientific Vegetable Production

Three training programmes were organised on scientific mushroom production, scientific beekeeping and protected cultivation of vegetables.

Project 14: Biotech KISAN (Krishi Innovation and Science Application Network) Hub Project

Biotech KISAN Project is sponsored by Department of Biotechnology, Ministry of Science & Technology, Government of India and is implemented in 02 Aspirational districts (Chandauli & Sonbhadra) along with 01 Hub district (Varanasi) and 01 Sub-Hub district (Ghazipur) in collaboration with FAARD Foundation, Varanasi. The project is mandated with enhancement of crop productivity along with intensification of vegetable cultivation besides training and capacity building of farmers and rural youth for self-sustainability and entrepreneurship development in selected districts.

During *Kharif*, 2020 demonstrations of two improved varieties of Paddy *viz.,* DRR 50 & Swarna Sub 1 along with Pigeon Pea (IPA 203 & NDA-2), Mungbean (IPM-410-3), Urdbean (IPU 02-43) and Pearl Millet (Pusa Composite - 701 & Hybrid Bio-Seeds 8290) were conducted at 331 farmers' field in an area of 100.43 ha in selected clusters which resulted in significant increase in total yield (excluding pigeon pea) by 27.0% and income

Table 9: Field Crops Demonstrated Interventions

Name of demonstrated interventions	Number of Beneficiaries	Average Yield (q/ha)		Yield increase (%)	Change in income (Rs/ha)	
		Demonstrated Field	Control Field		Before	After
DRR-50 (Paddy)	53	51.8	44.0	17.73	50000.0	59450.0
Swarna Sub-1 (Paddy)	55	58.3	44.0	32.50	52000.0	58530.0
Hybrid Bio-Seeds-8290 (Bajra)	17	29.5	20.5	43.9	47500.0	59715.0
Pusa Composite-701 (Bajra)	24	23.4	20.5	14.15	44500.0	49957.0
IPM-410-3 (Moong)	18	8.5	6.5	30.77	65000.0	77810.0
IPU-02-43 (Urd)	37	9.1	7.4	22.97	65000.0	71800.0
Narendra Arhar-2 (Arhar)	53	In Field	In Field	In Field	In Field	In Field
IPA-203 (Arhar)	74	In Field	In Field	In Field	In Field	In Field

by 16.4% ie., Rs. 37.7 lakh against Rs. 32.4 lakh from other practicing cultivars (Table 9). Similarly during Rabi 2020, demonstrations of wheat (HD 3086), Barley (DWRB-137), Chickpea (Pusa 3043 & JG-14), Field Pea (IPF 4-9) and Lentil (IPL 316) were conducted at 165 farmers' field in an area of 31.84 ha.

In vegetables during kharif season, successful demonstrations of cowpea (Kashi Nidhi), bottle gourd (Kashi Ganga), pumpkin (Kashi Harit), sponge gourd (Kashi Rakshita), chilli (Kashi Anmol & Kashi Ratna), brinjal (Kashi Sandesh), cauliflower (Kashi Gobhi 25), dolichos bean (Kashi Khushal) and Okra (Kashi Kranti, Kashi Lalima) were conducted at 975 farmers' field in an area of 60.11 ha in the selected clusters. This resulted in significant increase in total yield by 10.36% and income by 20.01% ie., Rs. 17.3 lakh against Rs. 14.4 lakh from other practicing cultivars (Table 10). Similarly during Rabi season demonstrations of tomato (Kashi Aman, Kashi Adarsh), Garden Pea (Kashi Udai, Kashi Mukti & Kashi Agati), French bean (Kashi Sampann) and Carrot (Kashi Arun) were conducted at 309 farmers' field in an area of 33.76 ha.

To address the nutritional security aspects of rural households 5800 kitchen garden seeds packets were provided to farmers including 310 COVID-19 migrants. On capacity building, 55 farmers (26 men and 29 women) were trained and developed as master trainers in Mushroom Production, who in turn trained another 150 women farmer in selected villages for entrepreneurship development.

Table 10: Vegetables Crops Demonstrated Interventions

Name of demonstrated interventions	Number of Beneficiaries	Average Yield (q/ha)		Yield increase (%)	Change in income (Rs/ha)	
		Demonstrated Field	Control Field		Before	After
Kashi Nidhi (Cowpea)	157	115.5	95	21.58	121307.5	168472.8
Kashi Harit (Pumpkin)	54	368.5	340.0	8.38	89109.0	117192.5
K. Rakshita (Sponge Gourd)	137	323.75	310.5	4.27	160720.0	179480.0
Kashi Ganga (Bottle Gourd)	139	365.1	325.0	12.34	109817.8	117525.0
Kashi Lalima (Okra)	11	111.5	110.8	0.64	137729.75	210500.0
Kashi Kranti(Okra)	130	123.75	110.8	11.69	137729.75	171055.1
Kashi Khushal (Sem)	128	343.1	297.5	15.33	127500.0	143100.0
Kashi Ratna (Chilli)	80	212.42	180.0	18.01	74033.12	90380.82
Kashi Anmol (Chilli)	53	192.55	180.0	6.97	74033.12	81365.5
Kashi Gobhi-25 (Cauliflower)	78	187.3	180.0	4.06	144000.0	157300.0
Kashi Sandesh (Brinjal)	8	641.75	580.0	10.65	264000.0	291750.0

Project 15: Farmer FIRST Program on "Intervention of Improved Agricultural Technologies for Livelihood and Nutritional Security Adhering Local Resources and Working Knowledge of the Farmers"

Farmers FIRST project was initiated in 06 villages of Araziline block in Varanasi district, U.P. namely Upadhaypur, Baburam Ka Pura, Paniyara, Dhanapur, Rajapur and Laskariya with an objective to strengthen crop diversification by supplying quality inputs for nutritional and livelihood security, and to empower farmers/farm women in different aspects of agriculture enterprises as a livelihood diversification option 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 ie., Horticulture based and Crop based, under which successful demonstrations of cowpea (Kashi Nidhi), Okra (Kashi Kranti), pumpkin (Kashi Harit), sponge gourd (Kashi Divya), bottle gourd (Kashi Ganga), tomato (Kashi Aman), chilli (Kashi Anmol), brinjal (Kashi Sandesh) and garden pea (Kashi Nandini) along with suran (Gajendra), turmeric (Megha-1), paddy (HUR-917) and wheat (HD-2967) were conducted at 1022 farmers' field in an area of 137.2 ha in the selected clusters. This resulted in significant increase in total yield by 22.37 % and income by 40.2 % ie., Rs. 33.81 lakh against Rs. 24.12 lakh from other practicing cultivars (Table 11).

Impact of Farmer FIRST Project resulted in not only doubling the income of farmers but also helped in maintaining better livelihood of their family. Mr. Anil Singh of Paniyara village, Varanasi, under this project cultivated early vegetable pea *var.* Kashi Nandini developed by ICAR-IIVR in one-acre area after paddy and before wheat crop, which fetched him about 35 Q yield and earned Rs. 90,000/- from 70 days crop duration. Sh. Anil Singh was also conferred *Innovative Farmer Award 2020* by ICAR-NAARM, Hyderabad on 1st September 2020 during its 45th Foundation Day Ceremony.

Table 11: Interventions Demonstrated in Vegetables and Cereals

Name of demonstrated interventions	Number of Beneficiaries	Average Yield (q/ha)		Yield increase (%)	Change in income (Rs/ha)	
		Demonstrated Field	Control Field		Before	After
Kashi Nidhi (Cowpea)	160	126.00	98.00	22.22	126367.05	189462.80
Kashi Kranti (Okra)	90	120.57	88.45	26.64	147519.75	187165.10
Kashi Harit (Pumpkin)	50	380.10	250.45	34.10	59106.70	116142.37
Kashi Divya (Sponge gourd)	50	310.00	275.00	11.29	186725.00	210490.00
Kashi Ganga (Bottle gourd)	50	385.23	290.43	24.60	75811.85	100525.30
Kashi Aman (Tomato)	90	412.35	340.32	17.09	320380.20	408250.50
Kashi Anmol (Chilli)	40	190.40	150.20	21.11	64033.12	80380.82
Kashi Sandesh (Brinjal)	42	650.43	500.21	23.09	750315.00	1170774.00
Kashi Nandini (Pea)	100	72.00	65.00	13.88	95000.00	126000.00
Gajendra (Suran)	70	310.00	225.00	27.41	310000.23	475000.35
Megha-1 (Turmeric)	55	195.00	130.00	33.33	144200.21	155275.11
HUR-917 (Paddy)	200	55.40	46.70	15.70	53175.15	68318.17
HD-2967 (Wheat)	25	43.15	34.37	20.34	79131.17	93121.37

Project 16: Validation and Promotion of Sustainable and Adaptable IPM Technology for Brinjal Crop

The IPM technology that was synthesized and validated in brinjal fields of selected farmers in the villages Marachh, Arazaline Sultanpur, Adalpura of Mirzapur; Kachhariya Village of Varanasi and Villages Nidur, Kurauna and Dilkoeran of Bhadohi district for the management of major insect pests and diseases of brinjal was as followed: seed treatment with *Trichoderma viride* (@ 5 g/kg seed; seedling root dip in carbendazim 1 g/lit for 20 min followed by rynaxpyr @ 0.5 ml/lit solution for three hours against seed borne diseases and shoot and fruit borer, respectively; clipping of borer damaged shoots and early infested fruits at weekly intervals; installation of pheromone traps @ 25-30 traps/ha for mass trapping of brinjal shoot and fruit borer (*Leucinodes orbonalis*); need based spray (ETL > 5%) of chlorantraniliprole 18.5 % SC @ 0.35 ml/lit or emmamectin benzoate 5 SG @ 0.4 g/lit or fenpropathrin 30% EC @ 0.33 ml/lit against brinjal shoot and fruit borer; need based spray of imidacloprid 17.8 SL (@ 0.4 ml/lit) or thiamethoxam 25 WG @ 0.35 g/lit or fenpropathrin 30% EC @ 0.3 ml/lit against sucking pests; collection and destruction of *Phomopsis*, *Sclerotinia* wilt damaged fruits and little leaf affected plants periodically; during winter rains and foggy weather need based application of Carbendazim 0.5-0.75 g/lit for management of leaf spot and fruit rot. IPM fields had fruit damage of only 9.89% as compared to non-IPM fields (24.18% fruit damage). Similarly, numbers of sucking pests were also higher in non-IPM field. The numbers of jassid per leaf in IPM adopted farmers' plot was only 2.59 where as it was 8.36 per leaf in non-IPM farmers' fields. Similarly, non-IPM farmers' plot had higher number of whitefly population (3.35 per leaf) as compared to IPM adopted farmers (6.94 per leaf). Interestingly, polyphagous predators' populations were higher in IPM field. Number of spiders per plant was 5.21 in case of IPM field where as the population was mere 1.69 in case of non-IPM field. Similarly, lady bird beetle population was maximum (10.55 per plant) in IPM than the non-IPM plots (3.17 per plant). In case of disease incidence, IPM farmers had only 17.05 PDI and 8.79 PDI of *Sclerotinia* rot and *Phomopsis* blight infestations, respectively, in their fields. In contrast, non-IPM farmers had 34.20 PDI and 66.20 PDI of *Sclerotinia* rot and *Phomopsis* blight infestations, respectively, in their field at the same time. In terms of economics, IPM farmers had higher benefit cost ratio (4.61:1) than the non-IPM farmers. Non-IPM farmers sprayed 18-23 rounds of spray throughout the crop growth period as compared to IPM farmers where only 9-10 need based sprays were done.

Fig. 16: Interactining with IPM adopted farmers at farmer's field

Fig. 17: Healthy brinjal fruits harvested from IPM adopted fields

Achievement of All India Coordinated Research Project on Vegetable Crops

During the year 2020-21, 2176 trials were conducted at 36 regular and 26 voluntary centres of AICRP on Vegetable Crops (Table-1).

Table 1: Details of the trials conducted during 2019-20 through AICRP (VC)

	Trials	No. of Trials	No. of Trials conducted by the centre
Crop Improvement	Plant Genetic Resources	30	112
	Varietal Trials	51	969
	Hybrid Trials	28	500
	Resistant Varietal Trials	8	165
Crop Production	Vegetable Production Trials	12	66
	Protected Cultivation	11	62
	Seed Production Trials	19	55
	Physiology & Biochemistry Trials	5	13
Crop Protection	Integrated pest management	23	96
	Integrated disease management	10	138
Total		**197**	**2176**

The following recommendations under Crop Improvement, Crop Production and Crop Protection were made during 38th Group Meeting of AICRP (VC) held online at ICAR-IIVR, Varanasi from 25-27th Sept., 2020 (Table-2, 3 & 4).

Crop Improvement

Variety evaluation trials: Twenty entries of 13 vegetable crops were identified for release and notification for different agro-climatic zones of the country.

Hybrid evaluation trials: Five entries of 5 vegetable crops were identified for release and notification for different agro-climatic zones of the country.

Resistant evaluation trials: Two entries of Brinjal Bacterial Wilt was identified for release and notification for different agro-climatic zones of the country.

Table 2: Varieties identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Amaranth	2016/AMVAR -6	UHF Chaulai 12-1	Ranichauri	IV
2.	Brinjal (Long)	2016/BRLVAR -3	PBL-234	PAU, Ludhiana	IV, VII
3.	Brinjal (Round)	2016/BRRVAR -9	GNRB-1	NAU, Navsari	I
		2016/BRRVAR -4	IVBR-17	IIVR, Varanasi	IV
		2016/BRRVAR -5	DBR-03	IARI, New Delhi	VII
4.	Carrot (Tropical)	2016/CARVAR -3	VRCAR-186	IIVR, Varanasi	VII, VIII
		2016/CARVAR -7	IPC-3	IARI, New Delhi	VI, VIII
5.	Cauliflower (Early)	2016/CAUEVAR -8	BRECF 117/13	BAU, Sabour	V
6.	Cowpea (Bush)	2016/COPBVAR -5	VRCP -12	IIVR, Varanasi	IV
7.	Dolichos bean (Bush)	2016/DBBVAR -5	VRBSEM-3	IIVR, Varanasi	VI, VII, VIII
		2016/DBBVAR -6	VRBSEM-9	IIVR, Varanasi	VII

8.	Dolichos bean (Pole)	2016/DBPVAR -1	IS-2016-9	IGKV, Raipur	VII
		2016/DBPVAR -4	DB-5	IARI, New Delhi	V
9.	Bottle gourd	2016/BOGVAR -5	NDBG-16	NDAUT, Faizabad	I, VIII
		2016/BOGVAR -3	Pb. Barkat	PAU, Ludhiana	V, VII, VIII
10.	French bean (Bush)	2016/FBBVAR -2	VRFBB-91	IIVR, Varanasi	I
11.	Pumpkin	2016/PUMPVAR -6	PP-225	PAU, Ludhiana	VI
		2016/PUMPVAR -1	VRPK-230	IIVR, Varanasi	V
12.	Sponge gourd	2016/SPGVAR -5	VRSG-195	IIVR, Varanasi	IV, VI
13.	Cherry tomato	2016/TOCVAR -6	Panjab Yellow Cherry	PAU, Ludhiana	III, IV, VI

Table 3: Hybrids identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Brinjal (Long)	2016/BRLHYB-4	IVBHL-20	IIVR, Varanasi	VII
2.	Cauliflower (Early)	2016/CAUEHYB-7	DCH 1467	IARI, New Delhi	IV
3.	Cucumber	2016/CUCUHYB-2	PCUCH-5	GBPUAT, Pantnagar	I, IV
4.	Tomato (Determinate)	2016/TODHYB-4	Result cannot disclose **(Testing fee not paid by the concern company)**	Pvt. Ltd. Companies	IV, VI, VIII
5.	Watermelon	2016/WMHYB -7	NWMH-945	Nirmal Seeds	IV, VII

Table 4: Resistant varieties identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Brinjal bacterial wilt	2016/BBWRES-3	BB-67	OUAT, Bhubaneswar	V, VIII
		2016/BBWRES-6	IIHR-37-36-4-20 (Arka Avinash)	IIHR, Bangalore	VIII

Production Technologies Developed (17)

Vegetable Production:

1. At IIVR Varanasi, on the basis of trial conducted on **organic production** of radish- coriander sequence for three consecutive years, it was concluded that the maximum green leaf yield of coriander (9.83 t/ha) and root yield of radish (43.2 t/ha) with net return Rs.81652/- and B:C ratio of 1.78 was obtained with application of 20t/ha FYM + 100:60:60 kg NPK/ha + IIHR microbial consortium @ 12.5 kg/ha + plant protection through organic methods. Hence, the above organic package can be recommended for organic production of radish and coriander in Agro-climate Zone-IV.
2. Three years study at Nagaland on **organic production** of spinach beet suggests that application of Vermicompost 5 t /ha + PSB + *Azospirillum* (each 5 kg/ ha) registered maximum leaf yield (172.83 q/ha) which was *at par* to application of FYM 20 t /ha + PSB + *Azospirillum* (each 5 kg/ ha). However, the maximum net return (Rs. 2,04,595) and B:C ratio (1:4.35) was recorded with application of FYM 20 t/ ha+ PSB + *Azospirillum* (each 5 kg/ ha). Hence, application of FYM 20 t/ ha+ PSB + *Azospirillum* (each 5 kg/ ha) can be recommended for organic production of spinach beet (Palak) in Agro-climatic zone III.
3. Three years study conducted at Dharwad reveals that application of FYM@ 20t/ha + NPK @80:60:80 NPK kg/ha +PP chemicals +IIHR microbial consortium @ 12.5 kg/ha produced the maximum yields in **coriander-radish** sequence with a B:C ratio of 2.88. Hence, the above organic package can be recommended for Agro-climate Zone-VIII.
4. Three years study on weed management in okra at Vellanikkara revealed that pre-emergence application of pendimethalin @ 6 ml/L + one hand weeding at 25 days after sowing was suitable for

maximum fruit yield of 143.58 q/ha with the BC ratio of 2.1. Hence this treatment can be recommended for **weed management** in okra in the tropical sub-humid laterite soils of Zone VIII.

