वार्षिक प्रतिवेदन
Annual Report
2018-19

भा.कृ.अनु.प.-भारतीय सब्जी अनुसंधान संस्थान
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ICAR-Indian Institute of Vegetable Research
Varanasi-221 305

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Dr. Jagdish Singh
Director (Acting)
ICAR-Indian Institute of Vegetable Research
Post Bag No. 1, P.O.- Jakhini (Shanshahpur)
Varanasi -221 305, Uttar Pradesh, India
Phone: +91-5422635236; 37; 47
Fax:+91-5443-229007
Email: directoriivr@gmail.com

Compilation and Editing :
Core Committee : P.M. Singh, R.N. Prasad, K.K. Pandey and Sunil Gupta
Sub Committee :
Vegetable Improvement : Shailesh Kumar Tiwari and Indivar Prasad
Vegetable Production : R.B. Yadav and Hare Krishna
Vegetable Protection : Anurag Chaurasia
AICRP (VC) : S.K. Verma, T. Chaubey and B.R. Reddy
Krishi Vigyan Kendras : Vikas Singh, A.K. Chaturvedi and Rajneesh Srivastava
Administration : Sujit Kumar Singh and U.K. Saxena

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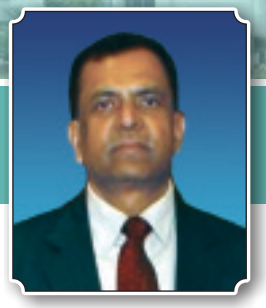
Contact : 9838106730; Email : graphicarts.vns@gmail.com

Preface



Vegetables contribute to healthier lives and more resilient livelihoods through greater diversity. Worldwide production of fruit and vegetable crops has grown faster than that of cereal crops. Even in India, the record horticultural production (vegetables contribute to about 59 – 61%), will mark the seventh continuous year of horticultural production outstripping that of food grains (estimated at 283.37 million tonnes in 2018-19), suggesting a structural change in Indian agriculture. Diversification into horticultural crops is becoming attractive for many poor farmers around the world. The per capita farm income to horticultural producers is many times higher as compared to cereal producers. Since horticultural production is usually labor intensive, the cultivation of fruits and vegetables allows for productive employment where the labor/land ratio is high. Increasing horticultural production contributes to commercialization of the rural economy and creates many off-farm jobs. The vegetable production during 2018-19 is estimated to rise by 1.6 per cent (around 187.47 million tonnes as compared to 184.39 million tonnes in 2017-18), whereas, it is about 3.7 per cent more than that in 2016-17. There is also marginal increase in area under vegetables during the current year (10.43 million ha as compared to 10.259 million ha in 2017-18).

However, this spectacular growth of vegetable production in the country is accompanied with several challenges like low and uneven productivity across the country; perishability and high cost of cultivation; inadequacy of multipurpose varieties especially those suitable for processing and eco-friendly agro-techniques for improving total factor productivity (TFP); poor management of dwindling natural resources and poor quality of the produce including food safety issues. In addition to this the issues like lack of market access and market information need to be addressed.

To bridge the productivity gap, concerted efforts have been made by the institute in the field of basic, strategic and applied research. During the year, 28 vegetable varieties and 07 hybrids in 20 vegetable crops were notified by CVRC. Under biotechnology, Optimization of Agrobacterium mediated genetic transformation of cauliflower, In-Planta transformation in okra, CRISPR/Cas9 mediated genome editing work in okra and tomato was undertaken. The R&D programmes are further supplemented by 20 externally funded projects including one on introgression of begomovirus resistance genes in tomato using MAS and genomic approach. The institute activities have also been strengthened in vegetable seed production (27075.53 kg of OP varieties and 151.4 kg of hybrids) and transfer of technologies with the support of its Regional Research Station at Kushinagar and 3 KVKs at Bhadohi, Deoria and Kushinagar. The institute has a proud history of capacity building. During the year, 26 training programmes of extension professionals and vegetable farmers were conducted. The institute also organized MANAGE, Hyderabad sponsored Certified Farm Advisor (Module II) training programme for participants from 11 different states in two batches. In addition to this, a massive Krishak Jagrukata Abhiyan was organized in 03 blocks of Varanasi district covering 10868 farmers of 463 villages. Efforts have also been made for improving the livelihood and nutritional status of 1512 selected tribal households in Chopan Block of Sonbhadra district under TSP component.

Constant encouragement, support and guidance of Dr. T. Mohapatra, Secretary (DARE) and Director General, ICAR; Dr. Anand Kumar Singh, Deputy Director General (Horticultural Science), ICAR and Dr. T. Jankiram, Assistant Director General (HS), ICAR have gone a long way in effectively accomplishing research and physical targets for the year 2018-19 by the institute. All the scientists, technical and administrative staff of our vegetable fraternity especially Dr. P. M. Singh, Chairman PME Cell and Dr. Sunil Gupta, Member Secretary PME Cell are duly acknowledged for their untiring cooperation, coordination, compilation of information and timely bringing out this document.

Varanasi
June 30, 2019

Jagdish Singh
Director

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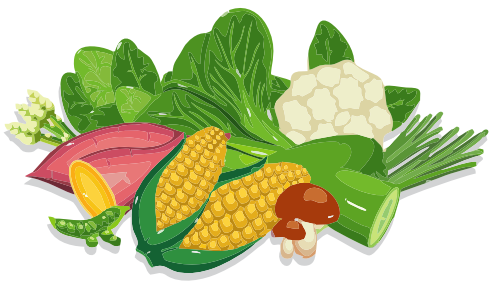


Executive Summary

Vegetable research, extension and development activities at ICAR- Indian Institute of Vegetable Research, Varanasi have been framed into six Mega-programmes.

Under sub project entitled genetic improvement of tomato, test hybrid VRT16-11 × VRT16-12 was found promising for high yield. Among the segregating lines, VRT-34 and VRT-16-1 were suitable for rainy season with low ToLCV incidence coupled with good yield whereas, lines VRTKB-14, VRTKB-8, VRTKB-9 and VRNRT-12 were superior for nutritional values. In red fruited cherry tomato, VRCRT-2, VRCRT-14 and VRCRT-9 were superior for high yield and TSS, while in yellow fruited cherry tomato, advance lines VRCYT-6, VRCYT-3 and VRCRT-9 were better for nutritional attributes.

In brinjal, two hybrids *viz.* HRB/B3-17 (IVBHR-19) in round fruited and HLB/B3-36 (IVBHL-23) in long fruited segment have been identified for multi-location testing. Among advance lines, CHBR-2 x BCB3-1 (IVBR-20) in round fruited type and Uttara x JB-7 (IVBL-28) in long fruited type were identified as promising. Variety Kashi Himani (IVBL-26) was released and notified for cultivation in Uttar Pradesh.

In chilli, an inbred line IIVRC-18132 derived from the cross of VR 339 x VR 338 has been found promising and identified for multi-location testing. Among hybrids, hybrid A7 X EC 519625 and A1 X VR 339 was found promising and VR 339 emerged as superior combiner for yield and disease resistance in many hybrids. Twenty F_6 families derived from an inter-specific cross of chilli such as IIVRC-GT-191-2-2-4-2 and IIVRC-GT-183-2-1-4-2 were promising with respect to ChiLCV resistance. Two Hybrids, Kashi Ratna and Kashi Tej and one variety Kashi Abha were released and notified for cultivation in Uttar Pradesh.

Under genetic improvement of pea, multi-flowered pea genotype VRPM–901–5 was found promising for pod yield/plant. Among early maturity group, three advance breeding lines *viz.*, VRPE-29, VRP-16 × VRP-25 and VRP-22 × DARL-404 were found promising for earliness and pod yield/plant while VRPE-66 and VRPE-60 were promising early lines with long pod. A new entry 'VRPE-903' was identified for multilocation testing in mid-season trial segment.

In cowpea, advanced breeding lines VRCP 218-1 and VRCP 68-2 were promising for yield and horticultural traits. IC number was obtained for eleven advance breeding lines.

Under sub project, genetic improvement of Indian bean & French bean, two varieties *viz.*, Kashi Khushaal and Kashi Sheetal of pole type Indian bean, and two varieties *viz.*, Kashi Rajhans and Kashi Sampann of vegetable type french bean were released and notified for cultivation in Uttar Pradesh.

Among seed propagated gourds, advance lines VRBTG-47-1 and VRBTG-10 of bitter gourd were found promising for various horticultural traits. In white fruited lines, VRBTG-37 and VRBTG-11-1 were found promising for yield and quality attributes. The hybrid VRBTG-5 x VRBTG-2-1 was found superior for yield. In bottle gourd, long fruited hybrids VRBG-1 x VRBG-3 and VRBG-8 x VRBG-6 were promising while VRBG-27 x VRBG-34 and VRBG-4 x VRBG-59 were found promising with respect to yield in round segment. Three varieties *viz.*, Kashi Kirti, Kashi Kiran and Kashi Kundal were released and notified for commercial cultivation in Uttar Pradesh.

Under genetic improvement of Luffa, sponge gourd variety Kashi Shreya and hybrid Kashi Rakshita were released and notified for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. Beside these, variety Kashi Jyoti and hybrid Kashi Saumya were also released and notified for commercial cultivation in Uttar Pradesh. In line VRSG-7-17 of sponge gourd, a special aroma like 'Basmati Rice' has been found due to presence of high concentration of Hexenal and 3 Octanone. In ridge gourd, the entries such as VRRG-110, VRRG-1-16 and VRRG-8-17 were found promising for horticultural traits and were free from *Sponge Gourd Mosaic Virus* (SGMV) and downy mildew disease symptoms under field conditions. Satputia genotypes

VRS-24-1, VRS-25, VRS-20, VRS-36 and VRS-11 were found promising for horticultural traits.

Under genetic improvement of pumpkin and cucumber, maximum yield per plant was reported in advance lines of pumpkin VRPK-9-01 followed by VRPK-222, Kashi Shishir, an early maturing hybrid of pumpkin, Kashi Subhangi, a medium maturing, bushy variety of summer squash and cucumber hybrid Kashi Nutan were released from state variety release committee and notified for Uttar Pradesh. In summer squash, advance lines VRSS-65 and VRSS-66 were found promising in terms of yield and quality. Twenty hybrids of cucumber were evaluated for yield and yield contributing traits and VRCUH-16-01 was found promising. Among advance cucumber lines, VRCU-Sel.-12-03 and VRCU-Sel.-12-02 were promising based on the fruit colour, appearance and yield.

In melons, fifteen advance lines of muskmelon (andromonoecious or monoecious) were evaluated and VRMM-170 and VRMM-186 were found promising. Wild accession of muskmelon, RCM/PK/45 was found resistant to downy mildew disease under field condition. Watermelon lines VRW-514-1 and VRW-514 were found promising for high yield and TSS. An unique inbred line (VRW-14-1) having yellow vein leaf marker with fruits having yellow skin and yellow flesh was identified. Among round melon genotypes, VRM-1, VRM-5 and VRM-11-1 were found promising. In long melon, VRLM-01, VRLM-40, VRLM-24-1, VRLM-28 and VRLM-29-1 were found to be superior for yield and quality attributes.

In okra, a total of 47 new accessions were augmented from western Uttar Pradesh and Odisha. Out of ninety okra hybrids evaluated, VRO-178 × 416-10-1, VRO-110 × Kashi Kranti and OK-99-335 × VRO-109 were found promising for yield and YVMV resistance. VRO-120 and VRO-125 were identified as most promising genotypes for fruit yield, quality and disease resistance. Among wild accessions of okra, *A.enbeepeegearense, A. crinitus, A. angulosus* var *grandiflorus*, *A. moschatus* subsp *tuberosus*, *A. manihot* and *A. moschatus* showed immune type reaction to both YVMV and ELCV disease under field condition which was also confirmed through molecular screening using begomo virus specific primer. Two okra varieties *viz.* Kashi Chaman and Kashi Lalima and one hybrid Kashi Shrishti were released from state variety release committee and notified for Uttar Pradesh.

In cole crops, among 72 genotypes of cauliflower, VRCF-75-1 and VRCF-86 in mid-October maturity; VRCF-102, VRCF-27, and VRCF-32 in late-October to mid-November maturity and VRCF-104, VRCF-202 and VRCF-22 in late-November to mid-December maturity group were found promising. A variety ready to harvest during 1st fortnight of November 'Kashi Gobhi-25 (VRCF-50)' was released and notified for Uttar Pradesh. Best promising CMS-based hybrids expressing 15-25% heterosis and developing curds at different temperature were identified as VRCF-41×VRCF-75-1 (28-30 °C), VRCF-41×VRCF-50 and VRCF-131×VRCF-86 (25-28 °C), and VRCF-110×VRCF-50 and VRCF-110×VRCF-104 (20-25 °C). Tropical kale genotype 'VRKALE-1' induced bolting and flowering, set seeds in the North Indian plain and did not require any vernalization. Under root crops, in carrot, the most promising genotypes with better quality traits and higher root yield were VRCAR-186, VRCAR-201, VRCAR-185 and VRCAR-109 (red root); VRCAR-126, VRCAR-124 and VRCAR-89-1 (black root); VRCAR-91-1 and VRCAR-91-2 (orange root); VRCAR-153, VRCAR-127 and VRCAR-178 (yellow root); VRCAR-160 (cream root); and VRCAR-107-1, VRCAR-107-2 and VRCAR-171-1 (rainbow-type root). A black coloured variety of carrot named Kashi Krishna (VRCAR-126), and two varieties of radish *viz.*, Kashi Mooli-40 & Kashi Lohit were released and notified for UP state. Among radish hybrids evaluated, VRRAD-11×VRRAD-203, VRRAD-201×VRRAD-203, VRRAD-201×VRRAD-216, VRRAD-201×VRRAD-90, VRRAD-13×VRRAD-200 and VRRAD-201×VRRAD-200 were found promising.

Under biotechnological interventions including transgenics for managing stresses in vegetables, protocol for *Agrobacterium*-mediated genetic transformation of cauliflower *(Brassica oleracea* L. *var. botrytis*) was optimized. Magnitude of cross transferability of the cotton SSR in okra was assessed giving around only 6% of cross transferability. Molecular characterization of *Okra Enation Leaf Curl Virus* was completed.

Further pathogecity study of βC1 gene of OELCB was established in model plant. For PCR based detection of ChiLCV, ToLCGV, ToLCNDV, ToLCKV, ToLPMV and RalCV in host plants, the specific primers of respective viruses were designed. Independent in-planta transformation of okra in the cultivar Kashi Kranti was repeated. A total 2500 seedlings were transformed and the presence of *npt II* gene confirmed in

20 T_0 events. CRISPR/Cas9 mediated genome editing work in okra and tomato was continued towards the development of vector for plant transformation. High-density genetic linkage map based on arbitrary and microsatellite markers using mapping population of RILs in eggplant (*Solanum melongena* L.) was constructed. Work on diversity analysis and validation of powdery mildew linked markers in pea germplasm was undertaken and several DNA markers (*PSMPSAD60, PSMPSAA374, PSMPA5* and *ScX171400 etc.*) were found to be linked to powdery mildew resistance genes *er*-1 and *er*-2.