5. Grafting study at IIHR Bengaluru suggests that the use of *S. torvum* as **rootstock** for hybrid brinjal (MAHYCO-9) as scion produced maximum fruit yield (740.8 q/ha) with B:C of 3.11 and net return of about Rs 6.0 lakhs/ha. Similarly, at PAU, Ludhiana the maximum brinjal yield of 503.7 q/ha with B:C ratio of 2.75 was achieved when PBH 3 hybrid was grafted over *S. torvum*. Hence, *Solanum torvum* can be recommended as a potential rootstock for hybrid brinjal in Agro-climatic Zone IV and VIII.
6. In okra cv. Parbhani Kranti, 2-3 hand weedings gave highest yield (158.44 q/ha) along with highest cost: Benefit ratio of 1:4.05 under Srinagar condition.
7. Pre emergence application of Pendimethalin 6ml/l alongwith one hand weeding gave highest okra yield of 144.94 q/ha with highest B:C ration of 2.13 in okra cv. Arka Anamika under Nagaland condition.

Seed production:

1. Soil application of 75% RDF +25% NPK as bio-fertilizers (*Azosporillum*+PSB+K' solubilizing bacteria each @ 2kg/acre) + bio-control agent *Trichoderma Viridae* @ 2kg/acre + Micorrhiza (VAM @ 5kg/acre) recorded highest seed yield (11.40) and the highest B:C ratio (2.73) in chilli var. LCA-620 under Lam conditions.
2. In pumpkin cv. Arka Suryamukhi, physiological maturity of seed was attained when fruits were harvested 45 days after anthesis. The 10 days of pre-storage period before seed extraction resulted in maximum seed yield and quality under IIHR, Bangalore conditions (zone-VIII). These seeds also retained their viability and vigour even after 12 months of storage under ambient conditions.
3. Spraying with mixture of Ferrous sulphate @ 0.2%, Calcium nitrate @ 0.2% and Boron @ 0.1%), gave maximum seed yield (10.07 q/ha) with highest B: C ratio (2.63) in chilli var. LCA-620 at Lam. Whereas the same treatment at Kanpur gave the maximum seed yield (122.45 kg/ha) with highest BC ratio (2.35) in Chilli var. Azad Mirch-1 and at Jabalpur recorded the maximum seed yield of 2.80 q/ha in chilli var. Pusa Jawala. Hence, it is recommended for Lam (zone-VI), Kanpur (zone-IV) and Jabalpur (zone-VII) conditions.
4. Punjab 8 variety of Okra when sown in third week of June recorded best quality seeds with higher seed yield under IIHR, Bangalore conditions (zone-VIII).
5. In the trial on management of dormancy in vegetables, seeds of palak variety Punjab Green when treated with Ethylene 1000 ppm for 12 hours or HNO_3 500 ppm for 12 hour improved the germination even thirty days after harvest at Ludhiana (zone-IV).

Protected cultivation:

1. A three year study conducted at Srinagar for standardizing the production technology for high value bell pepper revealed that the capsicum var. Bomby gave the highest yield (546.07q/ha) when plants were pruned to train four stems.
2. Pooled analysis of three years data pertaining to the performance of parthenocarpic cucumbers under protected condition at Jorhat showed that the higher fruit weight (179.33 g) and higher fruit yield per plant (2.93 kg) led to the highest total fruit yield (692.06 q/ha) in var. PPC-3 with the maximum benefit: cost ratio of 1.92.
3. At Ludhiana, fertigation studies in parthenocarpic cucumber var. Parthenocarpic Cucumber-2 showed that the maximum yield of 1186.0 q/ha was recorded when N:P:K were applied @ 150:112:188 with the highest B:C ratio i.e. 3.14. Similar trend was noted at IIHR, where the same treatment recorded the highest yield of 1126 q/ha and the B:C ratio of 2.07 based on a 3-year study.

Physiology, Biochemistry and Processing:

1. Estimation of antioxidant components of several crops including tomato, pumpkin and muskmelon etc. were presented. Several quality parameters like vitamin C, TSS, carotenoids and lycopene content were assessed in different vegetables at PAU, Ludhiana. In another trial, the oxalate content in AVT-I and AVT II tomato lines varied between 4.83-6.24 mg/100g and 4.36-6.36 mg/100g, respectively. The acidity level ranged between 0.36-0.45% and

0.33-0.47%, as citric acid respectively in AVT-I and AVT-II lines at IIVR, Varanasi centre. It was emphasized that there is a strong correlation between oxalate content and acidity content in tomato genotypes.

2. Tomato varieties suitable for processing were highlighted. The varieties recommended for processing were TODVAR-3, TODVAR-5, TODVAR-6, TODVAR-7, TODVAR-9, TODVAR-11 and TODVAR-12. The processed tomato contained lower level of oxalate content than the unprocessed tomato lines both in AVT I and AVT II lines. The oxalate content in unprocessed tomato in AVT I lines varied between 4.83-6.24 mg/100g which was reduced to 4.03-5.38 mg/100g after processing. TSS level in unprocessed and processed tomato lines varied 3.27-4.16% and 4.13-5.22%, respectively in AVT I and II. In another trial, for quality assessment of tomato varieties/genotypes after processing to tomato pulp, the TSS content in tomato lines under AVT-I and AVT-II varied between 3.27-4.16% and 3.73-4.35%, respectively while lycopene content in AVT-I and AVT-II lines varied between 2.11-2.46 mg/100g and 2.07-2.79 mg/100g, respectively during ripe stage of harvest.

Protection Technologies Developed (12)

Integrated Disease Management:

1. Veg 8.18. Nursery disease management using bio-agents and new fungicides

At Kanpur (T9) drenching of Fenamidone + Mancozeb @ 0.25% in the nursery may be recommended in Chilli variety G-4. At Hyderabad the same treatment i.e. (T9) drenching of Fenamidone + Mancozeb @ 0.25% in the nursery may be recommended in Chilli variety LCA- 334 and Tomato variety Arka Vikas. However, at Hyderabad in brinjal (T4) Seed treatment by talc based formulation of *Trichoderma harzianum* (Kalyanpur isolate) @ 0.4% + nursery soil application 10 g/m^2 and soil drenching @ 5% was most e ective.

At Varanasi (T1) Seed treatment by talc-based formulation of *Bacillus subtilis* (IIVR isolate) @ 0.4% + nursery soil application 10 g/m^2 and soil drenching @ 5% was best for Brinjal variety Kashi Taru; T4- bioagent *Trichoderma harzianum* (Kalyanpur isolate) for Tomato variety Kashi Aman while (T6) Seed treatment with carbendazim + mancozeb @1.5g/kg + drenching @0.1% for Chilli variety Kashi Anmol.

2. Veg 8.19. Integrated management of vector borne virus diseases of chilli

For integrated management of vector borne virus diseases of chilli in Lam, Bhubaneswar, Hessarghatta, Parbhani and Coimbatore region, application of neem cake @1.0kg/sq.mt in the seed bed, seed treatment with imidacloprid @8gm/kg, spraying of cyazpyr @1.8ml/liter 2-3 three days before transplanting, seedling dip of imidacloprid @0.5ml/L and growing of two rows of maize/sorghum as border crop in the main field along with sliver agrimulch sheet + rotational spray of insecticides (Acephate @1.5 g/L + Neem oil @2.0ml/L) + (Fipronil @1.0 ml/L + Neem oil @2.0ml/L) + (Imidacloprid @2 g/15L + Neem oil @ 2.0ml/L) + (Cyzpyr @1.8ml/L) at 7 days interval till fruit formation recommended. Residual analysis of pesticides used in this treatment has indicated that the acephate @1.5g/L, fipronil @1.0 ml/L, imidacloprid @2g/15L and cyzpyr @ 1.8 ml per liter were not detected in HPLC/GLC testing. The CB ratio varied from 1:1.9 to 1:3.1 at different centers.

3. 8.20 IDM package for tomato diseases

At Coimbatore, Parbhani and Hessaraghatta, integrated management module comprising of Covering of nursery with 40-60 mesh white nylon net until transplanting, Border crop with maize in main field Nursery treatment (application of Seed Pro bio-formulation) **i)** Seed priming @ 4g/kg, **ii)** soil application @10 g/Kg of soil while potting, and **iii)** soil drenching @5% after seed germination) and main field treatment (Seedling dip with 0.1 % (Carbendazim 12% + Mancozeb 63% WP) + spray with Acephate 75% WP @1.5 g/l on 10 days after transplanting + spray with Fipronil 5% SC @ 1.5 ml/l on 20 DAT+ spray with Copper hydroxide 77% WP (2.0 g/l) on 25 DAT + spray with imidacloprid 70% WG @ 2g / 15 l on 40 DAT + spray with Fenamidone 10% + Mancozeb 50% WDG (0.25%) two to three times from 45 DAT at 10 days intervals (T5) was found most effective in the management of tomato diseases (damping off, early blight, late blight, bud necrosis and leaf curl disease) and maximum fruit yield. Pesticide Residue Analysis for this treatment revealed that no pesticides have been detected. The C:B ratio was varied from 1:2.5 to 1:10.3. However,

at Kalyanpur T4 was most effective resulted damping off (5.8%), early blight (1.4%), mosaic (2.2%), fusarium wilt (4.3%) with collar rot (1.7%) late blight (9.5%), early blight (8.6%), mosaic (5.4%), fusarium wilt (5.5%), collar rot (4.4%) with BC ratio of 4.0 may be recommended.

4. Veg 8.21. Collection and diversity analysis of collar rot (Sclerotium rolfsii)

Ten isolates of *S. rolfsii* from Brinjal (Junagadh), Brinjal (Anand), Brinjal (Navsari), Brinjal (Bharuch), Chilli (Anand), Chili (Navsari), Chilli (Bharuch), Indian bean (Navsari), Indian bean (Bharuch) and Pigeon pea (Junagadh) have indicated no morphological difference. Molecular characterization was carried using ITS and tublin genes universal and specific primer through PCR assay at IIHR and positive amplicons were cloned and sequenced. The phylogenetic analysis indicated three distinct subgroups comprises solanaceous hosts formed one subgroup, cucurbits formed second subgroup and legumes formed third subgroup based on geographical origin and host.

5. Veg 8.22. IDM packages for cucurbit diseases

At Lam (Ridge gourd cv. Local), Junagadh (Bottle gourd cv. Pusa Naveen), Parbhani (Cucumber cv. Pune Khira) and Sabour Integrated management practice module (T5) involving growing of two rows of maize as border crops and use of agri silver mulch sheet followed by seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of captan 70% + hexaconazole 5%WP @ 0.1% 15 days after germination followed by spraying of tebuconazole 50% + trifloxystrobin 25% @1g/l + spray with (imidacloprid 17.8 SL @7.5 ml/ 15 L+ Neem oil 0.2%) followed by fosetyl-Al @ 0.1% followed by spraying of tebuconazole 50% + trifloxystrobin 25% @1g/l + spray with (imidacloprid 17.8 SL @7.5 ml/ 15 l + neem oil 0.2%) followed by fosetyl-Al @0.1% at 10 days interval was highly effective in reducing severity of damping off, Alternaria leaf blight , Cercospora leaf spot, downy mildew and mosaic diseases. Pesticide Residue Analysis for this treatment revealed that no pesticides have been detected. The C:B ratio for the above treatment was ranging between 1:1.3 to 1:17.9.

At Varanasi (Bitter gourd cv. Kalyanpur Barahmasi) and Bhubhaneswar (Cucumber cv. Kumuda) integrated module (T6) comprising of growing of two rows of maize as border crops and use of agri silver mulch sheet followed by Seed treatment with carbendazim 12% + mancozeb 63% @ 3g/kg and drenching with captan 70% + hexaconazole 5% WP @ 0.1% at 15 daysafter germination followed by spray with (imidacloprid 17.8SL @7.5ml/ 15L + Neemoil 0.2%) followed by spraying of captan 70% + hexaconazole 5% WP @ 0.1% followed by Fosetyl-Al @0.1% followed by spraying of captan 70% + hexaconazole 5% WP @ 0.1% + spray with (imidacloprid 17.8SL @7.5ml/ 15L + Neemoil 0.2%) followed by Fosetyl-Al @0.1% at 30 days drenching has recorded minimum severity of mosaic, downymildew, leaf spot, powdery mildew and collar rot diseases. The C:B ratio for the above treatment was ranging between 1:2.1 to 1:3.5.

At Vellanikkara for the integrated management of diseases of bitter gourd, (T2) seed treatment with Carbendazim 12% + Mancozeb 63% @3 g/kg and drenching of Captan 70% + Hexaconazole 5% WP @ 0.1% at 1st true leaf stage after germination, followed by 5-6 spraying of Seed Pro (1%) at 10 days interval in rotation with Neem oil (0.2%) alternatively after 15 days after drenching is found to be a effective practice with very good disease control and a CB ratio of 1:1.78

6. Veg 8.23 Biointensive management of diseases of Capsicum under protected cultivation

At Solan, treatment combination (T5) consisting of the use of seed pro @10g/kg seed for seed treatment and application of soil solarization to soil bed followed by incorporation of 5kg FYM fortified with 500g neem cake and 50 g *Trichoderma* sp.+ 50 g *Paecilomyces lilacinus*at the time of bed preparation when combined with periodic spray and drenching of Phyton @4ml/L, three times at 15 days interval beginning from 30 days after transplanting proved most effective in limiting all diseases like collar rot/root rot (2.6), powdery mildew (15.5), YLCV (14.3). Fruit yield of colored capsicum was found highest (663.95/ha) and BC ratio 9.99.

Insect Pest Management:

1. In search of new alternatives to neonicotinoid insecticides against sucking insect pests of okra, Flupyridifurone 200 SL @ 2.5 ml/l was found most promising with lowest whiteflies (4.38/3 leaves), leaf hoppers (4.86/3 leaves) accompanied with highest fruit yield (10.94 t/ha) and maximum CB ratio of 1:3.22 under Raipur condition.