In under-exploited and future vegetables, 153 germplasm lines of winged bean were characterized for different horticultural traits. Genotypes *viz.*, VRWB- 29, VRWB- 45, VRWB- 46, VRWB- 56, VRWB- 57, VRWB- 60, VRWB- 71, VRWB- 77, VRWB- 91 and VRWB- 94 were identified as promising for pod yield, whereas, genotype VRWB-69 was adjudged as promising for tuber traits. In cluster bean, the promising genotypes were VRCB-95, VRCB-96, VRCB 105, VRCB-128 VRCB-47, VRCB-48, Avani-117 and Dilojan-3 for different horticultural traits and disease resistance. A total of 115 Faba bean genotypes were evaluated for yield and horticultural traits. Some promising genotypes were Muradabad-103, EC- 628941, EC- 628921, EC-841776, Cherry, EC-841609, ET-3160 and ET-1107 for yield and disease tolerance. Among 125 genotypes of vegetable soybean characterized for various horticultural traits, genotypes Swarna Vasundhara, EC-148, AGS-406, AGS-447, EC-215 and AGS-429 were found superior for pod yield per plant. Water chestnut genotype, VRWC-1 was found promising for dry matter content and fruit yield. In lotus, VRL-1 genotype was found promising. In water spinach, VRWS-1, VRWS-4, VRWS-8, VRWS-9, VRWS-23, VRWS-24 and VRWS-25 were found promising. Biochemical analysis of BSLB resistant and susceptible inbred lines in baby corn revealed that resistant inbred line (IIVRBC-13) contains the highest and susceptible line (IIVRBC-19) the lowest total phenol content.

Seven genotypes/varieties of bathua, a leafy chenopod, were evaluated and biomass yield of three varieties namely Kashi Bathua-2 (VRCHE-2, green leaves), Kashi Bathua-4 (VRCHE-4, purplish-green leaves) and Pusa Bathua-1 (purplish-green leaves) were found promising. Kashi Bathua-2 (VRCHE-2) and Kashi Bathua-4 (VRCHE-4) were released and notified for UP state. VRPLK-2 was found to be the best performing beet leaf (Palak) genotype as compared to the popular variety All Green in three dates of sowing viz. late-August, late-September and late-October. Among 165 germplasm lines of Amaranth evaluated, the promising genotypes for green leaf yield were AM-2, AM-2A, AM-8, AM-32, AM-42, AM-44, AM-64, AM-64A, AM-131 and AM-133. In amaranth, variety Kashi Suhaavani was released and notified for Uttar Pradesh.

Under sub project entiltled genetic improvement of vegetatively propagated and perennial vegetable crops, pointed gourd genotype VRPG-217 was found promising with 13kg fruit yield/vine. Pointed gourd variety Kashi Suphal and Kashi Amulya were notified and released for Uttar Pradesh. In teasle gourd, maximum fruit yield per plant was found in VRSTG-38 (2.44 kg) followed by VRSTG-20 (1.95 kg) and VRSTG- 6 (1.94 kg) whereas in spine gourd, genotype VRSEG-14 (2.18 kg) gave maximum fruit yield per plant followed by VRSEG-10 (1.81 kg) and VRISEG-9 (1.75 kg). Out of 14 lines of Ivy gourd, highest fruit yield per plant was observed in line VRIG-16 (15.19 kg) followed by VRIG-14 (14.78 kg). In basella, promising genotypes with higher yield were VRB-2, VRB-3, VRB-4, VRB-10, VRB-13, VRB-17 and VRB-19. Rapid screening protocol for screening against collar rot pathogen in basella was also developed. Three varieties of basella *viz.*, Kashi Poi-1, Kashi Poi-2 and Kashi Poi-3 were released and notified for cultivation in Uttar Pradesh. In moringa, the promising genotypes VRMO-17, VRMO-16, VRMO-21, VRMO-9, VRMO-10, VRMO-12 and VRMO-14 reorded more than 200 fruits/plant/year.

Under the mega project on Integrated Gene Management, genetic resources of 44 major and minor vegetable crops (including wild/related species) were maintained. A total of 74 breeding materials developed (24 in brinjal, 6 in okra, 9 in vegetable pea, 11 in cowpea, 8 in sponge gourd and 16 in tropical cauliflower), were assigned IC numbers from NBPGR, New Delhi. During germplasm explorations in current year, 253 accessions of 20 vegetable crops were augmented. Besides, 1063 accessions of 22 species of vegetable crops were shared/distributed to different organizations for use in research after signing the material transfer agreement (MTA).

Under mega programme on seed enhancement in vegetables, a total of 27075.53 kg vegetable seeds in 22 vegetable crops were produced for distribution amongst the seed indenters and growers. Among the total seeds, 23811.03 kg were truthfully labelled seeds of the open pollinated varieties of ICAR-IIVR and 3083.00

kg were breeder seeds produced against 1524.40 kg national indent. Apart from OP varieties, 151.4 kg F_1 hybrid seeds of brinjal, tomato, chilli and sponge gourd were also produced for the growers. At the Regional Research Station, Sargatia, a total of 29482 kg seed and planting materials were produced including turmeric and elephant foot yam. In priming, coating, ovule conversion and seed enhancement studies, priming of basella seeds with Zn and Fe nano particles was found to effectively alleviate the Lead (Pb) toxicity. While studying morpho-biochemical changes during seed development, maturation and desiccation tolerance in *Moringa oleifera*, it was found that seed germinability increased with the advancement of seed towards maturity and seed attains desiccation tolerance and germinability 49 days after anthesis onwards. In pollination studies for seed augmentation in vegetables including support of honey bees, treatment comprising 5% sugar + 5% jaggery + multivitamin + 200 ppm nano-ZnO attracted maximum number of pollinators across the time in sponge gourd and bottle gourd. Under sub project entitled drying and storage studies on vegetable seeds, it was found that maximum moisture content from seeds was removed within first 24h of drying in ash gourd cv. Kashi Dhawal by using desiccants like zeolite beads and silica gel. While standardizing the seed storage methods with zeolite beads and silica gel in seeds of pumpkin cv. Kashi Harit, radish cv. Kashi Hans and vegetable cowpea cv. Kashi Nidhi, it was found that the seeds stored in cold storage with zeolite beads maintained significantly higher seed quality after 12 months of storage period.

In the Division of Vegetable Production, studies carried out under naturally ventilated polyhouse conditions revealed that two-stem training system in tomato was most suitable recording an yield of 11.3kg per plant in cv. NS-4266 as compared to single stem trained and unpruned plants. Spray of PGRs comprising of NAA@15ppm + SA was found to be the best in terms of yield (10.63 kg per plant), fruit length (4.78 cm), fruit diameter (5.63 cm) followed by GA_3+ salicylic acid in tomato cv. NS-4266. Choice of training system in Capsicum may depend upon market requirement as two-stem gives fewer but larger fruits. Likewise, three-stem produces less but fairly good size fruits.

Under vegetable based cropping system, after one complete cycle of 2017-18, the highest total productivity (278.97 q/ha) in terms of rice equivalent yield (REY) was obtained with cowpea-tomato-okra cropping sequence followed by okra-tomato-cowpea (271.98 q/ha). During *kharif* season -2018, the highest productivity in terms of REY was obtained with brinjal (177.57 q/ha). During *Rabi*-2018-19, the highest REY was recorded with tomato (112.48 q/ha). Bottle gourd-wheat-amaranth cropping system was found the most profitable with the highest B:C ratio of 2.43.