2. To identify the eco-friendly and green pest management options, application of Neem seed powder extract @ 40 g/L and Diafenthuron 50 WP @ 1 g/L consistently resulted significant reduction of aphid population over control and provided significantly higher yield (193.35 q/ha and 200 q/ha respectively) in cabbage. Hence, these two treatments can be recommended for the management of cabbage pests specially cabbage aphids during Rabi season in mid hills conditions of Himachal Pradesh.
3. To promote organic pest management in okra, seed treatment with *Bacillus pumilus* 1% A.S @ 10 ml/kg seed and application of 20 tons of FYM enriched with *B. pumilus* @ 5 lit/ha recorded the maximum decrease in *M. incognita* population (67.57%) accompanied by highest yield (30.83% over control) with cost benefit ratio (1:1.93). It was at par with seed treatment with *P. putida* 1% A.S @ 10 ml/kg seed and application of 20 tons of FYM enriched with *P. putida* @ 5 lit/ha in reducing the final nematode population (66.51%) and increasing the yield (29.44% over control) and cost benefit ratio (1:1.91) under IIHR, Bangalore condition.

Breeder Seed Production

During the year 2019-20 a total of 26426.070 kg breeder seed produced against the indent of 15563.950 for 129 varieties of 34 vegetable crops by 21 coordinating centres.

During the year 2020-21, an indent of 10060.080 kg breeder seed for 125 varieties of 30 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi and the same have been allotted to 19 coordinating centres for under taking the production. A total of 4713.660 kg of Breeder Seeds has been produced in *Kharif* season against the indents. However, the final production figures are awaited from many centres.

ICAR- KRISHI VIGYAN KENDRA, KUSHINAGAR

Training Programmes : Krishi Vigyan Kendra, Kushinagar organized 70 need based On and Off–campus training programmes under human resource development comprising diverse aspects of production technologies of cereals, oilseeds, pulses, vegetables, livestock, mushroom production, soil health management, value addition, household food security, and women empowerment benefitting a total of 1957 participants comprising 409 female and 1548 male farmers, rural youth and extension functionaries in the year 2020 (Table 1 & Fig. 1&2).

Table 1: Training programmes organized

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	38	536	276	812
Rural youths	3	3	58	61
Extension functionaries	3	27	39	66
Sponsored Training	8	378	10	388
Trainings under GKRA	18	604	26	630
Total	**70**	**1548**	**409**	**1957**

Fig. 1: Training - Farm Mechanization under GKRA

Fig. 2: Training - Farm Mechanization under GKRA

Front line demonstration: Front line demonstration were conducted in 202.65 ha area with 243 units at 839 farmers field on DSR of Paddy, Mustard, Soybean, Pigeon Pea, Lentil, line sowing, zero till of Wheat, varietal evaluation of di erent crops, Sugarcane inter cropping, Seed Treatment, Fodder production, Nutritional Garden and mushroom (Table 2 & Fig. 3, 4 & 5).

Table 2: FLD organized on Crops

S. No.	Crop	Technology demonstrated	Horizontal spread of technology				
			No. of farmers	Area in ha	Demo Yield	Check Yield	Yield Increase %
1.	Mustard	Line sowing	79	25.00	13.5	9.1	48.35
2.	Soybean	Weed management	05	10.00	12.35	7.45	39.68
3.	Mustard	Varietal evaluation	67	30.00	Result Awaited		
4.	Pigeon pea	Line sowing	60	10.00	18.45	13.35	38.20
5.	Lentil	Line sowing	109	10.00	9.8	6.5	50.76
6.	Pigeon pea	Line sowing	46	10.00	Result Awaited		
7.	Lentil	Line sowing	52	10.00	Result Awaited		
8.	Wheat	Line Sowing	15	05.00	41.5	33.5	23.88
9.	Wheat	Zero Tillage	15	05.00	39.8	33.5	18.8
10.	Wheat	Seed treatment	16	4.75	43.2	36.8	17.3
11.	Paddy	Sowing with Drum Seeder	07	03.00	47.6	33.7	41.24
12.	Paddy	Sowing with Drum Seeder	06	03.00	40.2	29.3	37.20
13.	Paddy	Seed treatment	12	01.00	41.4	30.1	37.54

14.	Paddy	Scented rice	30	15.00	40.2	29.3	37.20
15.	Brinjal	Varietal evaluation	12	01.00	562.5	445.6	26.23
16.	Sugarcane	Integrated Pest Management- Light Trap	05	01.23	845.4	757.6	11.58
17.	Sugarcane	Integrated Pest Management- Tricho card	05	2.63	874.3	801.7	9.1
18.	Brinjal	Integrated Pest Management- Light Trap	05	1.04	565.7	514.4	9.97
19.	Banana	Integrated Nutrient Mgt.	35	50.00	725.35	375.75	93.04
20.	Sugarcane	Intercropping	15	05.00	861.75	575.85	46.65
21.	Berseem	Fodder Production	22	22	7.343	6.425	14.29
22.	Supplementary feeding	Wheat flour +Green gram flour +Till(70:25:05)	69	69	Avg. Height-104.57	Avg. Height-98.1	6.6% in height,
					Avg.Weight-18.5	Avg.Weight-14.18	30 % in weight
23.	Mushroom	Button Mushroom	12	12 unit	7 kg	-	100
24	Nutritional garden	Nutritional garden (Rabi 2019)	15	15 (150 m^2)	469	382	22.78
25.	Nutritional garden	Nutritional garden (Zaid 2020)	17	17 (150 m^2)	401	318	26.1
26.	Nutritional garden	Nutritional garden (Kharif 2020)	08	08 (150 m^2)	341.9	301.7	13.32
27.	Nutritional garden	Nutritional garden (Rabi 2020)	100	100 (50 Sq. M)	132	98	34.69
		Total	**839**	**202.65 ha (243) unit**			

Fig. 3: CFLD on Lentil

Fig. 4: FLD on Paddy Drum Seeder

Fig. 5: CFLD on Lentil

Technology Assessment and Refinement

Intercropping of cauliflower with banana for increasing income per unit area: Krishi Vigyan Kendra, Kushinagar conducted On farm trial in year 2019-20 on effect of intercropping of cauliflower (Kashi Gobhi 25) with banana (G-9) at four selected farmer's field to enhance the total income per unit area of the farmers. Result showed that (T_1) i.e., intercropping of cauliflower (Kashi Gobhi 25) with banana (G-9) gave higher yield i.e.781.2q/ha with B.C. ratio 2.49:1 in comparison to banana cultivation as mono-cropping (G-9) (T_0) i.e. 535.0q/ha with B.C. ratio 1.99:1 (Fig. 6, 7 & 8).

Fig.6: Standing Crop of Banana with Cauliflower intercrop

Fig.7: Harvested Cauliflower

Fig.8: Fruiting in Banana

- **Management of False smut in paddy:** Krishi Vigyan Kendra, Kushinagar conducted On farm trial in year 2020 on judicious use of agrochemicals at selected farmer's field to reduce the damage to paddy as a result of false smut and thereby enhance the total income per unit area of the farmers. Result showed that Propiconazole @ 1ml/ltr 15 days to flowering and later on need based application later on (T_1) gave higher yield i.e. 42.78q/ha with B.C. ratio 1.82:1 in comparison to Injudicious use of agrochemicals by farmers (T_0) i.e. 33.45q/ha with B.C. ratio 1.43:1.
- **Preservation of Vegetable Pea:** Krishi Vigyan Kendra, Kushinagar conducted on farm trial on preservation of vegetable pea at 15 farm women home in the march 2020, in which in the trial one, Pea was blanched for 2-3 minute in boiling water and rinsed in cold water and kept in 0.5% preservative for one hour and then sun dried. In trial two, the pea was blanched for 2-3 minutes in boiling water and rinsed in cold water and then kept in 0.5 % preservative solution for one hour and then freeze dried. It was observed that fresh pea had the shelf life of 6-7 days and the sun dried peas had the shelf life of 210 days while the freeze dried peas had the shelf life of more than 270 days. The organoleptic evaluation showed that sun dried peas was neither liked nor disliked but the freeze dried peas were liked very much (Fig. 9, 10 & 11).

Fig. 9: Peeling of Pea

Fig. 10: Cooling after blanching

Fig. 11: Showing to Farm women

- **Control of mortality in newly born calves in dairy animals:** Krishi Vigyan Kendra, Kushinagar conducted On Farm Trial on 10 calves to control mortality in newly born calves due to endo-parasites during the year 2019-20. In the trial one no use of dewormer was done while in trial two Deworming (Albomar) Ist dose – after one week of calving – 15 ml , IInd dose after 21 days – 15 ml , IIIrd dose after 60 days – 20 ml & IVth dose after 90 days – 30 ml was given. The result showed that trial two recorded 0.0% mortality of newly born calves.

Extension Activities

To expedite the process of transfer of technology programme the KVK, organized 5 kisan gosthis where in 411 farmers participated. KVK participated in 5 exhibitions for awareness creation of farmers benefitting a total of 3225 farmers. A total 327 scientific visits to farmer's field visits by KVK officials and 183 diagnostic visits were made by the KVK scientists and S.M.S. for the benefit of 3016 farmers. One soil health campaign was undertaken to benefit 20 farmers. 77 lectures were delivered as resource person benefitting more than 5510 farmers of kushinagar and adjoining districts. 5341 farmers visited KVK during January to December 2020. (Fig. 12, 13 & 14).

Fig. 12: Best KVK award by NRC Banana

Fig. 13: Mahila Kisan Diwas at KVK

Fig. 14: World Soil Day at KVK

Table 3: Mobile Advisory Services

No. of SMSs sent	No. of farmers benefited
522	3029

Table 4: Seed and Planting Material

Particular	Quintal/Number	Farmer
Seed (q)	2780.49	503
Planting material (No.)	15672	1310
Value added product (kg)	119	59
Bio-Products (kg)	30	01
Livestock Production (No.)	25	02

ICAR-KRISHI VIGYAN KENDRA, DEORIA

Krishi Vigyan Kendra, Deoria, provided training programmes, on-farm trails, frontline demonstrations, and other extension activities based on the priority areas identified following a survey of agricultural communities. Selected programmes were organized

thematically on HYV promotion in cereal, oilseed, pulses, vegetable & fruit crops, promotion of farming system approach for sustainable agriculture, integrated pest management, integrated nutrients management, and resource conservation technology, entrepreneurship development in mushroom cultivation, beekeeping, boiler production, vermi-compost production, and so on. During the COVD-19 pandemic, a lot of farm advice on various crops and associated enterprises were issued to farmers via internet and print media.

Training programmes

To enhance the income of agricultural communities, a total of 35 training courses, both on and off campus, in various subject areas were arranged, with 1185 farmers and farm women benefiting. In addition, 18 agricultural entrepreneurial training programmes for migrant labour/rural youth were created, with 215 rural youth participating. Thus, a total of 53 training programmes were held, with a total of 1838 participants being trained and benefiting from various technologies for agricultural and allied enterprises.

Table 5: Details of On and off campus Training Programmes

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	10	248	57	305
Rural youths	3	42	21	63
Extension functionaries	3	36	102	138
Vocational Training	19	583	96	679
Migrant labour	18	559	94	653
Total	**53**	**1468**	**360**	**1838**

OFT (On Farm Trials): Two On Farm Trails (OFTs) were conducted on 16 farmers field at adopted villages of KVK, Deoria for assessment of selected technologies on agriculture and allied field.

OFT 1. Problem definition: Low yield in pigeon pea due to low moisture during pod filling.

Technology assessed or refined (as the case may be): Irrigation Management in Pigeon pea at Pod Formation Stage.

KVK, Deoria, Uttar Pradesh performed an on-farm trial to evaluate Irrigation Management in Pigeon Pea during the Pod Formation Stage at the 5 deference site. The results showed that irrigation at the pod formation stage in raised bed sown pigeon pea crop increased yield by 36.16 percent over no irrigation at the pod formation stage and 17.87 percent over irrigation at the pod formation stage in broadcasted pigeon pea crop.

Fig. 15: OFT on Pigeon Pea

OFT 2. Problem definition: Low income due to sowing of Sugarcane as mono crop.

Technology Assessed or Refined: Intercropping of Cowpea in spring sown Sugarcane

Today, intercropping plays a great importance on uplift of economic status of farmers. The KVK, Deoria, U.P. laid out an on-farm trail on intercropping of cowpea with spring sown sugarcane to assess the increase in income through intercropping. The intercropping of cowpea in double row with sugarcane sown through trench method gave maximum yield of sugarcane (896.85q/ha.) and cowpea (78.3/ha) along with highest B:C ratio (4.81). It is also observed that due to intercropping of cowpea

Table 6: Effect of irrigation at pod formation stage in pigeon pea

Crop	Thematic Area	Technology Option	No. of trials	Yield (qt/ha)	% Increase in yield over farmer's practice
Pigeon pea	Yield loses due to lack of moisture at pod formation stage	T1-No irrigation at pod formation stage	05	11.2	-
		T2-Irrigation at pod formation stage in broadcast sown		13.2	17.87
		T3-Irrigation at pod formation stage in raised bed sown		15.25	36.16

Table 7: Intercropping of Cowpea with Spring sown Sugarcane

Technology Option	No. of trials	Sugarcane Yield q / ha	Cowpea yield q/ha	Cost of cultivation in Rs. / unit	Total return in Rs. / unit	Net Return in Rs. / unit	B:C Ratio
Farmers practice (Sugarcane).	11	726.34	-	68390	236060	167670	3.45
Sugarcane + Cowpea as two row intercrop.		896.85	78.3	84870	408926	324056	4.81

which is a leguminous crop the yield of sugarcane also increased 23.47 percent over check in double row planting of cowpea.

C. Front Line Demonstration: FLD programmes for oilseed, pulses, cereals, and vegetable crops, as well as CFLD for pulses and oilseeds, were carried out this year in 309 beneficiary farmer fields totaling 98.8 ha.

Table 8: Details of Front Line Demonstration

Enterprise	No. of Farmers	Area (ha)
Oilseeds	98	25
Pulses	112	53.47
Cereals	39	15.25
Vegetables	60	5.08
Total	**309**	**98.8**

Table 9: Performance of Frontline demonstrations, Frontline demonstrations on oilseed crops

Crop	Thematic Area	Technology demonstrated	Variety	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase in yield	BCR (R/C)	
						Demo	Check		Demo	Check
Groundnut (Kharif 2020)	Varietal Evaluation	Introduction of HYV	HNG 123	73	15	17.20	13.10	31.30	2.67	2.09
Mustard (CFLD 2019-20)	Varietal Evaluation	Introduction Of HYV	RH 749	25	10	23.25	16.5	40.9	3.10	2.28

Fig. 16: CFLD on Mustard Var. RH 749

Fig. 17: CFLD on Groundnut Var. HNG 123

Table 10: Frontline demonstration on pulse crops

Crop	Thematic Area	Technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase in yield	BCR (R/C)	
					Demo	Check		Demo	Check
Pigeon pea (CFLD Kharif 2019)	Integrated crop management	HYV IPA 203	64	20	10.4	7.6	36.8	2.06	1.57
Chickpea (CFLD Rabi 2019-20)	Integrated crop management	HYV JG 14	79	15.56	10.1	8.4	20.23	1.46	1.31
		HYV GNG 1581	14	3.53	10.4	8.4	23.8	1.51	1.31
		HYV Ujjwal	8	3.38	9.2	8.4	9.5	1.33	1.32
Lentil (CFLD Rabi 2019-20)	Integrated crop management	HYV IPL 316	47	10	16.3	12.5	30.6	2.29	1.83

Fig. 18: CFLD on Chick Pea Var. GNG 1581

Fig. 19: CFLD on Pigeon Pea Var. IPA 203

Fig. 20: CFLD on Lentil Var. IPL 316

Table 11: 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
Cereals									
Paddy (Kharif 2020)	Resource Conservation	Direct Sowing of Rice (Var. PS 2511)	13	5	62.8	56.8	10.56	3.23	2.71
Paddy (Kharif 2020)	Integrated crop management	Introduction of HYV (PS 1850)	2	0.25	53.6	46.7	14.77	2.72	2.53
Paddy (Kharif 2020)	Integrated crop management	Introduction of HYV (PS 2511)	4	1.0	56.8	46.7	21.62	2.71	2.53
Wheat (Rabi 2019-20)	Resource Conservation	Zero tillage sowing of HYV HD 2967	12	5	52.4	46.2	13.41	2.55	1.92
		Introduction of HYV HD 2967 with line sowing	8	4	53.1	46.2	14.93	2.21	1.92
Vegetables									
Cowpea (Zaid 2020)	Integrated crop management	Introduction of HYV (Kashi Kanchan)	19	2	154.2	132.40	16.64	3.81	3.41
Ridge gourd (Satputiya) (Zaid 2020)	Integrated crop management	Introduction of HYV (Kashi Khushi)	21	**1.08**	**252.6**	**206.4**	**22.38**	**4.38**	**3.65**
Okra (Zaid 2020)	Integrated crop management	Introduction of HYV (Kashi Pragati)	20	**2**	**152.6**	**125..20**	**21.88**	**4.75**	**4.03**

* Economics to be worked out based total cost of production per unit area and not on critical inputs alone.
** BCR= GROSS RETURN/GROSS COST

Fig. 21: Direct Sowing of Rice (Var. PS 2511)

Fig. 22: Zero tillage sowing of HYV HD 2967

Fig. 23: HYV HD 2967 with line sowing

Fig. 24: FLD on HYV (Kashi Kanchan)

Fig. 25: FLD on HYV (Kashi Pragati)

D. Extension Activities: During the fiscal year under review, the KVK organized 335 extension events, which included advising services, diagnostic visits, Kisan Ghosthi, exhibitions, method demonstrations, and celebrations of important and special days. In addition, an extension bulletin on "Arhar utpadan ki unnat takneek" was issued under CFLD, as were two radio talks, three popular articles, and 52 newspaper articles published. During the COVID-19 lockdown, a total of 55 alert messages were issued over social media, benefiting approximately 6000 farming communities.