Under agronomic bio-fortification studies in vegetables, foliar application of crop group specific micronutrient formulations for solanaceous and cole crops (tomato, cabbage and cauliflower) resulted into enhancement of yield by 13.6 to 17.8% in tomato, 11.9 to 18.5% in cabbage, and 9.4 to 20.0% in cauliflower, respectively over control. Micronutrient profiling for Cu, Fe, Zn and Mn in 18 genotypes of cowpea and 41 genotypes of okra revealed large variation in these micronutrients across the genotypes in both the crops.

The organic farming of vegetables was observed to be remunerative with application of FYM/ NADEP compost @ 25t/ha or FYM@ 10t/ha + Vermicompost @ 3.5 t/ha, as it increased the yield of carrot, pea and *Kasuri methi* by 14.60, 36.39 and 81.21%, respectively with B:C ratio ranging between 1.99 to 6.17 over conventional inorganic farming. In tomato and broccoli, the yield level achieved under organic farming was marginally lower (8.06 and 1.15%) than inorganic system. The quality of the vegetables under organic system in terms of ascorbic acid, total phenol and anti-oxidant content was superior by 40.1, 43.4 and 16.8% in broccoli, and 31.8, 48.8 and 14.96% in *Kasuri methi* over inorganic system. The organic carbon content of the soil improved by 17.63 and 22.42%, respectively with the application of NADEP compost and FYM @ 25t/ha.

Studies on drip irrigation under different crop sequences revealed maximum yield in cowpea (10.90 t/ha), tomato (39.93 t/ha), okra (7.51 t/ha), cabbage (53.19 t/ha) and cauliflower (48.47 t/ha) under drip irrigation at 100% ET, however, the water use efficiency ranging between 0.35 to 1.82 t/ha-cm was maximum under 75% ET.

Inter-specific grafting study demonstrated that tomato cv. Kashi Aman registered 28.67% and 36.36% higher fruit yield with brinjal rootstock of IC 111056 and IC 354557, respectively. Similarly, indeterminate hybrid tomato (NS 4266) registered 79.8% higher fruit yield when grafted on IC 111056 rootstock. Significantly higher TSS content in fruits was recorded in graft combination of *S. torvum* x Kashi Aman and Surya x

Kashi Chayan, whereas higher lycopene content was recorded in IC-354557 x Kashi Chayan and *S. laciniatum* x Kashi Adarsh combination. Ascorbic acid content in fruit was maximum in IC-354557 x Kashi Chayan (31.25 mg/ 100 g) followed by *S. aethiopicum* x Kashi Adarsh (27.50 mg/ 100 g).

Weed control studies in cowpea recorded maximum yield (15.6 t/ha) with black polythene mulch followed by organic mulch (14.8 t/ha). Among herbicide treatments, maximum pod yield (12.3 t/ha) was recorded with sequential application of pendimethalin 750 g/ha (pre-emergence) + imazethapyr (post emergence).

In French bean, maximum weed control index (WCI) 98.9 %, was recorded with black polythene mulch. Among the herbicide treatments, maximum WCI (97.2 %) was observed with sequential application of pendimethalin 750 g/ha (pre-emergence) + sodium acifluorfen + clodinafop 100 g/ha (post emergence), followed by application of pendimethalin 750 g/ha (pre-emergence) + imazethapyr 100 g/ha (post emergence; 95.7%).

Black polythene mulch treatment in French bean recorded significantly superior yield (16.9 t/ha). Among herbicide treatments, maximum yield (13.4 t/ha) was attained with sequential application of pendimethalin 750 g/ha (pre-emergence) + sodium acifluorfen + clodinafop 100 g/ha (post emergence).

Under conservation agriculture in vegetable based cropping system, zero tillage with residue retention produced maximum green cob yield (13.0 t/ha) in sweet corn followed by conventional tillage with residue incorporation (12.6 t/ha).

Studies on postharvest management and value addition in vegetables revealed that the shelf life of cucumber can be extended to 28 days at 15°C in modified atmospheric packaging in 30µ flexfresh bags. The gaseous composition in cucumber varied (16.6-19.9% oxygen/3.2-3.7% carbon dioxide) during MAP storage of cucumber at 10 and 15°C. The increased level (3.2-3.7%) of carbon dioxide was helpful in reducing the respiratory activity and subsequently increasing the shelf life. Total phenol content reduced in cucumber during storage and the decrease was 58% and 53.4% after 28 days of MAP storage at 10 and 15°C, respectively.

The economic impact assessment of IIVR developed technologies indicated that approximate spread of area under Kashi Kanchan variety of vegetable cowpea was 90314.8 ha during 2007-08 to 2018-19 covering 443 districts of 29 states and 2 Union Territories (calculated from the sale of both TL and breeder seeds). Around 65% of the estimated total area covered comprised of Uttar Pradesh and Bihar. Cowpea variety Kashi Kanchan has earned around Rs. 24.6 lakhs during this period under commercialization to 7 different private seed companies.

The results of economic surplus model showed that the producer surplus generated from Kashi Kanchan variety of vegetable cowpea was Rs. 38.5 crore, consumer surplus was Rs. 128.4 crore and total economic surplus of Rs. 166.9 crore generated from the variety for the last 13 years. The net profit earned was Rs. 36406 higher than that of local variety by growing Kashi Kanchan during rainy season and Rs. 84942 earned during summer season. The B:C ratio was 3.26 and 3.04, respectively for Kashi Kanchan in both the seasons and 1.43 for the local variety in rainy season grown in the farmer's field. The economic worthiness of growing Kashi Kanchan variety over the local variety was around Rs. 86691/ha mainly due to savings in its cost of cultivation on staking and labour as it is a short stature variety.

In the Division of Crop Protection, under toxicological investigations, thiamethoxam, imidacloprid and dimethoate were found to be most effective with 68.05, 65.12 and 64.87 per cent protection against aphid population respectively, as compared to other novel insecticides and untreated control. DBM population was significantly reduced by cyantraniliprole with 76.02 per cent protection over untreated control. Among different insect-acaricides, chlorfenapyr and fipronil were found to be most effective against mites and thrips with 63.16 and 75.69 per cent reduction in population, respectively. Spinosad, indoxacarb, chlorantraniliprole and emamectin benzoate were found most effective giving 87.37, 78.64, 77.73 and 73.53% protection against cowpea pod borer population, *Maruca vitrata* with higher yield 142.47, 135.80, 134.77 and 120.27 q/ha, respectively. Indoxacarb, chlorantraniliprole and spinosad were found most effective giving 85.92, 84.73 and 80.03 % protection, respectively in Amaranth leaf webber, *Spoladea recurvalis* population. *S. obliqua* larvae were found highly susceptible to lambda cyhalothrin and quinalphos with lowest LC_{50} values at 24 and 48HAT, respectively when tested by leaf dip method. *S. litura*

larvae proved to be highly susceptible to indoxacarb in leaf dip (31.28 ppm) and topical application method (11.16 ppm) and to emamectin benzoate in direct spray method (186.34 ppm) with lowest LC_{50} values recorded at 24 hours after treatment (HAT). Among three bioassay methods, leaf dip method recorded maximum larval mortality and found to be the suitable method to determine toxicity of new insecticide molecules.