Production of Seed / Planting Material and Bio-Products: During the fiscal year, 36.75 q cereals, pulses, oilseed, and vegetable seeds, as well as about 88000 vegetable seedlings and fruit plant saplings, were produced and distributed.

Table 12: Detals of Extension Programmes

Activities	No. of Programmes	No. of farmers	No. of Extension Personnel	Total
Advisory Services	226	226	16	242
Diagnostic visits	70	150	5	155
Kisan Ghosthi	2	141	20	161
Exhibition	6	15000	60	15060
Method Demonstrations	26	197	10	207
Celebration of important days	2	174	2	176
Special day celebration	3	75		72
Total	**335**	**15963**	**113**	**16073**

Fig. 26: Field Visit by Director ICAR-IIVR, Varanasi

Fig. 27: Farmer Visit KVK Farm

Fig. 28: Line Department visit KVK Farm

Fig. 29: Organize Gosthi for Poshan Mah Sept. 2020

Fig. 30: Organize Virtual Training Programme on Zoom Meeting

Fig. 31: Organize Virtual Training Programme on Zoom Meeting

Table 13: Production of seeds by the KVK

Enterprise	Name of crop	Name of Variety	Quantity (q)	Value (Rs)	Distributed to No. of farmers
Cereals	Wheat	DBW 187	7	22400	20
		PBW 550	3	9000	8
		PBW 725	2	6000	7
		HD 2967	10	30000	35
	Paddy	HUR 917	2.54	8124	26
		PS 2511	5.545	19962	76
		Kala Namak	2.16	7776	36
		Pusa Sambha 1850	0.29	899	5
		CO 51	1.16	3596	16
	Total		**33.695**	**107757**	**229**
Oilseeds	Mustard	Giriraj	1.1	8800	65
		RH 749	0.5	4000	32
	Total		**1.6**	**12800**	**97**
Pulses	Pigeon pea		0		
	Lentil	Pusa Shiwalik	0.8	6400	12
	Total		**0.8**	**6400**	**12**
Vegetables	Vegetable Pea		0		
	French bean	Kashi Param	0.44	1320	3
	Other (Spinach)	All Green	0.01	250	1
	Other (Spong Gourd Seed)	Kashi Divya	0.03	3000	1
	Total		**0.48**	**4570**	**5**
	Grand Total		**36.575**	**131527**	**343**

Table 14: Planting Material Production

Enterprise	Name of crop	Name of Variety	Quantity (No.)	Value (Rs)	Distributed to No. of farmers
Vegetables	Brinjal	Kashi Uttam	9210	6094	157
		Kashi Sandesh	2380	1666	11
	Chilli	Kashi Anmol	7799	6166	158
	Tomato	Kashi Aman	9775	7727	185
	Cabbage	Hybrid	1550	1220	28
	Cauliflower	Kashi Gobhi -25/ Hybrid	9166	6825	117
	Broccoli	Hybrid	640	512	11
	Onion	ALR	46350	15450	82
	Cucumber	Swarna Ageti	125	625	19
	Bottle gourd	Kashi Ganga	119	595	26
	Bitter gourd	Kashi mayuri	330	2457	46
	Satputia	Kashi Khushi	13	104	3
	Sponge gourd	Kashi Divya	210	1050	31
	Pumpkin	Kashi Harit	53	265	12
	(Ridge gourd)	Kashi Jyoti	90	450	14
	Others	-	225	180	6
	Total		**88035**	**51386**	**906**
Fruits					
	Litchi	Shahi	20	1200	10
	Papaya	-	224	2240	39
	Lemon	-	3	150	3
	Others (Moringa)	-	81	810	31
	Total		**328**	**4400**	**83**
Ornamental	Marigold	-	80	64	2
	Total		**80**	**64**	**2**
	Grand Total		**88443**	**55850**	**991**

ICAR- KRISHI VIGYAN KENDRA, BHADOHI

Training Programme: KVK-Bhadohi conducted 97 training programme to farmers, rural youths and extension personnel to orient them in the frontier areas of technology development under cereals, oilseeds, pulses, vegetables, fruits, livestock and home science covering a total of 2072 beneficiaries including 1468 male and 604 female participants (Table 15 & Fig. 32&33).

Table 15: Training programmes organized

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	86	1364	483	1847
Rural youths	05	35	35	70
Extension functionaries	06	69	86	155
Sponsored Training	0	0	0	0
Vocational Training	0	0	0	0
Total	**97**	**1468**	**604**	**2072**

Front Line Demonstration: A total of 18 front line demonstrations (FLDs) on pulses, oilseeds, paddy, wheat, vegetables and fodder crops were conducted in 119.05 ha area in order to establish the production potential of improved technologies at the 412 farmers' fields (Table 16 & Fig. 34 & 35).

Fig. 32: Extension functionaries Training

Fig. 33: Training on Mushroom Production

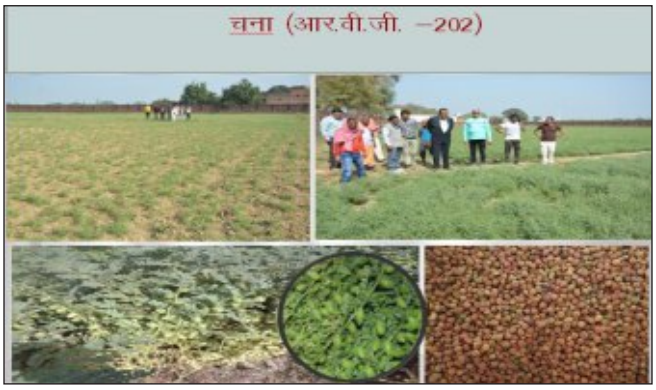


Fig. 35: CFLD on Chick Pea (RVG-202)

Table 16: Front Line Demonstration on crops (Jan-2020 to Dec. 2020)

Crop	Variety	No. of Farmers	Area (ha)	Yield (q/ha)				% Increase in yield
				Demo			Check	
				High	Low	Average		
Mustard	RH-749	45	20.0	24	16	80	22	41.02
Mustard	Pusa Tarak	35	7.5	18	15.7	16.2	15.6	3.85
Pigeon Pea	NDA-2	30	10.6	9.4	6.6	7.2	5.4	33.33
Pigeon Pea	NDA-2	28	10	21.7	11.5	17.2	10.3	66.99
Moong	IPM-2-3	27	10.0	9.5	6.8	7.2	6.3	14.29
Chickpea (2019-20)	JG-14	27	10.0	8.4	6.8	7.7	5.8	32.76
Chickpea	RVG-202	30	10	23.3	17.7	21.2	15.9	33.33
Field pea	IPFD 10-12	41	10.0	10.9	7.8	8.5	7.4	14.86
Lentil (2019-20)	IPL-316	20	10.0	11	7.2	8.0	6.8	17.64
Lentil (2019-20)	L-4147	02	0.25	11.5	7.0	8.4	6.8	23.53
Lentil (2020-21)	IPL-316	26	10.0	11.8	7.4	8.8	7.3	20.54
Paddy (P-2511)	P-2511	15	2	62	44	50	33	51.51
Paddy (PS-1850)	PS-1850	04	0.5	64	51	55	50	10
Wheat	HD-2967	25	3.2	51.20	38.50	42.5	32.7	29.7
Bajra	NBH-4903	11	2.0	22.5	15.5	20.2	15.2	32.89
Tomato	Kashi Aman	23	1.0	470.6	373.2	432.8	260.4	66.21
Vegetable pea	Kashi Mukti	40	1.0	138.20	103.8	122.5	111.6	9.77
Cowpea	Kashi Nidhi	33	1.0	115.70	71.0	89.6	65.6	36.0
Total	**18**	**412**	**119.05**					

Fig. 34: CFLD on Mustard (RH-479)

Front Line Demonstration on Livestock

Under livestock production, a total 04 demonstrations were conducted on disease management in dairy animals and sheep & goat at (Table 17).

Fig. 36: Deworming of Goat for selective breeding

Fig. 37: Vaccination in Cattle and Buffalo against H. S.

FLD on Other Enterprise

A total no. of 03 demonstrations on kitchen gardening under nutritional security for women empowerment conducted at 30 farmers' field respectively as details given in table 18.

Table 17: Front Line Demonstration on livestock

Category	Thematic Area	Name of the technology demonstrated	No. of Farmers	No. of Units (Animal/ Poultry/ Birds, etc)	Major parameters		% change in major parameter
					Demo	Check	
Cattle & Buffalo	Disease Management	Control of endo-parasite	32	68	98 % animal disease free	45% animal disease free	53
Sheep & Goat	Disease Management	Control of liver fluke endo-parasite	36	2098	91% animal disease free	55% animal disease free	36
Cattle & Buffalo	Disease Management	Control of ecto-parasite	49	49	69 % animal disease free	25% disease free	44
Cattle & Buffalo	Disease Management	Vaccination against Contagious disease	27	52	72% animal disease free	37% disease free	35
Total	4		144	2267 animal			

Table 18: FLD on Nutritional Security

Category and Crop	Thematic area	No. of Farmer	No. of Units	Yield (Kg)		% change in yield
				Demonstration	Check	
Rabi (November, 2019- March, 2020)	Nutritional Security	10	10	2010	1650	21.81
Zaid, 2020	Nutritional Security	10	10	749	596	25.67
Kharif, 2020	Nutritional Security	10	10	781	693	12.69

Table 19: FLD in Plant Protection

Category & Crop	Thematic Area	Name of the technology	No. of Farmers	Area (ha)	Yield (q/ha)				% Change in Yield
					Demo			Check	
					High	Low	Average		
Paddy	IDM	Seed treatment with Carbedazim @ 2.5 gm/ kg seed + Spraying of Propiconazole 25%EC @ 0.1% during panicle initiation (booting stage/ initiation of 5% Ear) for false smut	4	0.5	55	50	51	45	13.33
Okra	IPM	•Tolerant variety • Sticky trap • Use of neem	11	0.5	149.30	117.80	136.60	107.20	27.40
Brinjal	IPM	• Regular clipping of infested twigs and fruits • Installation of pheromone traps, sticky tra • Need based use of pesticides	13	1.0	308	282	295	251	17.5

Category	Name of the technology demonstrated	No. of Farmer	No.of units	Major parameters		% change in major parameter	Other parameter		Economics of demonstration (Rs.) or Rs./unit			
				Demo	Check		Demo	Check	Gross Cost	Gross Return	Net Return	BCR (R/C)
Oyster Mushroom	Production of oyster mushroom	14	14	75 Kg/100 Kg wheat straw	-	-	1.5kg/ bag (of 2 kg)	-	105090*	300000	194010	2.85:1

Fig. 38: Nutritional Garden under NARI

Fig. 39: FLD on Nutritional Garden

Fig. 40: Mushroom Production under FLD

Fig. 41: FLD Tomato and Cow Pea

Technology Assessment and Refinement: A total of numbers of 09 On Farm trials (OFTs) were conducted in different villages of KVK Bhadohi for assessment of selected technologies in agriculture & allied subjects. \

- ***Performance of Turmeric as inter crop in mango*:** The turmeric variety Megha was sown in month of April. At the time of harvesting yield was recorded 160.3 q/ha and net income was Rs. 160300.00 / ha as additional income after the new intervention of intercropping in mango orchard. Whereas farmers practices they using orchard for mango production. The cost benefit ratio was calculated 2.22.
- **Performance of cowpea as inter crop in sugarcane:** To promote the inter cropping in Surgarcane crop with cowpeas as a intercrops. The cowpea variety Kashi Nidhi was shown in month of February. At the time of harvesting yield was recorded 62.6 q/ha and net income was Rs. 112680.00/ha as additional income after the intervention of intercropping in sugarcane. Whereas farmer practices was using sugarcane production only. The cost benefit ratio was calculated 3.46.
- **Improvement of local goat breeds in bhadohi district by selective breeding:** A trial were conducted at 22 farmers fields in 22 goat flocks and regular deworming and vaccination were recommended by the training programme. To find out suitable method for improvement of goat breed as the recommended practice could not improve the breed of goat and kidding size. The technology

recommended was fine-tuned by selective breeding of improve and healthy breeding in a herd and allow them to bred other neighbor herd in the village. The result were observed that the twining and singlet rate were 31 and 53 in treatment group as compared to the farmers practices as the twining and singlet rate were 10 and 77 percentage respectively. The income per flock per year were recorded was Rs. 3200.00 in farmer practices in comparison to treated group 7800.00.

- **Improvement of fertility by uses of UMMMB and dewormer supplementation in dairy animals due to deficiency of micro and macro nutrients:** In dairy cattle due to deficiency of micro and micro nutrient the animals does not come into heat & show the estrus, which is a great loss for the dairy owners. Keeping in view UMMM- Azolla Block (Urea Molasses Mineral Mixture Azolla Block) were used to activate the hormones responsible for the cycle again with normal physiology. Under trial 81.8% animals come into heat & conceived as against 10 percent in farmers practices. In lactating animal the use of UMMM Azolla Block daily the milk production were increased about 1.03 litre per day per animal. The additional cost Rs. 10 per day/ animal against farmers practices.
- **Management of pod borer in Pigeon Pea-** Pigeon 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 @ 100 gm/ha reduced the percentage of pod damage from 17 to 6.4 and yield was increased by 13.9%.
- **Management of little leaf in Brinjal:** Brinjal (eggplant) is an important vegetable crop of Eastern Uttar Pradesh and high incidence of little leaf disease resulting in yield loss. Kashi Uttam variety of brinjal were assessed with the Seed treatment with tetracycline @ 500 ppm for 20 minutes + spray of tetracycline @ 500 ppm + spray of thiomethaxam @ 1 gm/5 liter water reduced the percentage of disease incidence from 34 to 3 and yield was increased by 35.1%.
- **Enhancing health status of farm women with use of Ragi (Finger Millet):** An On Farm Trial at 05 farm women's field were conducted. A pre interventional test was conducted to find out calcium level in the body. Blood samples were collected and analysed. On the basis of report, 05 farm women selected whose calcium content in the body was low (average 08.88 mg/dl). Their calcium level was much lower than the normal range. Ragi has the highest calcium content (344mg/100gm) among all the grains currently found. Farm women were introduced to ragi flour in their diet at the rate of 100gm/day for 30 days daily. The blood test were conducted for analysis of Calcium level observed that the average range of calcium level in blood were 9.46mg/dl. The results were very satisfactory; their calcium level was in the normal range. Average calcium range of all the beneficiaries was 09.46 mg/dl.
- **Enhancing nutritional status of farm women with use of Bajra (Pearl Millet) and fortification in wheat:** An On Farm Trial were conducted at 10 farm women's field. A pre interventional test was conducted to find out the haemoglobin level in the blood. Blood samples were collected for analysis of haemoglobin level in blood. On the basis of report, 10 farm women were selected whose haemoglobin content in the body was low as the Haemoglobin content was observed at average range 10.68 gm/dl. Haemoglobin level was much lower than the normal range value. Bajra (Pearl Millet) is the rich source of iron content (8.0mg/100gm) after rice bran and rice flakes. Farm women were also introduced fortification in wheat with Jau atta and Flax seed powder. Farm women were also encouraged to include iron rich food items like beets and amaranth etc. to enhance iron content that increase the formation haemoglobin in the body. Farm women were recommended to take fortified wheat flour (Wheat flour @ 45gm/day, Gram Flour @50gm/day and Flax seed powder @5gm/day) @ 100gm/day and Bajra flour @50gm per day for a period of 30 days and also advised to take vitamin c after having iron rich diet. After a month of trial a subsequent test was conducted to find out the haemoglobin level in the body. Their blood samples were collected for analysis of haemoglobin level. The results were very satisfactory because their haemoglobin level was in the normal range. Average haemoglobin level in all the beneficiaries was 11.76mg/dl.

Fig. 42: OFT- Evaluation of Cropping system

Fig. 43: OFT- Intercropping of Cowpea in Sugarcane

Fig. 44: OFT- Urea Molasess Mineral Mixture Block

Fig. 45: Control of Little leaf in Brinjal

Extension programmes: Extension programme were conducted to disseminate and popularize improved agricultural technology for the benefit of the stakeholders of the farming community. During the period under report KVK has organized 07 special days like International Womens Day, Kisan Diwas, Mahila Krishak Diwas, Poshan Abhiyan and COVID-19 Awareness Programme involving 359 beneficiaries. For the dissemination of the technology KVK has organized 07 field days on Vegetable Pea (Kashi Mukti), Paddy (P-2511), Mustard (RH-749), Lentil (IPL-316) and Field Pea (IPFD-10-12), where 295 farmers & farm women participated. Besides these, KVK organized PM Live stream for Kisan Samman Nidhi, Exhibition, Krishak Goshthi, World Soil Health Day, Field Visit, Diagnostic Visits and Film Show, Animal Health camp benefitted 4332 farmers. In category of other extension programme 291 newspaper coverage published, 01 Radio Talk and 41 Popular Article were published. (Fig. 46-51).

Fig. 46: International Women's Day Celebration

Fig. 47: Plantation by Honorable MLA Aurai

Fig. 48: Diagnostic Visit

Fig.49: Fish Spawn under IFS

Fig.50: Poshan Maah Celebration

Fig. 51: World Water Day Celebration

Institutional Activities

INSTITUTIONAL ACTIVITIES FOR TRANSFER OF TECHNOLOGIES

Promotion of Vegetable-based farming systems under NEH Component

The NEH region is having hills and mountain ecology; soils are mostly acidic in nature. The Agro-ecosystem is fragile with problems of soil erosion and high rainfall. Overall, the Agro-ecosystem is not very conductive for agricultural development. The farmers are mostly resource poor and tribal and their socio-economic

condition is not so good for taking scientific agriculture for making farming with modern practices. Under this situation needs were felt to provide farmers input and technical support for enhancing productivity and profitability from farming. More than 80 % of farmers in this region are small and marginal. Considering the above, a project entitled "Promotion of Vegetable-based farming systems for tribal and resource poor farmers of

NEH region" was developed and implemented in Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Sikkim, Meghalaya and Tripura under the support of NEH scheme which resulted in increase in vegetable productivity by 60-80% and resource use e ciency by 40-60% in the region. The farmers of all eight states of NEH Regions viz., Meghalaya, Mizoram, Manipur, Arunachal Pradesh, Nagaland, Tripura, Assam and Sikkim were given critical inputs for vegetables production along with skill development trainings in area of vegetable farming, kitchen gardening and associated income generating activities which could enhance their capacity for adopting the improved production technology.

Livelihood Security of Tribal under Scheduled Tribes Component (Earlier Tribal Sub Plan)

Chopan block of Sonbhadra district, Uttar Pradesh have high tribal population (1,35,261) with 22,263 households. The primitive tribe habitats are Chero, Bhaiga, Agaria, Gaur, Kharwar, Panika & Pathari. The major constrains of that area is scanty irrigation water due to undulated and hilly land, unavailability of quality seed and planting materials, poor technical knowhow and illiteracy. Under Tribal Sub Plan, ICAR-IIVR has adopted 1512 tribal households from 14 villages namely Salaivanwa, Dahkudandi, Sanathdandi, Dhawaidandi, Hetwa, Sarpatwa, Vashuda & Bhakshiva from Kota

Gram Panchayat and Bhalukudar, Badera, Madaria, Kekrahuwakheri, Satdwari & Peprahwa from Padrach Gram Panchayat. Keeping in mind nutritional security of the tribal families 1750 kitchen garden packets were provided during Kharif and Rabi season. Apart from kitchen garden seeds, demonstrations for commercial adoption were conducted for cowpea var. Kashi Kanchan in 2.5 ha, Bottle gourd var. Narendra Rashmi in 3.5 ha, Pea var. Kashi Mukti in 2.5 ha, Tomato var. Kashi Aman in 4.5 ha, Elephant Foot Yam (Gajendra) in 0.5 ha and Turmeric (Megha-1) in 0.25 ha. area which resulted in average yield increase by 12 to 27 % in di erent crops over local practicing varieties. Further, considering water scarcity, short duration and less water required paddy var. DRR Dhan-44 and CRR Dhan were demonstrated in an area of 6.5 ha and 7.0 ha respectively which not only fetched 18.3 % higher yield but also the grain quality is much more better than other practicing variety in the area.

Livelihood Security of Scheduled Caste under Scheduled Castes Sub Plan (SCSP) Component

"Scheduled Castes Sub-Plan" has been implemented by ICAR-IIVR among 1574 SC families from 31 villages in 07 clusters of Varanasi, Mirzapur, Sonbhadra and Chandauli districts of Uttar Pradesh with an objective to promote economic development through family-oriented improved agricultural technologies. During 2020, despite of COVID pandemic, scientists of the institute were regularly visiting their villages apart from technical discussions and field demonstrations; they were creating awareness among villagers towards COVID-19 and suggesting them to follow COVID guidelines. During this pandemic year 1900 kitchen garden seeds packets were provided to SC farmers in di erent selected districts. Apart from kitchen garden, demonstrations of successful technologies like cowpea (Kashi Nidhi) in 11.3 ha, pumpkin (Kashi Harit) in 4.2 ha, okra (Kashi Kranti) in 6.2 ha, tomato (Kashi Aman) in 16.3 ha, elephant foot yam (Gajendra) in 2.25 ha and turmeric in 1.5 ha area were conducted for economic development among selected clusters which fetched an average increase of yield upto 23.1%. During Rabi 2020, demonstrations of wheat variety HD 2967 was conducted at 384 farmers' field in an area of 75 ha which not only help the farmers for seed replacement but also better quality of grains.

Institute's Visit by Hon'ble MP of Gondia (Maharashtra)

Shri Sunil Baburao Mendhe, Hon'ble Member of Parliament, Bhandara - Gondia (Maharashtra) visited the institute in Varanasi with a group of farmers on 14th January 2020. They interacted the scientists at the institute's Research Farm for knowing the improved technologies related to vegetables. Speaking to the scientists he said that advanced technologies developed by scientists should be displayed in the farmers' field on a pilot basis so that farmers could increase the productivity of vegetables at lower cost. Chemicals should be used judiciously to increase vegetable productivity and prevent toxicity to human health. Shri Mendhe emphasised about market information and market intelligence for benefiting the farmers and reducing post-harvest losses.

Organized Solanaceous Field Day for Commercialization of Improved Varieties

The solanaceous field day was organized by the ZTMU, ICAR-IIVR, Varanasi on 18th January, 2020 for demonstration and commercialization of tomato, brinjal and chilli species and upgraded materials developed at the Institute. The event was attended by 35 representatives of 19 major private sector seed companies like Sungro, Sakata, Cauvery, Nath Biogenes, Meta Helix, HM Claus, Kisan Crop, Eagle,

East West, Tashita Agrotech, Ruchi Hrich, Rishiraj, Noble, Safal, Bombay Super, Seed Work, Dinkar, Indigo and Indo- American Seed Company. The event was inaugurated by Dr. Pritam Kalia, Member of Quinquennial Review Team (QRT) of the Institute. The event showcased various improved varieties of brinjal, chilli and tomato 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.

Implementation of 3rd Phase of Constitution Day Campaign

The Constitution Day Campaign-III was organized on 20th January, 2020 at ICAR-Indian Institute of Vegetable Research, Varanasi on the occasion of 70th anniversary of Constitution Day. Scientists/o cers/sta of the Institute participated in the event. Dr. Rajesh Kumar, Principal Scientist delivered a talk on new Seeds Bill, 2019. He said the Union Government is likely to introduce the Seeds Bill, 2019 in the near future. The government, however, has sought suggestions from the people on the draft bill. The objective of the Bill is to regulate the

quality of seeds sold to farmers, import and export good quality seeds as well as facilitate production and supply of quality seeds.

Republic Day celebration at ICAR-Indian Institute of Vegetable Research

Republic Day was celebrated with great enthusiasm at the institute's campus on 26th January, 2020. Scientists/o cers/sta and students of the Institute participated in this programme. Dr. S.K. Verma, Director-in-Charge of the Institute explained the importance of the Republic day, the structural history of the Constitution and how the country adopted it. He said

that India is a republic country whose Constitution is the largest written Constitution in the world, which took 2 years, 11 months and 18 days to write. The Constitution is like a backbone for a democracy which helps in maintaining the country's judicial system in a better way and can also be amended appropriately for the welfare of the people if required. He also highlighted the achievements of the Institute.

Implementation of Phase IV of Constitution Day Campaign

ICAR-Indian Institute of Vegetable Research, Varanasi, in the presence of the o cers/employees of the Institute,

concluded the Constitution Day campaign-fourth phase on 19th February 2020. Dr. A. N. Tripathi delivered a talk on "Constitution and civic duties, land laws and reforms". Dr. Jagdish Singh, Director of the institute said that our country is a symbol of unity in diversity and our Constitution has been framed systematically under which rights as well as fundamental duties have been incorporated. He explained the responsibilities of a citizen and duties for his country for compliance and achievement of objectives of the Constitution. At the same time, the protection of natural resources is also the responsibility of the people.

Training cum Awareness Programme organized under SCSP and NICRA Project

Training cum Awareness Programme for farmers was organized by Indian Institute of Vegetable Research under Schedule caste Sub Plan and NICRA Project at Badagaon Varanasi on 25th February 2020. The Chief Guest of the event, Dr. Anand Kumar Singh, DDG (Horticulture Science), Indian Council of Agricultural Research, New Delhi said that improved varieties of

vegetables should be extended to the farmers along with production technologies. Director of the Institute Dr Jagdish Singh emphasized that the scheme is being run to impart technical knowledge to the farmers. He said about training in the institute for beekeeping, poultry farming and mushroom production. Advised to adopt processing and value addition of tomatoes and green chillies to fetch good prices for vegetables. A technical session was organized to address the problems of farmers in which more than 300 farmers were present.

Virtual Training on beekeeping on the occasion of "World Bee Day"

Virtual training on beekeeping was organised by IIVR on the occasion of 'World Bee Day' during 20th May, 2020. On this occasion discussions were held with the beekeepers who virtually participated and shared their experiences and constraints. Dr. K.K. Pandey, Head of the Department, Plant Protection and Dr. A.N. Tripathi, Scientist discussed in detail to solve the problems of farmers and delivered lecture on scientific techniques of beekeeping. In coming days the Integrated Beekeeping Centre of IIVR will organize physical training programs for beekeepers and help in processing of raw honey for the farmers. Beekeepers were told about the safe use of insecticides, bio-pesticides and the use of chemicals obtained from bio-botanical sources. The main objective of this event was to inform the farmers about the conservation of bees and entrepreneurship through beekeeping to increase income, employment opportunities and production of quality honey.

ICAR Award to three scientists of Indian Institute of Vegetable Research

On the occasion of 92nd Foundation Day celebrations of Indian Council of Agricultural Research, Dr. D.R. Bhardwaj and Dr. Rekha Singh were awarded Dr. Rajendra Prasad Award 2019 for writing original book published in Hindi titled "Vegetables: Genetic Wealth, Use and Management" and "Industrial Crop Processing and Rural Women Empowerment", Under which an award of One lakh rupees each was given. Dr. Vidya Sagar, scientist of the institute, received the prestigious Jawaharlal Nehru Outstanding Thesis Award for the year 2019 for PhD research work. An incentive amount of fifty thousand rupees was given to Dr. Vidyasagar by the Council as a mark of respect. These awards were given to the recipients by the Hon'ble Union Agriculture Minister Shri Narendra Singh Tomar on 16th July 2020.

Parthenium Awareness Week Organized at ICAR-IIVR

Parthenium awareness week was organized on 21st

August, 2020 at IIVR Research farm under the chairmanship of Dr. Jagdish Singh, Director, IIVR, Varanasi. More than 50 scientists and other sta participated in this programme. Due to concerted e orts for removal of Parthenium, the research farm is almost free from Parthenium. However, wherever the plants were seen, it was removed by all those who participated in this event. On this occasion, scientists discussed the ill e ects and eradication measure of this obnoxious weed.

Hindi Chetna month at ICAR-IIVR

Hindi Chetna month was started on 14th September, 2020 with the organization of Hindi Diwas at ICAR-Indian Institute of Vegetable Research, Varanasi. On this occasion the chief guest Prof. Vashistha Narayan Tripathi, Professor, Department of Hindi, Banaras

Hindu University, Varanasi said that Hindi is not only a language but also a carrier of culture. He gave a detailed lecture on the story of the development of the o cial language Hindi and its utility in the field of agricultural science. The Director of the institute, Dr. Jagdish Singh, in his address, reviewed the work and activities being done in the o cial language in the institute.

Okra Field Day 2020 organized at ICAR-IIVR, Varanasi

Okra field day was organized at ICAR-IIVR, Varanasi by its Zonal Technology Management Unit on 28th October, 2020 to showcase and commercialize the promising okra varieties, hybrids and advanced lines developed by the Institute. Keeping in view the Covid Pandemic, the event was organized in virtual mode. The event was attended by more than 40 breeders and marketing strategists from 29 private vegetable seed-companies like Ankur Seeds,

Mahyco Seeds, Advanta Seeds, Sayaji Seeds, Namdhari Seeds, Nuziveedu Seeds, Nunhems Seeds, Dayal Seeds, Dinkar Seeds, Indo-American Hybrid Seeds, Nirmal Seeds, Nath Seeds, East West seeds and others. Five representatives from companies having their research and marketing team at Varanasi attended the program physically and participated in field visit. Kashi Lalima-the red coloured Bhindi along with advance breeding lines tolerant to Okra Yellow Vein Mosaic Virus and

Enation Leaf Curl Virus like VRO-120 and VRO-124 were the centre of attraction for the delegates. The representatives critically observed the promising materials and expressed their desire to get some of the promising advanced breeding lines, combining virus-resistance and high-yield. The delegates thoroughly interacted with the team of scientists of the institute and provided valuable feedback on the current market needs of okra.

Constitution Awareness Campaign Twelfth Phase concluded

The Constitution Day campaign-twelfth phase was concluded on 31st October, 2020 at ICAR-Indian Institute of Vegetable Research, Varanasi in the presence of the o cers/sta of the institute. On this occasion, Dr. Jagdish Singh, Director, inspired everyone to participate

in this campaign. The Indian Constitution and Fundamental Duties were discussed in detail by Dr. Atmanand Tripathi, scientist of the institute. He told that as a citizen of India, we should be aware of fundamental rights and duties. Let us take a vow that we should make our countrymen aware about our duties towards the country.

"Swachhata Hi Seva" campaign launched

As a part of Swachh Bharat Abhiyan, "Swachhata Hi Seva" campaign was launched at ICAR-Indian Institute of Vegetable Research, Varanasi with "Swachhata Shapath" by the sta of ICAR-IIVR, Varanasi on 16th December 2020. The sta committed themselves for at least 100 hours of Cleanliness drive on their part, at

Institute as well as their residential surroundings per year. Director, ICAR-IIVR, Varanasi, briefed the action plan of the Institute during ongoing campaign from 16-31st December 2020. The main entrance of the institute was thoroughly cleaned by the sta during the drive.