56 different strains of microbial bioagents including endophytic bacteria (12), *Trichoderma harzianum* (3) and 41 actinomycetes were isolated and pure cultures were established on specified agar medium. *In-vitro* antagonism of three *T. harzianum* strains were tested against soil borne vegetable pathogens (*Fusarium oxysporum, Rhizoctonia solani, Macrophomina phaseolina, Sclerotium rolfsii, F. verticilloide*) under dual culture confrontation test and highest bio-efficacy towards mycelial growth inhibition recorded with Th-2 (42.85-100%) followed by Th-3 (28.57-100%) and Th-1 (14.28-100%). Among tested bio control modules, the highest yield was recorded with treatment T2 - *B. subtilis* IIVR strain CRB-7 (root dipping @1%, soil application of enriched NADEP compost (10g/kg) with 3 soil drenching @1% at 15 days' intervals after transplanting) in tomato. On the basis of cultural and biochemical test of bacterial wilt pathogen isolated from wilted plants of brinjal and chilli, it was identified and confirmed as race-1/ biovar III of *Ralstonia solanacearum*. Chemo sensitivity of bacterial pathogen (*X. compestris* pv. *vesictoria*, *R. solanacearum*, fluorescent and non-fluorescent Pseudomonads) were tested with copper oxychloride 50%WP and azoxystrobin 23% SC, streptomycin sulphate + tetracycline hydrochloride, streptomycin and Nimbicidine tested pathogens showed resistance towards chemicals in all tested concentration (ppm). Field evaluation of different bioagents and chemicals against bacterial diseases revealed highest yield (24.76 t/ha) in tomato (cv. Kashi Amrit) with use of talc based formulation of *T. asperellum* IIVR strain @10 g/l.

The observation on different diseases component ravealed that biological module (T2) was best for minimum early blight and maximum marketable yield in tomato. Unmarketable yield comprising maximum 60% diseased fruits, 20% bird damage, 10% borer and *Tuta*. Out of total diseased fruits, 50% were early blight infected fruits, 25% late blight, 20% *Rhizoctonia* infected fruits, 5% soft rots and other secondary pathogens infected fruits. Total soil fungi were reduced to 7.3×10^3 in solarized soil which was significantly high (2.37×10^4) in unsolarized nursery beds. Pathogenic fungi like *Phythium* and *Fusarium* suppressed during solarization process. Total actinomycetes count was 3.9×10^5 in solarized soil and 6.6×10^5 in unsolarized soil. Weeds, particularly motha/nut grass (*Cyprus rotundas*) population drastically reduced (95.1%) in solarized nursery bed over unsolarized beds. The quantity of available Phosphorus, Sulphur, Boron, Zinc and Copper slightly increased after solarization of nursery beds. Total fungi were maximum 1.18×10^4 cfu/g in vermicopmost sample as compared to NADEP (5.3×10^3). Pathogenic fungus *Fusarium* and *Pythium* was recorded in vermicompost but not in NADEP. The population of *Trichoderma asperllum* decreased after amalgamation at all dose in vermicompost as well as NADEP. Gradually, colony of *Trichdoerma* increased at higher dose in both the organic matter. Three different entomopathogenic fungi *viz., Beauveria bassiana*, *Lecanicillium lecani* and *Metarhizium anisopliae* were completely antagonized by the *Trichoderma* under *in vitro* dual culture test. Total five different isolates of *Trichoderma* was purified and pure culture is maintained in the laboratory. The isolates of *Trichoderma* was named as TTV-1, TTV-2, TCV-1, TCV-2 and TBG-V and compared with *Trichoderma asperllum* as well as BATF-43-1 isolate of IIVR.

Under characterization of viruses infecting vegetable crops and their management, survey has been conducted on cucurbitaceous crop in 9 agro-climatic zones of Uttar Pradesh and documented the viruses infecting cucurbitaceous crops. Major viruses infecting cucurbits are *Cucumovirus* (6.11%), *Potyvirus* (39.44%), *Polerovirus* (10%), *Tobamovirus* (38.33%) and *Orthotospovirus* (2.22%). Mixed infection of more than one virus was also detected among 64% of samples. Infection of watermelon bud necrosis virus (WBNV) on round melon has also been documented for the first time from India based on serological and molecular characterization of coat protein and replicase gene. Sponge gourd seeds extracted from mature fruit of infected plant were tested for the presence of begomovirus through Dot-IBA using SLCV antiserum among 72% of seeds tested. Characterized bipartite begomovirus associated with leaf curl disease of basella as tomato leaf curl Palampur virus based on their complete genome for the first time from India and their genome (DNA A) is found to be recombinant one between unknown major parent and tomato leaf curl New Delhi virus as minor parent. For the management of brinjal little leaf disease (BLLD), planting of brinjal seedlings during September first week is found to be

optimum time which has recorded least disease incidence with optimum yield. Also, among the different modules evaluated for the BLLD management under field conditions, integrated module with black silver mulching (Module 2) is performing better than other modules by recording highest fruit yield (323.33q/ha) with least disease incidence of 2.2%.

Under *in vitro* condition, two nematicidal *Bacillus* strains, *Bacillus subtilis* CRB7 and *Bacillus marisflavi* CRB2 considerably enhanced the percent germination and vigour index (I and II) compared to control. Through polymerase chain reaction (PCR), presence of maximum 10 AMP genes were identified from *B. marisflavi* strain CRB2 which are responsible for the biosynthesis of iturin, bacilysin, bacillomycin, surfactin, subtilin, mersacidin, ericin, subtilosin and mycosubtilin followed by *B. subtilis* strain CRB7 with eight AMP genes. Under field condition, biocontrol efficacy of nematicidal *Bacillus* strains, *Bacillus subtilis* CRB7 and *Bacillus marisflavi* CRB2 were evaluated against *Meloidogyne incognita* infecting okra cv. Kashi Pragati. Among imposed twelve treatments, the two treatments T7 and T8 having different delivery mechanisms such as seed treatment with *Bacillus subtilis* CRB7 @20 g/kg seed + soil application of *Bacillus subtilis* CRB7 enriched vermicompost (2 tonnes/ha) + Soil drenching *Bacillus subtilis* CRB7 @ 1% at 30 days interval and seed treatment with *Bacillus marisflavi* CRB2 @20 g/ kg seed + soil application of *Bacillus marisflavi* CRB2 enriched vermicompost (2 tonnes/ha) + soil drenching *Bacillus marisflavi* (CRB2) @ 1% at 30 days interval respectively were found effective in reducing maximum final root knot nematode population in soil 62.5 and 58.9%, egg mass per root system 56.1 and 54.0% with lesser gall index 1.73 and 1.87 and maximum yield of 16.79 and 16.30 tonnes/ha, respectively compared to control (12.26 t/ha). Under pot condition through nematode inoculation, brinjal root stock (*Solanum melongena* EG-219) was found moderately resistant to root knot nematode (*Meloidogyne incognita*).