Later, a special Swachhta campaign under the aegis of "Swachha Bharat Abhiyan" was also organized at ICAR-IIVR, Varanasi on 21st December, 2020. A massive cleanliness drive was organized on that day. The roads, demonstration blocks, experimental farms etc. were thoroughly cleaned. Parthenium and other associated weeds in vegetables and road sides were also uprooted.

Visit of Additional Chief Secretary (Agriculture), Government of Uttar Pradesh

Additional Chief Secretary (Agriculture) Dr. Devesh Chaturvedi along with District Magistrate Shri Kaushal Raj Sharma visited ICAR-IIVR, Varanasi on 28th December 2020. The Secretary expressed satisfaction over the achievements of the institute and called upon the scientists that the varieties and technologies

developed need to reach the farmers in time to strengthen their income and economic status. Promoting agricultural diversification should be the first priority for doubling the income of farmers. All the o cers of Animal Husbandry and Agriculture Department were present on this occasion.

AWARDS, HONOURS, RECOGNITIONS AND PATENTS

Awards

- "Young Horticultural Scientist Award-2019" conferred on Dr. Sujan Mazumdar for significant contribution by Association of Plant Science Researchers during February, 2020.
- Third Best oral paper award conferred on Dr. Jaydeep Halder for the research paper "Impact of bio-intensive pest management module against major insect pests of tomato and its safety to predatory mirid bugs" in the session-VI: Plant Health Management. *In*: "Indian Horticulture Summit-2020 Mitigating climatic change and doubling farmers' income through diversification" at MGCGV, Chitrakoot, Madhya Pradesh during February, 2020.
- Young Horticultural Scientist Award-2019 conferred on Dr. Jaydeep Halder for significant contribution in Horticultural Sciences (Vegetable Crop Protection) by the Society for Horticultural Research & Development at Ghaziabad, Uttar Pradesh during February, 2020.
- Dr. Rajendra Prasad Puraskar-2019 for best book in Hindi conferred on Dr. D.R. Bhardwaj and Dr. Rekha Singh by Indian Council of Agricultural Sciences, New Delhi in July 2020.
- Harbhajan Singh Memorial Award 2019 conferred by Indian Society of Vegetable Science for the best paper entitled "Identification of resistant sources against chilli leaf curl virus disease through field and molecular screening in chilli" by Kumar R, Prasad I, Singh AK, Rai A, Nagendran K, Singh PM and Singh J in the journal *Vegetable Science* 46: 17-22-declared in September 2020.
- Young Scientist Award 2020 conferred on Dr. Shweta Kumari by the Agricultural & Environmental Technology Development Society (AETDS), U.S. Nagar, Uttarakhand, India; during October, 2020.
- Dr. Kirti Singh Gold Medal in Vegetable Science (2019), conferred on Dr. D.R. Bhardwaj by Indian Academy of Horticultural Sciences, New Delhi in November 2020.
- Jawaharlal Nehru outstanding Ph.D. thesis award conferred on Dr. Vidyasagar.

Honours & Recognitions

- Dr. D.R. Bhardwaj became Fellow of National Academy of Agricultural Sciences (NAAS) 2020.
- Dr. T. Chaubey became Fellow of Indian Society of Vegetable Science (ISVS)-2019 in September 2020.
- Dr. R.K. Dubey became Fellow of Indian Society of Vegetable Science (ISVS)-2019 in September 2020.
- Dr. P.M. Singh became Fellow of Indian Academy of Horticultural Sciences (IAHS)-2019 in November 2020.
- Fellowship of U.P. Academy of Agril. Sciences (UPAAS)-2017 conferred on Dr. Rajesh Kumar.
- BIOVED Fellowship 2020 conferred on Dr. S.K. Verma.
- BIOVED Fellowship 2020 conferred on Dr. T. Chaubey.
- Fellowship of Society for Horticultural Res. and Dev. 2020 conferred on Dr. N. Rai.
- Fellowship of Indian Society for Noni Sciences 2020 conferred on Dr. N. Rai.
- Fellowship of Indian Society for Noni Sciences 2020 conferred on Dr. S.N.S. Chaurasia.
- Dr. N. Rai inducted in the P.G. School faculty of IARI in the discipline of Vegetable Science.
- Dr. R.K. Dubey inducted in the P.G. School faculty of IARI in the discipline of Vegetable Science

Patents

- The patent for "Method for Preparation of Green Chilli Powder" was granted. Indian Patent No.-347131 dated 18/09/2020.

HUMAN RESOURCE DEVELOPMENT

Training and Capacity Building

Training

Name of IIVR Scientists/KVKs SMS	Title of training	Duration	Held at
SM Vanitha	Use of statistical tools and techniques for social science research.	20-23 April, 2020	Institute of Management Studies, Davangere University, Karnataka(Virtual/online)
S.K. Tiwari & Indivar Prasad	Webinar on "Intellectual Property Rights in Agricultural Research in India"	12-28 September, 2020	ICAR, KAB, Pusa, New Delhi
Shweta Kumari	Training programme on "Climate change: Challenges and Response" (online)	5-9 October, 2020	LBSNAA, Mussoorie
Pratap A. Divekar	Training programme on "Introduction to Plant Biosecurity & Plant Quarantine" (online)	12-16 October, 2020	NIPHM, Hyderabad
P.M. Singh	MDP on PME in Agricultural Research Projects (online)	12-17 October, 2020	HRM Unit, ICAR, New Delhi
Swati Sharma	AICTE-ATAL sponsored training programme on "Emerging Technologies in Postharvest Management and Value Addition in Horticultural Commodities" (online)	2-6 November, 2020	Department of Environmental Sci., NIFTEM,
SM Vanitha	Market Research & Value Chain Management of Agricultural Commodities	17-21 November, 2020	ICAR-NAARM, Hyderabad(Virtual/online)
Sujan Majumder	Training programme on "Importance of Participation in PT/ILC for Quality Assurance in Testing" (online)	18 November, 2020	NIPHM, Hyderabad
Sujan Majumder	Training programme on "Sampling of Fruits and Vegetables for Pesticide Residue Analysis" (online)	8-9 December, 2020	NIPHM, Hyderabad
Sujan Majumder	Training programme on "Basic requirement of pesticide residue analysis and equipment maintenance" (online)	15-16 December, 2020	NIPHM, Hyderabad

Training and Skill Development of Farmers and Field Functionaries conducted

Sl. No.	Name of training programme	Date	Sponsored by	No. of participants
1.	Entrepreneurship development programme on vegetables for young vegetable growers of East Champaran district, Bihar	4-24 February, 2020	NHB, Gurugram	26 Farmers
2.	Seasonal and off-season vegetable cultivation and their pest and disease management	25-29 February, 2020	ATMA, Lohardaga	17 Farmers
3.	Vegetable cultivation and IPM	4-6 March, 2020	NGO, Ara	27 Farmers
4.	Agri-enterprise development by scientific mushroom cultivation	7-9 October, 2020	Jointly organised by DBT, Biotech Kisan and ICAR-NASF project	30 Farmers

5.	Entrepreneurship development through scientific beekeeping	28-30 October, 2020	Jointly organised by DBT, Biotech Kisan and ICAR -NASF project	27 Farmers
6.	Mushroom Production at Gaurahi, Sonbhadra	28-29 December, 2020	DBT-Kisan Biotech	25 women Farmers

Seminar/symposium/conference/workshop attended

Name of Scientist	Title of seminar/ symposium/ conference/ workshop	Duration	Organized by
National			
Jaydeep Halder	International Conference on "Agrochemicals Protecting Crops, Health & Natural Environment (APCHNE)- Discovery & development of synthetic & natural products for health & pest management	07-10 January, 2020	NAAS Complex, New Delhi
	Indian Horticulture Summit-2020 Mitigating climatic change and doubling farmers' income through diversification"	14-16 February, 2020	MGCGV, Chitrakoot, MP
	"International Web Conference on Ensuring Food Safety, Security and Sustainability through Crop Protection	05-06 August 2020	BAU, Sabour, Bihar
	Webinar on "Fruit fly Awareness Day" organized by Association for Advancement in Plant Protection (AAPP)	08 August, 2020	BCKV Nadia, West Bengal
	Webinar on "Agro-Business Venture on Bee keeping & Honey Processing"."	11 November, 2020	ICAR-NEH Manipur Imphal
	National Webinar on "Transboundary Pests – Threat to Bio-security & Bio-safety issues"	21 December, 2020	ANGRAU, Andhra Pradesh
Sujan Majumder	International Conference on "Agrochemicals Protecting Crops, Health & Natural Environment (APCHNE)- Discovery & development of synthetic & natural products for health & pest management	07-10 January, 2020	NAAS Complex, New Delhi
Pratap A. Divekar, Sujan Majumder, Vijaya Rani	International webinar on "Nanotechnology in Agriculture and Biotechnology"	19-21 October, 2020	Department of Seed Science and Technology, TCA, Dholi
Rakesh K. Dubey	International conference on pulses as the climate smart crops: Challenges and Opportunities	10-12 February, 2020	Bhopal, Madhya Pradesh.
	National webinar on "Strategies and Technological Interventions for Sustainable Horticulture in North Eastern Region	05-07 August, 2020	CHF, CAU, Pasighat, Arunachal Pradesh
	National Web Conference on Augmenting vegetable Productivity through recent techniques	10 September, 2020	Bihar Agricultural University, Sabour, Bihar
	e-International training on "Neglected and Underutilized Crop Species (NUS) for Food and Nutritional security during time of uncertainties	16-29 October, 2020	Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.)
Hare Krishna	National Webcon 2020	06-08 May, 2020	CSAUA&T, Kanpur (U.P.)

Kuldeep Srivastava	Webinar on Post Pandemic (COVID-19) Challenges and Options in Agriculture including Horticulture	28 May, 2020	Confederation of Horticulture Association of India (CHAI), New Delhi
	National Webinar on Recent Trends in Horticultural Entomology	27 August 2020	Sardarkrushinagar Dantiwada Agricultural University, Gujarat
SNS Chaurasia	Protected cultivation	28 June, 2020	CSA, Kanpur (Virtual/online)
	Scope of Farm mechanization	30 June, 2020	ICAR-CIAE, Bhopal (Virtual/online)
All Scietnists of the Institute	38th AICRP (VC) group meeting	25 – 27 September, 2020	Project Coordinating Unit, ICAR-IIVR, Varanasi
Swati Sharma	COVID-19 Pandemic: Innovative Agri-Solution in Vegetable Sector.	03 July, 2020	ICAR-IIVR, Varanasi (Virtual/online)
	Prime minister's formalization of micro food processing enterprises for sustainable livelihood.	27 November, 2020	UAHS, Shivamogga, Karnataka, India. (Virtual/online)
	Global conference on "Emerging agricultural research to endure the predicament of COVID-19 pandemic".	12-13 December, 2020	Triveni Devi Bhalotia college, Kazi Nazrul University, Raniganj, West Bengal (Virtual/online)
	Fruit and Vegetable Processing.	27 December, 2020 - 01 January, 2021	IIFPT & NIFTEM (Virtual/online)
Shubhadeep Roy	Webinar on "Formation and effective functioning of Farmers Producer Organization"	18 August, 2020	ICAR- Research Complex for Eastern Region Patna, Bihar
Vijaya Rani	National Webinar on "Recent Advances in Soil Microbiological Research with a Special Thrust to Biofertilizer Technology"	25 August, 2020	BAU, Sabour, Bhagalpur
	Webinar on "Omics in Agriculture" organized by College of Basic Sciences & Humanities	07-09 October, 2020	Dr. R.C.P.A.U. Pusa, Samastipur
SM Vanitha, Vijaya Rani	Webinar on "Future Perspectives in Agricultural Education"	05 September, 2020	NAHEP(ICAR)-CAAST, IARI, New-Delhi (Virtual/online)
SM Vanitha	Sustainable Agriculture in India – Future Challenges & Goals	10 September, 2020	Pride Energy, Environmental Resources Research Institute (PEERRI), Bangalore, Karnataka (Virtual/online)
Pratap A. Divekar	International Webinar on "Perspective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020)"	04-06 October, 2020	International Web U.S. Nagar, Uttarakhand, India
Pratap A. Divekar, SM Vanitha	Webinar on "Challenges and Opportunities of Vegetable Production in Warm Humid Tropics"	11-13 November, 2020	Department of Vegetable Science, College of Horticulture, Kerala Agricultural University & Indian Society of Vegetable Science (Virtual/online)

SM Vanitha	Virtual global summit on Artificial Intelligence: Responsible AI for Social Empowerment (RAISE 2020)	05-09 October, 2020	Ministry of Electronics & IT, Niti Ayog, GOI (Virtual/online)
	28th Annual Conference Agricultural Economics Research Association on Future of Indian Agriculture: Challenges and Opportunities	16-18 December, 2020	UAS, Bengaluru, Karnataka (Virtual/online)
	Women Scientists & Enterpreuner's Conclave, India International Science Festival (IISF-2020)	22-25 December, 2020	Ministry of S&T, Ministry of Earth Sciences, Ministry of Health & Family Welfare, GOI (Virtual/online)
Jyoti Devi	International E –Conference on "Multidisciplinary approaches for plant disease management in achieving sustainability in agriculture"	06-09 October, 2020	Department of Plant Pathology, College of Horticulture, Bengaluru
BK Singh	Webinar on Plant Science & Biosecurity	12-13 October, 2020	Osaka, Japan www.acpb2020.com (Virtual/online)
	Three days training on "Skill Development Programme" under ICAR-SC Sub Plan Scheme	17 December, 2020	GBPUAT, Pantnagar, Uttarakhand
Shubhadeep Roy	National workshop on "Psychometric scale construction: Basic to advances"	24-28 November 2020	ICAR-NDRI, Karnal, Haryana

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APPOINTMENTS, TRANSFERS, PROMOTIONS AND SUPERANNUATION

Transfers

- Dr. Manimurugan C., Scientist transferred from ICAR-IIVR, Varanasi to ICAR-IIOR, Hyderabad on 14.08.2020.
- Dr. B.R. Meena, Scientist transferred from ICAR-IIVR, Varanasi to ICAR-NBPGR, New Delhi on 21.08.2020.

Promotion

- Sh. U.K. Saxena, SF&AO, ICAR-IIVR, Varanasi promoted from Rs. 15600-39100 + GP 5400 to 15600-39100 + GP 6600 w.e.f. 06.01.2020.
- Sh. R.K. Mehrotra, Assistant, ICAR-IIVR, Varanasi promoted from Rs. 5200-20200 + GP 2800 to 9300-34800 + GP 4200 w.e.f. 23.10.2020.
- Sh. Rajesh Kumar Rai, AAO, ICAR-IIVR, Varanasi promoted from Rs. 9300-34800 + GP 4200 to 9300-34800 + GP 4600 w.e.f. 30.12.2020.

Supperannuation

- Dr. Sudhir Singh, Principal Scientist, ICAR-IIVR superannuated from services on 29.02.2020.
- Dr. S.K. Verma, Principal Scientist, ICAR-IIVR superannuated from services on 31.08.2020.