कार्यकारी सारांश

भा.कृ.अनु.प.– भारतीय सब्जी अनुसंधान संस्थान, वाराणसी के अन्तर्गत अनुसंधान, प्रसार एवं विकास की गतिविधियाँ, छः वृहद् कार्यक्रमों क्रमशः (1) एकीकृत जीन प्रबंधन (2) सब्जियों में बीज संवर्धन (3) बेहतर संसाधन प्रबंधन के माध्यम से उत्पादकता वृद्धि (4) तुडाई उपरान्त प्रबंधन एवं मूल्य संवर्धन (5) अनुसंधान व विकास की आवश्यकताओं की प्राथमिकता एवं भारतीय सब्जी अनुसंधान संस्थान द्वारा विकसित प्रौद्योगिकी के प्रभाव का विश्लेषण (6) एकीकृत पौध स्वास्थ्य प्रबंधन और 15 बाह्य वित्तपोषित परियोजनाए चल रही है। इन सभी वृहद् कार्यक्रमों में विशिष्ट उद्देश्यों के साथ कई उप–परियोजनाएं समाहित है।

टमाटर के अनुवांशिक उन्नयन परियोजना के अंतर्गत संकर वी. आर. टी. 16–11 को अधिक उत्पादन के लिए उत्कृष्ट पाया गया। वर्षा ऋतु में टमाटर के पृथक्कृत वंशक्रम वी. आर. टी. 34 तथा वी. आर. टी. 16–1 में पर्णकुंचन रोग का प्रभाव कम रहा तथा उच्च उत्पादन की क्षमता भी पायी गयी जबकि अग्रिम पंक्तियाँ वी. आर. टी. के. बी. – 14, वी. आर. टी. के. बी. – 8, वी. आर. टी. के. बी. – 9 तथा वी. आर. एन. आर. टी. – 12 पोषण सम्बंधित गुणों हेतु उत्कृष्ट पायी गयी। लाल फल वाली चेरी टमाटर के अंतर्गत वी. आर. सी. आर. टी. –2, वी. आर. सी. आर. टी. – 14 एवं वी. आर. सी. आर. टी.– 9 अधिक उत्पादन के साथ साथ उच्च टीएसएस के लिए उत्कृष्ट पायी गयी जबकि चेरी टमाटर समूह में पीले फल वाली उच्चीकृत वंशक्रम वी. आर. सी. वाई. टी.–6, वी. आर. सी. वाई. टी.–3 तथा वी. आर. सी. आर. टी.–9 पोषकीय गुणों हेतु उत्तम पायी गयी।

बैंगन के दो संकरों आई. वी. बी. एच. आर.– 19 (एचआरबी / बी 3–17– गोल फल) तथा आई. वी. बी. एच. एल. – 23 (एचएलबी / बी 3–17– लम्बा फल) का चयन अखिल भारतीय समन्वित अनुसंधान परियोजना (सब्जी फसल) के अंतर्गत बहुस्थानीय परीक्षण के लिये किया गया है। बैंगन के उच्चीकृत वंशक्रमों में गोलाकार फल समूह में सी एच बी आर–2 x बी सी बी 3–1(आई. वी. बी. आर.–20) एवं लम्बे फल समूह में उत्तरा x जे बी –7 (आई. वी. बी. एल.– 28) अ. भा. स. अनु. प. (सब्जी फसल) के परीक्षणों में उत्कृष्ट पाये गये। बैंगन की प्रजाति काशी हिमानी को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है।

मिर्च में वी. आर. 339 x वी आर 338 के संकरण से प्राप्त एक अन्तः प्रजाति वंशक्रम आई. आई. वी. आर. सी. –18132 उत्कृष्ट पायी गयी है तथा इसका चयन अ.भा.स.अनु.प. (सब्जी फसल) के अंतर्गत बहुस्थानीय परीक्षण के लिये किया गया है। मिर्च के संकर ए–7 x ईसी– 519636 तथा ए–1 x वी. आर.–339 उत्कृष्ट पाये गए तथा कई संकर संयोजनों ने सम्मिलित वी. आर.–339 अधिक उत्पादन एवं रोग प्रतिरोधिता के लिए उत्कृष्ट पितृ पाया गया। मिर्च में अंतरजातीय संकरण से प्राप्त 20 पौध समूह पर्ण कुंचन रोग प्रतिरोधिता हेतु उत्कृष्ट पाये गए। मिर्च की दो संकर प्रजातियों (काशी तेज एवं काशी रत्ना) तथा एक किस्म (काशी आभा) को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है।

मटर के अनुवांशिक उन्नयन के अंतर्गत बहु फूल प्रभेद वी. आर.पी.एम.–901–5 फली उपज प्रति पौध गुण हेतु उत्कृष्ट पाया गया। कम अवधि में पकने वाली समूह में तीन उच्चीकृत वंशक्रम वी.आर.पी.ई.–29, वी.आर.पी.–16 x वी.आर.पी.–25 तथा वी.आर.पी.–22 x डी.ए.आर.एल.–404 अगेतीपन तथा फली उपज प्रति पौध गुण हेतु उत्कृष्ट पाये गए जबकि वी.आर.पी.ई. –60 एवं वी.आर.पी.ई.– 66 लम्बी फली वाली उत्कृष्ट अगेती वंशक्रम पाये गये। मटर की नयी किस्म वी.आर.पी.ई.–903 को बहुस्थानीय परीक्षण हेतु चयनित किया गया।

लोबिया के उच्चीकृत वंशक्रम वी.आर.सी.पी.–218–1 तथा वी.आर.सी.पी.–68–2 उपज तथा औद्यानिकी लक्षणों के लिए उत्कृष्ट पाये गये। लोबिया की 11 उच्चीकृत वंशक्रमों को भा.कृ. अनु.प.–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो में जमा कर के उनका आई.सी. क्रमांक प्राप्त किया गया।

सेम तथा फराश बीन के आनुवांशिक उन्नयन की उप–परियोजना के अंतर्गत लतानुमा सेम की दो किस्में क्रमशः काशी कुंडल एवं काशी शीतल एवं सब्जी योग्य फराश बीन की दो किस्में काशी राजहंस एवं काशी सम्पन्न को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है।

बीज जनित गोर्ड्स फसलों में करेला के उच्चीकृत वंशक्रम वी.आर.बी.टी.जी.–47–1 तथा वी.आर.बी.टी.जी.–10 विभिन्न औद्यानिकी गुणों हेतु उत्कृष्ट पाये गए। सफेद फल वाले वंशक्रमों में वी.आर.बी.टी.जी.–37 तथा वी.आर.बी.टी.जी.–11–1 उपज एवं गुणवत्ता घटकों हेतु उत्कृष्ट पाये गए। वी.आर.बी.टी. जी.–5 x वी.आर.बी.टी.जी.–2–1 नामक संकर उपज के लिए बेहतर पाया गया। लौकी के लम्बे फल समूह के संकरो में वी. आर.बी.जी.–1 x वी.आर.बी.जी.–3 तथा वी.आर.बी.जी.–8 x वी.

आर.बी.जी.–6 उत्कृष्ट पाये गए जबकि गोल फल समूह के संकरों में वी.आर.बी.जी.–27 x वी.आर.बी.जी.–34 एवं वी.आर.बी. जी.–4 x वी.आर.बी.जी.–59 अधिक उपज के लिए उत्कृष्ट पाये गए। लौकी की तीन किस्मों काशी कीर्ति, काशी कुंडल एवं काशी किरण को उत्तर प्रदेश में व्यापारिक खेती हेतु विमोचित एवं अधिसूचित किया गया है। मोम रहित पेठा के पृथक्कृत वंशक्रमों का प्रदर्शन भी बेहतर पाया गया।

चिकनी तोरई की किस्म काशी श्रेया तथा संकर काशी रक्षिता को पंजाब, उत्तर प्रदेश, बिहार एवं झारखण्ड में खेती हेतु विमोचित एवं अधिसूचित किया गया है। इसके अलावा काशी ज्योति नामक किस्म एवं काशी सौम्य नामक संकर को भी उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है। चिकनी तोरई के वंशक्रम वीआरएसजी–7–17 में बासमती चावल जैसी विशेष सुगंध का कारण हेक्सेनल और 3–आक्टानॉन की उच्च मात्रा पाई गयी है। नसदार तोरई की प्रविष्टियाँ जैसे वीआरआरजी– 110, वीआरआरजी– 1–16 और वीआरआरजी–8–17 औद्यानिकी गुणों के लिए उत्कृष्ट पाई गईं एवं प्रक्षेत्र दशा में नसदार तोरई के मोजैक विषाणु एवं मृदु रोमिल आसिता रोग के लक्षणों से मुक्त पाए गए। सतपुतिया के चार प्रभेद औद्यानिकी गुणों के लिए उत्कृष्ट पाए गए।