Classified Abstracts of Expenditure
(2020)

ICAR-Indian Institute of Vegetable Research (Plan)

(In Lakhs)

Sub-head	Plan	
	Provision made in RE	Expenditure
Establishment Charges	1616.14	1616.13
Wages	0.00	0.00
O.T.A.	0.00	0.00
T.A.	22.50	22.38
Other Charges (Contingency)	477.50	472.68
H.R.D.	4.0	3.81
Works	65.00	64.23
Equipment	58.00	48.90
Library	0.00	0.00
Vehicle	10.00	7.50
Annual Repairs /Maintenance	0.00	0.00
Furniture & Fixture	10.00	7.28
Information Technology	10.00	4.40
TSP NEH	60.00	58.51
Total	**2491.14**	**2460.41**

Revenue generation

(In Lakhs)

Particulars	Target	Revenue generation
IIVR	85.00	72.00

Krishi Vigyan Kendra (Plan)

(In Lakhs)

KVKs	RE	Expenditure
KVK, Kushinagar	153.77	126.16
KVK, Deoria	136.21	108.03
KVK, Sant Ravidas Nagar	133.73	116.13
Total	423.71	350.32

Externally Funded Projects

(Rs. In lakhs)

Name of project	Funding agency	Duration of projects	Allocation & Expenditure 2020	
			Allocation	Expenditure
Crop Improvement				
National Innovations in Climate Resilient Agriculture (NICRA)	ICAR	2017 - 2020	48.50	48.27
CRP on Hybrid Technology Project	ICAR	2015 - 2021	17.75	16.79
Network Project on Transgenic Crops (NPTC)	ICAR	2017 - 2021	6.85	6.85
CRP on Agrobiodiversity	ICAR	2015 - 2021	6.63	5.57
Central Sector Scheme for Protection of Plant Varieties and Farmer's Rights Authority (Dust testing of tomato, brinjal, okra, cauliflower, cabbage, vegetable pea, French bean, bottle gourd, bitter gourd, pumpkin and cucumber).	PPVFRA	2009 - 2020	21.85	21.37
Agri Business Incubator (ABI)	ICAR	2017 - 2020	7.75	7.64
Zonal Technology Management Unit (ZTMU)	ICAR	2017 - 2020	4.15	4.14
Monecious sex expression in muskmelon (Cucumis melo L.): Inheritance and molecular mapping of monoecisum using linked markers.	DST-SERB	2019 - 2022	10.00	10.00
Development and evaluation of annual moringa for food fodder and nutritional content in U.P.	UPCAR	2020-2023	2.25	0.74
Identification of suitable varieties/hybrids of cucurbitaceous crops and development of production protocol for better livelihood of river bed (diara land) farming community.	UPCAR	2020-2023	4.35	2.58
Crop Production				
Efficient Water Management in Horticultural Crops (under Agri-CRP on Water Project)	ICAR	2016 - 2021	22.20	12.70
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 - 2021	16.50	13.75
ICAR-NASF Project "Development and validation of need based delivery model through Farmer Producer organization in Eastern Region of India".	ICAR	2019-2022	9.07	7.59
Crop Protection				
AICRP on Biocontrol	ICAR-NBAIR	2018 - 2021	6.74	1.14
Validation & pro motion of sustainable and adaptable IPM technology for brinjal crop	ICAR-NCIPM	2019 - 2022	2.07	1.25

Staff Strength

(as on 31.12.2020)

S.N.	Category	Sanctioned Strength	Staff in Position	Vacant
SCIENTIFIC				
1.	Scientist	44	35	09
2.	Senior Scientist	12	10	02
3.	Principal Scientist	01	01	-
	TOTAL	**57**	**46**	**11**
TECHNICAL				
1.	Technician	11	10	01
2.	Senior Technician	-	-	-
3.	Technical Assistant	13	08	05
4.	Senior Technical Assistant	02	01	01
5.	Technical Officer	-	-	-
6.	Senior Technical Officer	-	-	-
7.	Assistant Chief Technical Officer	-	-	-
	TOTAL	**26**	**19**	**07**
ADMINISTRATIVE				
1.	Senior Administrative Officer	01	01	-
2.	Finance & Account Officer	01	01	-
3.	Assistant Finance & Accounts Officer	01	-	01
4.	Assistant Administrative Officer	01	01	-
5.	Assistant	05	02	03
6.	Private Secretary	01	01	-
7.	Personal Assistant	01	-	01
8.	Stenographer Gr. III	02	02	-
9.	UDC	02	02	00
10.	LDC	04	01	03
	TOTAL	**19**	**11**	**08**
SKILLED SUPPORTING STAFF				
1.	S.S.S	16	15	01
	TOTAL	**16**	**15**	**01**
	Grand Total	**118**	**91**	**27**

Staff Strength of Krishi Vigyan Kendras

(as on 31.12.2020)

KVK Sargatia, Kushinagar

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	-	01
2.	Subject Matter Specialist	06	06	-
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	10	06

KVK, Deoria

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	-	01
2.	Subject Matter Specialist	06	04	-
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	-	-
8.	Driver (T-1)	02	02	-
9.	SSS	02	-	02
	Total	16	08	08

KVK, Bhadohi

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	-	-
7.	Stenographer Gr. III	01	-	01
8.	Driver (T-1)	02	02	-
9.	SSS	02	-	02
	Total	16	11	05

Staff in Position

(as on 31.12.2019)

Sl. No.	Name	Designation	Email
1.	Dr. Jagdish Singh	Director (Acting)	directoriivr@gmail.com
Director's Cell			
2.	Sh. Ajay Uniyal	Personal Assistant	Ajay.uniyal1@gmail.com
Project Coordinator Cell			
3.	Dr. Ram chandra	Principal Scientist	rchandraiivr2016@gmail.com
4.	Dr. T. Chaubey	Principal Scientist	tchaubay@gmail.com
5.	Dr. B. Rajasekhar Reddy	Scientist	rajasekharhortico@gmail.com
6.	Dr. A.P. Singh	Senior Technical Officer	apsinghento@gmail.com
Division of Vegetable Improvement			
7.	Dr. P.M. Singh	Principal Scientist & I/C Head	pmsiivr@gmail.com
8.	Dr. Nagendra Rai	Principal Scientist	nrai1964@gmail.com
9.	Dr. D.R. Bhardwaj	Principal Scientist	dram_iivr@yahoo.com
10.	Dr. Rajesh Kumar	Principal Scientist	rajes74@gmail.com
11.	Dr. Sudhakar Pandey	Principal Scientist	sudhakariivr@gmail.com
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16.	Dr. Shailesh Kumar Tiwari	Senior Scientist	tiwarishailu@gmail.com
17.	Dr. Pradip Karmakar	Scientist	pradip9433@gmail.com
18.	Dr. Yerasu Suresh Reddy	Scientist	yerasusureshreddy@yahoo.co.in
19.	Dr. Indivar Prasad	Scientist	indivar234@gmail.com
20.	Dr. Jyoti Devi	Scientist	jyoti17iivr@gmail.com
21.	Sh. K.K. Gautam	Scientist	kkgautam008@gmail.coms
22.	Sh. S.G. Karkute	Scientist	suhaskarkute@gmail.com
23.	Sh. Nakul Gupta	Scientist	nakulgupta1988@gmail.com
24.	Dr. Vidya Sagar	Scientist	vidya.sagarkaushal@gmail.com
25.	Sh. A.K. Singh	Assistant Chief Technical Officer	ashoksinghiivr@gmail.com
26.	Dr. Rameshwar Singh	Assistant Chief Technical Officer	bisen.singh@gmail.com
27.	Sh. Ashutosh Goswami	Assistant Chief Technical Officer	ashutosh12031972@gmail.com
28.	Sh. Chandra Bushan	Technical Officer	cb.dubey2011@gmail.com
29.	Sh. Subhash Chandra	Senior Technical Assistant	subhash301269@gmail.com
30.	Sh. Sudhir Kumar	Technical Assistant	sudhir2203@gmail.com
Division of Vegetable Production			
31.	Dr. R.N. Prasad	Principal Scientist & I/C Head	rnprasad_zcu@rediffmail.com
32.	Dr. S.N.S. Chaurasia	Principal Scientist	chaurasiaiivr@gmail.com

33.	Dr. R.B. Yadav	Principal Scientist	raj_yadava@rediffmail.com
34.	Dr. Neeraj Singh	Principal Scientist	neerajatic@gmail.com
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38.	Dr. Shubhadeep Roy	Scientist	shubhadeepiari@gmail.com
39.	Dr. S.M. Vanitha	Scientist	vanita.gkvk@gmail.com
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Division of Vegetable Protection			
45.	Dr. K.K. Pandey	Principal Scientist & I/C Head	kkpiivr@gmail.com
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54.	Dr. Sujan Majumdar	Scientist	sujaniari@gmail.com
55.	Ms. Vijaya Rani	Scientist	ranivijaya78@gmail.com
56.	Sh. Raghubansh Mani Rai	Assistant Chief Technical Officer	raghubanshmaniiivr@gmail.com
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57.	Sh. Sujit Kumar Singh	Senior Administrative Officer	saoiivr@gmail.com
58.	Sh. U.K Saxena	Senior Finance & Account Officer	iivrfao@gmail.com
59.	Sh. Gopi Nath	Assistant	gopiiivr@gmail.com
60.	Sh. Rajesh Rai	Assistant Administrative Officer	rai.rajesh72@gmail.com
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64.	Sh. S.K. Gupta	Upper Division Clerk	sushilskg@yahoo.co.in
65.	Sh. Sudeep Singh	Lower Division Clerk	singhabc16@gmail.com
66.	Sh. Ankit	Stenographer	Ankit@icar.gov.in
67.	Sh. Manish Dwivedi	Stenographer	Manish.Dwivedi@icar.gov.in
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68.	Sh. Vishwanath	Assistant Chief Technical Officer	vishwanathbhargava@gmail.com
69.	Sh. Pankaj Kumar Singh	Technical Officer	pksinghiivr@gmail.com

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71.	Dr. Sunil Gupta	Chief Technical Officer	gupta.sunil191@gmail.com
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72.	Sh. S.K. Singh	Chief Technical Officer	sksinghiivr@gmail.com
Institute Service Unit			
73.	Sh. M.L. Vishwakarma	Technical Officer	madanlalvishwa@yahoo.in
Vehicle Section			
74.	Sh. Sanjay Singh	Senior Technical Assistant	
75.	Sh. Rajendra Kumar	Senior Technical Assistant	-
76.	Sh. Manoj Kumar	Senior Technical Assistant	
77.	Sh. Ram Ashrey	Senior Technical Assistant	-
Skilled Supporting Staff (SSS)			
78.	Sh. Shiv Kumar	SSS	-
79.	Sh. Kailash Singh	SSS	-
80.	Sh. S.P. Mishra	SSS	-
81.	Sh. Naraini Singh	SSS	-
82.	Sh. S.K. Pandey	SSS	-
83.	Sh. Arun Kumar	SSS	aruniivr@gmail.com
84.	Sh. Ramraj	SSS	ramraj.iivr@gmail.com
85.	Sh. Suresh Kumar Yadav	SSS	-
86.	Sh. Suresh Kumar	SSS	-
87.	Sh. Virendra Prasad Gond	SSS	-
88.	Sh. Kamlesh Kumar Singh	SSS	-
89.	Sh. Anil Kumar Suman	SSS	-
90.	Sh. Ram Kunwar Chaubey	SSS	-
91.	Sh. Jata Shankar Pandey	SSS	-
92.	Sh. Shivajee Mishra	SSS	-
Regional Research Station, Sargatia, Kushinagar			
93.	Dr. Vikas Singh	Senior Scientist & I/C	vikaschf@gmail.com
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Krishi Vigyan Kendra, Sargatia, Kushinagar			
96.	Dr. R. P. Sahu	SMS (Agril. Extension)	ramdrprakash@gmail.com
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98.	Sh. Yogesh Kumar Yadav	SMS (AS)	yogeshkyadav001@rediffmail.com
99.	Smt. Anjali Sahu	SMS (HS)	anjalisahu13march@gmail.com
100.	Dr. T.N. Rai	SMS (Soil Science)	tnrai_78@rediffmail.com
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102.	Sh. Arun Pratap Singh	Farm Manager	arunkuwarsingh76@gmail.com

103.	Sh. Prasant Kumar Gupta	Office Superintendent	pkg1981@gmail.com
104.	Sh. Motilal Kushwaha	Programme Assistant (Comp.)	motilalakushwaha@yahoo.com
105.	Sh. Pankaj Kumar Singh	(T-2) Driver	-
106.	Sh. Satish Kumar Singh	(T-2) Driver	sks.kvkkushinagar@gmail.com
Krishi Vigyan Kendra, Deoria			
107.	Sh. Rajneesh Srivastava	SMS (Horticulture) & I/C Head	rajneeeshkvk@gmail.com
108.	Dr. Ashok Rai	SMS (Ag.Extn)	ashokraibhu@gmail.com
109.	Sh. Kamalesh Meena	SMS (SS & Agro)	kamalaagronomy@gmail.com
110.	Sh. Ajay Tiwari	Farm Manager	ajitiwariiivr@gmail.com
111.	Sh. Bharat Singh	(T-2) Driver	bharatiivr@gmail.com
112.	Sh. Sharad Chand Rai	(T-2) Driver	scrai76@gmail.com
Krishi Vigyan Kendra, Bhadohi			
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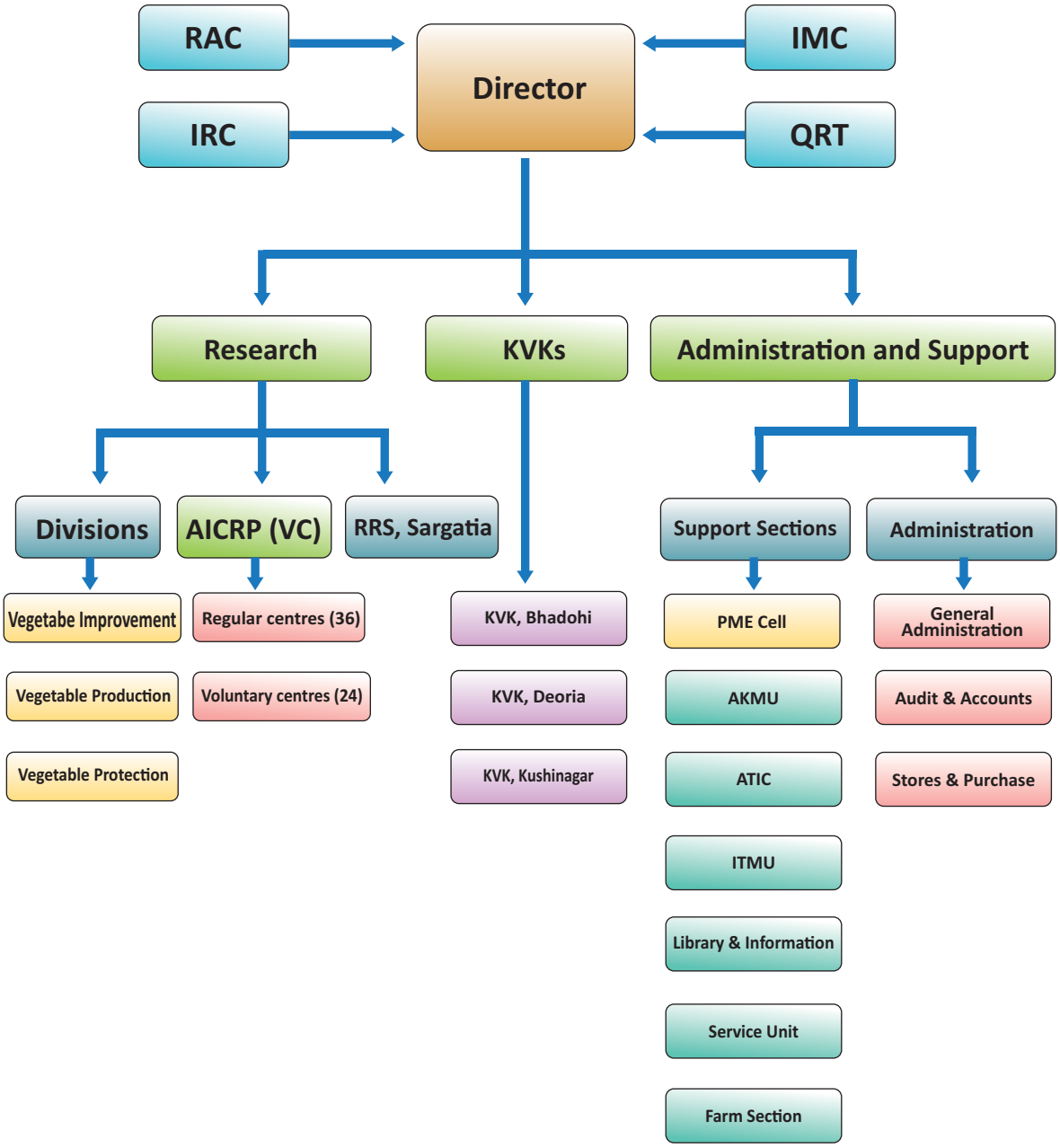
114.	Dr. A.K. Chaturvedi	SMS (Hort.)	akciivr@gmail.com
115.	Dr. G.K. Choudhary	SMS (AS)	drgovindvet@yahoo.co.in
116.	Dr. R.P. Choudhary	SMS (Ag. Extn)	rudalpd@rediffmail.com
117.	Dr. Rekha Singh	SMS (HS)	rekhaiivr@gmail.com
118.	Dr. Manoj K. Pandey	SMS (PP)	mkp_bxr@yahoo.co.in
119.	Dr. P.C. Singh	Farm Manager	prabhashiivr@gmail.com
120.	Sh. V.V. Diptikar	Programme Assistant (Comp.)	v_v_diptikar@rediffmail.com
121.	Sh. D.P. Singh	Programme Assistant	dpsinghkvk@rediffmail.com
122.	Sh. Sanjay Kumar Yadav	(T-2) Driver	sanjay8765275294@gmail.com
123.	Sh. Pramod Paswan	(T-2) Driver	pramodpaswan1084@gmail.com