कुम्हड़ा एवं खीरा फसल उन्नयन के अंतर्गत उच्चीकृत वंशक्रम वीआरपीके–9–01 एवं वीआरपीके–22 में अधिकतम प्रति पौध उपज पायी गयी। काशी शिशिर नामक कुम्हड़े की जल्दी पकने वाले संकर को उत्तर प्रदेश राज्य किस्म विमोचन समिति द्वारा विमोचित एवं अधिसूचित किया गया है। चप्पन कद्दू के उच्चीकृत वंशक्रम वीआरएसएस –65 और वीआरएसएस –66 उपज और गुणवत्ता के लिए उत्कृष्ट पाए गए। मध्यम अवधि में पकने वाली चप्पन कद्दू की झाड़ीनुमा किस्म काशी शुभांगी को राज्य किस्म विमोचन समिति द्वारा उत्तर प्रदेश के लिए विमोचित एवं अधिसूचित किया गया है। खीरे की उपज और उपज सम्बंधित लक्षणों के लिए संकर वीआरसीयूएच–16–01 को उत्कृष्ट पाया गया। खीरे के उच्चीकृत वंशक्रमों में वीआरसीयू से.–12–03 तथा वीआरसीयू से.–12–02 के फलों का रंग, दृश्यता एवं उपज गुणों हेतु उत्कृष्ट पाये गये। खीरे के संकर काशी नूतन को राज्य किस्म विमोचन समिति द्वारा उत्तर प्रदेश के लिए विमोचित एवं अधिसूचित किया गया है।

खरबूजे के 15 उच्चीकृत वंशक्रमों (एंड्रोमोनोसियस या मोनोसियस) का मूल्यांकन किया गया और वीआरएमएम –170 और वीआरएमएम –186 सबसे उत्कृष्ट पाए गए। खरबूजे की जंगली किस्म आरसीएम/पीके/45 एवं प्रक्षेत्र दशा में मृदु रोमिल आसिता रोग के प्रति प्रतिरोधी पाई गयी। तरबूज के वंशक्रम वीआरडब्ल्यू–514–1 और वीआरडब्ल्यू –514 को उच्च उपज और टीएसएस के लिए उत्कृष्ट पाया गया। पीली शिरा वाली पत्ती मार्कर युक्त एक अनोखी अन्तः प्रजाति वंशक्रम वीआरडब्ल्यू–14–1 की पहचान की गयी जिसमें फल की त्वचा एवं गूदा पीले रंग का होता है। टिंडे तथा ककड़ी के तीन–तीन प्रभेदों को उपज एवं गुणवत्ता घटकों हेतु उत्कृष्ट पाया गया।

2018–19 के दौरान पश्चिमी उत्तर प्रदेश एवं ओडिशा से भिन्डी की 47 नयी प्रविष्टियाँ एकत्र कर संवर्धित की गयी। भिन्डी के 90 संकरो के मूल्यांकन के पश्चात वीआरओ–178 x 416–10–1, वीआरओ –110 x काशी क्रांति और ओके–99–335 x वीआरओ –109 को उपज एवं पीत शिरा मोजेक विषाणु रोग प्रतिरोधिता के लिए उत्कृष्ट पाए गए। वीआरओ–120 और वीआरओ –125 फल उत्पादन, फल की गुणवत्ता और रोग प्रतिरोधिता के उत्कृष्ट पाए गए। भिन्डी की सात जंगली प्रजातियाँ प्रक्षेत्र दशा में पीत शिरा मोजैक विषाणु तथा ईसीएलवी रोग के लिए प्रतिरक्षी पायीं गयीं जिसकी पुष्टि बेगोमो विषाणु लक्षित प्राइमर का उपयोग करके हुए आण्विक परीक्षण में भी हुयी। भिन्डी की दो किस्में काशी लालिमा एवं काशी चमन तथा एक संकर काशी सृष्टि को राज्य किस्म विमोचन समिति द्वारा उत्तर प्रदेश के लिए विमोचित एवं अधिसूचित किया गया है।

गोभी वर्गीय फसलों के अंतर्गत, गोभी के 72 प्रभेदों का मूल्यांकन किया गया जिसमें मध्य अक्टूबर परिपक्वता समूह में वीआरसीएफ–75–1 एवं वीआरसीएफ–86, अक्टूबर अंत से मध्य नवम्बर परिपक्वता समूह में वीआरसीएफ–27 एवं वीआरसीएफ–32 तथा नवम्बर अंत से मध्य दिसम्बर परिपक्वता समूह में वीआरसीएफ–104, वीआरसीएफ–202 एवं वीआरसीएफ–22 उत्कृष्ट पाए गए। नवंबर के पहले पखवाड़े में तैयार हो जाने वाली काशी गोभी–25 किस्म को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है। कोशिकाद्रव्यी नर बन्ध्य संकरों वीआरसीएफ–41 x वीआरसीएफ–75–1 (28–30° से.), वीआरसीएफ–41 x वीआरसीएफ–50 एवं वीआरसीएफ–131 x वीआरसीएफ–86 (25–28° से.) तथा वीआरसीएफ–110 x वीआरसीएफ–50 एवं वीआरसीएफ– 110 x वीआरसीएफ–104 (20–25° से.) का चयन किया गया जिनमें 15–25 प्रतिशत तक संकर ओज तथा विभिन्न तापमानों पर कर्ड निर्माण होता है। उष्ण कटिबंधीय केल का एक प्रारूप वी आर केल –1 में उत्तर भारत के मैदानी क्षेत्रों में भी बोल्टिंग, पुष्पन एवं बीज बनना पाया गया है तथा इस किस्म में वसंतीकरण की जरूरत नहीं होती है।

जड़ वाली फसलों के अंतर्गत गाजर के प्रभेद वीआरसीएआर –186, वीआरसीएआर–201, वीआरसीएआर–185 एवं वीआरसीएआर–109 (लाल जड़), वीआरसीएआर–126, वीआरसीएआर–124 एवं वीआरसीएआर–89–1 (काला जड़), वीआरसीएआर–91–1 एवं वीआरसीएआर –91–2 (नारंगी

जड़), वीआरसीएआर–153, वीआरसीएआर–127 तथा तथा वीआरसीएआर –178 (पीला जड़), वीआरसीएआर –160 (क्रीम रंग का जड़) और वीआरसीएआर –107–1, वीआरसीएआर–107–2 एवं वीआरसीएआर –171–1 (इन्द्रधनुषी जड़) को जड़ की गुणवत्ता के साथ– साथ अधिक उपज के लिए बेहतर पाया गया। गाजर की काले जड़ वाली किस्म काशी कृष्णा (वीआरसीएआर –126) तथा मूली की दो किस्मों काशी मूली –40 एवं काशी लोहित को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है। मूली के संकरों के मूल्यांकन उपरान्त 6 संकर उत्कृष्ट पाये गए।

सब्जियों में तनाव प्रबंधन हेतु जैव तकनीकी एवं पराजीनी नवाचार के अंतर्गत फूल गोभी (*ब्रेसिका ओलेरेसिया*) में *एग्रोबक्टेरियम* मध्यस्थ आनुवांशिक रूपांतरण के प्रोटोकॉल को अनुकूलित किया गया। भिण्डी में कपास के एसएसआर मार्कर की हस्तांतरणीयता की संभावना का आंकलन किया गया जो केवल 6 प्रतिशत के लगभग पायी गयी। भिण्डी के इनेशन लीफ कर्ल वायरस के आणविक लक्षण का कार्य सम्पन्न हुआ।