ORGANOGRAM


RAC
IRC
Director
IMC
QRT
Research
KVKs
Administration and Support
Divisions
AICRP (VC)
RRS, Sargatia
Support Sections
Administration
Vegetabe Improvement
Vegetable Production
Vegetable Protection
Regular centres (36)
Voluntary centres (24)
KVK, Bhadohi
KVK, Deoria
KVK, Kushinagar
PME Cell
AKMU
ATIC
ITMU
Library & Information
Service Unit
Farm Section
General Administration
Audit & Accounts
Stores & Purchase

Annexure I

Research Advisory Committee

Dr. K. E. Lawande Former Vice Chancellor Dr. BSKKV, Dapoli (M.S.)	Chairman
Dr. S.M.S Tomar Cytogenetist Division of Genetics & Plant Breeeding IARI, Pusa, New Delhi	Member
Dr. Anil Sirohi Professor Division of Nematology IARI, Pusa, New Delhi	Member
Dr. D.P. Wasker Director (Research) Dr. VNMKVK, Parbhani (M.S.)	Member
Dr. P.S. Pandey ADG (EP&HS) ICAR, Pusa, New Delhi	Member
Dr. T. Janakiram Asstt. Director General (Hort.-II) ICAR, Krishi Anusandhan Bhawan-II ,Pusa,New Delhi	Ex- officio Member
Dr. Jagdish Singh Director ICAR-IIVR, Varanasi	Ex- officio Member
Dr. Sudhakar Pandey Principal Scientist ICAR-IIVR, Varanasi	Member Secretary

Annexure II

Institute Management Committee

Dr. Jagdish Singh Director ICAR-IIVR, Varanasi	Chairman
Dr. T.K. Behera Principal Scientist Vegetable Science Division ICAR- IARI, Pusa Campus, New Delhi	Member
Dr. P.M. Singh Principal Scientist & I/C Head Vegetable Improvement Division, ICAR-IIVR, Varanasi	Member
Dr. P.M. Thomas Principal Scientist ICAR-IIHR, Bangalore	Member
Dr. Ambika Baldev Gaikwad Principal Scientist Division of Genomic Resources, NBPGR, Pusa, New Delhi	Member
Dr. T. Janakiram Asstt. Director General (Hort.-II) ICAR, Krishi Anusandhan Bhawan-II ,Pusa,New Delhi	Member
Shri Prakash Yadav August Kunda, Lalia Gali, Varanasi	Non- official Member
Smt. Priyanka Patel Jalalpurmaafi, Narayanpur, Chunar, Mirzapur	Non- official Member
Shri Sujit Kumar Singh SAO ICAR-IIVR, Varanasi	Member Secretary

Annexure III

List of Ongoing Research Projects

A. Institutional

MEGA PROGRAMME 1 : INTEGRATED GENE MANAGEMENT			
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 Associates: P.A. Divekar (Insects), K.K. Pandey (Diseases), K. Nagendran (Viruses)
1..2	Genetic Improvement of Brinjal	SK Tiwari	S.K. Verma (upto Aug 2020) Associates: P.A. Divekar, Shweta Kumari (Phytoplasma), A.N. Tripathi (Diseases)
1.3	Genetic Improvement of Chilli	Rajesh Kumar	Indivar Prasad and Achuit Singh Associates: K.K. Pandey (Diseases), K. Nagendran (Viruses) , A.T. Rani (Insects)
1.4	Genetic Improvement of Pea	Jyoti Devi	R.K. Dubey Associate: A.N. Tripathi
1.5	Genetic Improvement of Cowpea.	B. Rajasekhar Reddy	N. Rai Associates: P.A. Divekar (Ins ects), A.N. Tripathi (Diseases) and K. Nagendran (Viruses)
1.6	Genetic Improvement of Indian bean and French bean.	N Rai	B. Rajasekhar Reddy
1.7	Genetic Improvement of seed propagated gourds	D.R. Bhardwaj	Sudhakar Pandey, Vikas Singh and K.K. Gautam (on Study leave w.e.f. Dec 2020) Associates: J. Haldar (Insects) and B.R. Meena (Diseases) (upto Aug 2020)
1.8	Genetic Improvement of Luffa	T. Chaubey	Sudhakar Pandey and R.K. Dubey Associates: J. Haldar (Insects), B. Meena (Diseases) (upto Aug 2020)
1.9	Genetic Improvement of Pumpkins and Cucumber	Sudhakar Pandey	D.R. Bhardwaj, T. Chaubey, Vikas Singh and KK Gautam (on study leave w.e.f. Dec 2020) Associates: J. Haldar (Insects), A.N. Tripathi (Diseases), K. Nagendran (Viruses)
1.10	Genetic Improvement of Melons	KK Gautam (on study leave w.e.f. Dec 2020) Vikas Singh w.e.f. Dec 2020)	Sudhakar Pandey , Pradip Karmakar Associates: K. Nagendran (Diseases/Viruses)
1.11	Genetic Improvement of Okra	Pradip Karmakar	Achuit Singh and Vidyasagar Associates: J Halder (Insects) and K. Nagendran (Diseases/Viruses)
1.12	Genetic Improveme nt of Cole crops and Root crops	BK Singh	P. Karmakar Associates: A.T. Rani (Insects), B. R. Meena (Diseases) (upto Aug 2020)
1.13	Biotechnological interventions including Transgenics for managing stresses in vegetables	Achuit Singh	Sudhakar Pandey, SK Tiwari, YS Reddy, Jyoti Devi, Vidyasagar, D.P. Singh, Indivar Prasad and Manimurugan C. (upto Aug 2020) Associate: K. Nagendran (Diseases)

1.14	Genetic Improvement of under exploited & future vegetables	R.K. Dubey	B.K. Singh, Jyoti Devi, Y.S. Reddy, Vidyasagar and Indivar Prasad Associates: P.A. Divekar (Insects) and B.R. Meena (Diseases) (upto Aug. 2020)
1.15	Genetic Improvement of clonally propagated & perennial vegetables	Vikas Singh	D.R. Bhardwaj, Ram Chandra, P. Karmakar and Vidyasagar Associates: J. Haldar (Insects), and B.R. Meena (Diseases) (upto Aug. 2020)
MEGAPROGRAMME 2: SEED ENHANCEMENT IN VEGETABLES			
Programme Leader :Dr. P.M. Singh			
2.1	Priming, Coating, ovule conversion and seed enhancement	P.M. Singh	Rajesh Kumar, T Chaubey, Vikas Singh , Manimurugan C. (upto Aug. 2020) Associate: J. Halder (Insects) and A.N. Tripathi (Diseases)
2.2	Pollination studies for seed augmentation in vegetables including support of honey bees	Rajesh Kumar	P.M. Singh, T. Chaubey, J. Halder, P.A. Divekar and Manimurugan, C. (upto Aug. 2020) Associate: A.N. Tripathi (Diseases)
2.3	Drying and storage studies on vegetable seeds including modified atmosphere storage	Manimurugan C. (upto Aug. 2020) P.M. Singh (w.e.f. Aug. 2020)	P.M. Singh, J. Singh Sudhir Singh, Rajesh Kumar, S. Roy and Nakul Gupta (on study leave w.e.f. 09.02.2019)
MEGA PROGRAMME 3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT			
Programme Leader : Dr. R. N. Prasad			
3.1	Technologies for protected vegetable production	Hare Krishna	Anant Bahadur, Jagdish Singh, R.N. Prasad, Swati Sharma and Rajeev Kumar Associates: K.K. Pandey (Diseases)
3.3	Vegetable based cropping systems	R.N. Prasad	S.K. Singh, R.B. Yadava and Vanitha S.M.
3.10	Agronomic bio -fortification studi es in vegetable crops	R.B. Yadava	Jagdish Singh, Hare Krishna and Rajeev Kumar
3.11	Development of agro -techniques for organic farming in vegetable crops	S.K. Singh	R.B. Yadava, Vijaya Rani and Swati Sharma Associates: K.K. Pandey (Diseases), Jaydeep Haldar (Insects), and Ram Chandra.
3.12	Improving water productivity of vegetable crop sequences through drip irrigation system	Anant Bahadur	Associates: Jaydeep Haldar (Insects)
3.13	Enhancing productivity, quality and tolerance to biotic and abiotic stresses in vegetables by grafting technology	Anant Bahadur	Hare Krishna and Rajeev Kumar Associates: K.K. Pandey (Diseases)
3.14	Weed management in vegetable crops	S. K. Singh	Jagdish Singh, Associates: Vijaya Rani and Sujan Majumder
3.15	Conservation agriculture under vegetable based cropping system	R. B. Yadav	S.K. Singh, Anant Bahadur and Hare Krishna Associates : Vijaya Rani and Sujan Majumder
3.16	Offseason cltivation of vegetables under protected environment	S.N.S. Chaurasia	Anant Bahadur, Hare Krishna and Swati Sharma Associates: K.K. Pandey (Diseases) and A.T. Rani (Insects)

MEGA PROGRAMME 4: POST HARVEST MANAGEMENT AND VALUE ADDITION			
Programme Leader : Dr. Sudhir Singh			
4.4	Influence of polyamines on postharvest senescence and quality of high value vegetables	Swati Sharma	R. N. Prasad and 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	Subhadeep Roy	Neeraj Singh and Vanitha S.M.
5.5	Economic impact assessment of IIVR developed technologies	Vanitha S.M.	Subhadeep Roy and Neeraj Singh
5.6	Development and promotion of nutri - garden module for rural households	Neeraj Singh	R. N. Prasad, S. N. S. Chaurasia, Subhadeep Roy and Vanitha S.M.
MEGA PROGRAMME 6: INTEGRATED PLANT HEALTH MANAGEMENT			
Programme Leader :Dr. K.K. Pandey			
6.1	Bio-intensive management of important pests of vegetable crops	Jaydeep Halder	P.A. Divekar, K. Nagendran and Sujan Majumder Associates: Neeraj Singh
6.2	Toxicological investigations on the novel and botanical insecticides against major insect pests of vegetables.	P. A. Divekar	A. T. Rani, J. Halder and Sujan Majumder
6.3	Biological control of major insect pests of vegetable crops	Jaydeep Halder	A.T. Rani and A. N. Tripathi
6.4	Development of effective integrated management package for important fungal diseases of vegetable crops	K.K. Pandey	B.R. Meena (upto Aug. 2020), A. N. Tripathi and Anurag Chaurasia
6.5	Bio-prospecting of microorganisms associated with vegetables against plant pathogens	B.R. Meena (upto Aug 2020) A. N. Tripathi (w.e.f. Aug 2020)	K.K. Pandey, Anurag Chaurasia, Sweta Kumari, Vijaya Rani and S. Maurya
6.6	Management of important bacterial diseases of vegetable crops	A.N. Tripathi	B.R. Meena (upto. Aug. 2020) and Vijaya Rani
6.7	Characterization of viruses infecting vegetable crops and their management	K. Nagendran	Shweta Kumari, K K Pandey and Manimurugan C. (upto Aug. 2020) Associates: Achuit K. Singh
6.10	Pest and disease dynamics, and behavior modifying strategies for major insect pests of important vegetable crops in relation to changing weather scenario	A.T. Rani	J. Halder, B.R. Meena (upto Aug 2020) and P.A. Divekar
6.11	Mapping and characterization of phytoplasmas infecting vegetable crops and its management	Shweta Kumari	K. Nagendran Associates: Shailesh K. Tiwari
6.12	Bio-management of post -harvest diseases in major vegetable crops	Vijaya Rani	B.R. Meena (upto Aug 2020), S. Maurya and Sujan Majumder Associates: Swati Sharma
6.13	Residue dynamics, safety evaluation and decontamination of chlorantraniliprole, deltametehrin, azoxystrobin and kresoxim-methyl in tomato, brinjal and chilli	Sujan Majumder	Vijaya Rani, J. Halder, P.A. Divekar and K.K. Pandey

B. Externally Funded

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	N. Rai	Y. S. Reddy
3.	Network Project on Transgenic Crops (NPTC)	Achuit K. Singh	Nagendran Krishnan
4.	CRP on Agrobiodiversity	S.K. Tiwari	P. Karmakar and Vidyasagar
5.	Central Sector Scheme for Protection of Plant Varieties and Farmers' Rights Authority (DUS Testing of tomato, brinjal, okra, cauliflower, cabbage, vegetable pea, French bean, bottle gourd, bitter gourd, pumpkin and cucumber)	Sudhakar Pandey	T. Chaubey
6.	Agri Business Incubator (ABI)	P.M. Singh	SK Tiwari, Shubhdeep Roy, Neeraj Singh and Sudhir Singh (up to Feb. 2020)
7.	Zonal Technology Management Unit (ZTMU)	P.M. Singh	SK Tiwari, Shubhdeep Roy, Neeraj Singh and Sudhir Singh (up to Feb. 2020)
8.	Cowpea golden mosaic disease (CPGMD) resistance: Agroinfectious clone development, Screening, Gen etics of inheritance, Molecular Tagging and Mapping for CPGMD resistance gene(s) in cowpea by using linked markers	B. Rajasekhar Reddy	Achuit K. Singh and K. Nagendran
9.	Monoecious sex expression in muskmelon (Cucumis melo L.): Inheritance and molecular mapping of monoecism using linked markers	P. Karmakar	-
10.	Development and evaluation of annual moringa for food fodder and nutritional content in U.P.	Vidyasagar	R.B. Yadav
11.	Identification of suitable varieties/hybrids of cucurbitaceous crops and de velopment of production protocol for better livelihood of river bed (diara land) farming community.	Sudhakar Pandey	K.K. Pandey, R.K. Dubey, Rajneesh Srivastava
Division of Crop Production			
11.	Efficient Water Management in Horticultural Crops (under Agri-CRP on Water Project)	Anant Bahadur	SNS Chaurasia
12.	Development of shelf stable intermediate moisture leafy vegetables using radiation processing	Sudhir Singh	-
13.	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, R.N. Prasad, D.R. Bhardwaj, S.K. Singh, S.M. Vanitha, G.K. Chaudhary and J. Singh
Division of Crop Protection			
14.	AICRP on Biocontrol	J. Halder	-
15.	Validation & promotion of sustainable and Adaptable IPM Technology for Brinjal crop	J. Halder	BR Meena (up to 21 Aug. 2020) & Manoj Kumar Pandey

Annexure IV

Distinguished Visitors

Shri Sunil Baburao Mendhe Hon'ble Member of Parliament Bhandara-Gondia (Maharashtra)	14th January 2020
Dr. Pritam Kalia Member of Quinquennial Review Team (QRT)	18th January, 2020
Dr. Anand Kumar Singh DDG (Horticulture Science) Indian Council of Agricultural Research, New Delhi	25th February 2020
Prof. Vashistha Narayan Tripathi Professor Department of Hindi Banaras Hindu University, Varanasi	14th September, 2020
Smt Smriti Irani Union Minister of Women and Child Development Government of India	03rd October 2020
Dr. Devesh Chaturvedi Additional Chief Secretary (Agriculture)	28th December 2020
Shri Kaushal Raj Sharma District Magistrate Varanasi	28th December 2020

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