इसी क्रम में ओइएलसीबी के बीटा सी–1 जीन के रोगजन्य सम्बंधित अध्ययन आदर्श पौध में स्थापित किये गए। आश्रयी पौधों में मिर्च पर्ण कुंचन विषाणु, टीओएलसीजीवी, टीओएलसीएनडीवी, टीओएलसीकेवी, टीओएलपीएमवी तथा आरएएलसीवी के पीसीआर आधारित चयन हेतु सम्बंधित विषाणुओं के लिए विशिष्ट प्राइमरों की अभिकल्पना की गयी। भिंडी की किस्म काशी क्रांति में स्वतंत्र इनप्लांटा रूपांतरण को दोहराया गया। कुल 2500 पौधों के रूपांतरण के पश्चात 20 टी–0 पौध क्रमों में एनपीटी–2 जीन की उपस्थिति की पुष्टि हुई। टमाटर एवं भिण्डी में क्रिस्पर कैस–9 मध्यस्थ जीनोम संपादन कार्य को आगे बढाया गया जिससे पौध रूपांतरण हेतु आवश्यक वेक्टर का निर्माण हो सके। बैगन (*सोलनम मेलानजीना*) में रिल्स के समूहों का उपयोग करके आरबिटरेरी और माइक्रो सैटेलाइट मार्करों पर आधारित उच्च घनत्व आनुवंशिक लिंकेज नक़्शे का निर्माण किया गया है। मटर के जनन द्रव्य में चूर्णिल आसिता सम्बंधित मार्करों की विविधता का मूल्यांकन एवं सत्यापन किया गया तथा कई डीएनए मार्कर चूर्णिल आसिता प्रतिरोधी जीन ईआर –1 एवं ई आर–1 से जुड़े हुए पाये गए।

अल्प प्रचलित एवं भविष्य में काम आने वाली सब्जियों के अनुवांशिक उन्नयन के अंतर्गत पंखियाँ सेम के 153 जननद्रव्य प्रविष्टियों का विभिन्न औद्यानिकी गुणों हेतु मूल्यांकन किया गया तथा प्रभेद वीआरडब्ल्युबी– 29, वीआरडब्ल्युबी– 45, वीआरडब्ल्युबी– 46, वीआरडब्ल्युबी– 56, वीआरडब्ल्युबी– 57, वीआरडब्ल्युबी– 60, वीआरडब्ल्युबी– 71, वीआरडब्ल्युबी– 77, वीआरडब्ल्युबी– 91 एवं वीआरडब्ल्युबी– 94 फली उत्पादन हेतु उत्कृष्ट पाए गये जबकि प्रभेद वीआरडब्ल्युबी– 69 कंद गुणों के लिए उत्तम पाया गया। ग्वार फली के आठ प्रभेद विभिन्न औद्यानिकी गुणों एवं रोग प्रतिरोधिता हेतु उत्कृष्ट पाये गये। बाकला के 115 प्रभेदों का उपज एवं औद्यानिकी गुणों हेतु मूल्यांकन किया गया तथा मुरादाबाद– 103, ईसी 628941, ईसी 628921, ईसी 841776, चेरी, ईसी 841609, ईटी– 3160 एवं ईटी–1107 जैसे प्रभेद उपज एवं रोग प्रतिरोधिता हेतु उत्कृष्ट पाए गये। सब्जी सोयाबीन के 125 प्रभेदो का विभिन्न औद्यानिकी गुणों हेतु मूल्यांकन किया गया जिनमें स्वर्ण वसुंधरा, ईसी– 148, एजीएस– 406, एजीएस– 447, ईसी– 215 तथा एजीएस– 429 फली उपज प्रति पौध के लिए उत्कृष्ट पाये गये। सिंघाड़ा का प्रभेद वीआरडब्ल्यूसी–1 शुष्क पदार्थ की मात्रा एवं फल उपज के लिए उत्तम पाया गया। कमल का प्रभेद वीआरएल–1 विभिन्न औद्यानिकी गुणों हेतु उत्कृष्ट पाया गया। इसके अलावा कमल में कायिक जनन की प्रक्रिया को मानकीकृत किया गया। करेमू साग के प्रभेद वीआरडब्ल्यूएस –1, वीआरडब्ल्युएस–4, वीआरडब्ल्यूएस –8, वीआरडब्ल्यूएस –9, वीआरडब्ल्यूएस –23, वीआरडब्ल्यूएस –24 एवं वीआरडब्ल्यूएस –25 विभिन्न औद्यानिकी गुणों हेतु उत्कृष्ट पाये गये। बेबी कॉर्न के बीएसएलबी प्रतिरोधी एवं ग्राही प्रभेदों के जैव–रासायनिक विश्लेषण से ज्ञात हुआ कि समग्र फिनॉल की मात्रा सबसे अधिक प्रतिरोधी अन्तःजात वंशक्रम (आईआईवीआरबीसी –13) में तथा सबसे कम ग्राही अन्तःजात वंशक्रम (आई आईवीआरबीसी –19) में पाई गई।

बथुआ के सात प्रभेदों के मूल्यांकन के पश्चात् तीन किस्में काशी बथुआ–2 (वीआरसीएचई–2, हरे पत्ते) काशी बथुआ–4 (वीआरसीएचई–4, बैंगनी हरे पत्ते) तथा पूसा बथुआ–1 (बैंगनी हरे पत्ते) जैव भार उपज के लिए उत्कृष्ट पाये गये। काशी बथुआ–2 एवं काशी बथुआ–4 को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया। चौलाई के 165 जननद्रव्यों के मूल्यांकन में एएम–2 ए, एएम–8, एएम–32, एएम–42, एएम–44, एएम–64 ए, एएम–131 एवं एएम–133 हरा पत्ता उपज के लिए उत्कृष्ट पाया गया। चौलाई की किस्म काशी सुहावनी को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है।

कायिक प्रजनित एवं बहुवर्षीय सब्जी फसलों के अनुवांशिक उन्नयन की परियोजना के अंतर्गत परवल का प्रभेद वीआरपीजी –217 को फल उपज प्रति लता 13 किलोग्राम के साथ उत्कृष्ट पाया गया। परवल की किस्म काशी सुफल एवं काशी अमूल्य को राज्य किस्म विमोचन समिति द्वारा उत्तर प्रदेश के लिए विमोचित एवं अधिसूचित किया गया है। ककरोल के प्रभेद वीआरएसटीजी–38 (2.44 किग्रा), वीआरएसटीजी–20 (1.95 किग्रा) एवं वीआरएसटीजी–6 (1.94 किग्रा) फल उपज प्रति पौध हेतु क्रमशः उत्कृष्ट पाये गए, जबकि करतोली के प्रभेद

वीआरएसईजी–10 (1.81 किग्रा) एवं वीआरएसईजी–9 (1.75 किग्रा) फल उपज प्रति पौध के लिए उत्तम पाये गए। कुंदरू के 14 जननद्रव्यों के मूल्यांकन के उपरांत वीआरआईजी–16 (15. 19 किग्रा), वीआरआईजी–14 (14.78 किग्रा) एवं वीआरआईजी–4 (7.95 किग्रा) फल उपज प्रति पौध हेतु क्रमशः उत्कृष्ट पाये गए। पोई साग के सात प्रभेद अधिक उत्पादन हेतु उत्कृष्ट पाये गए। पोई साग में कालर सड़न रोग के त्वरित पहचान हेतु विधि विकसित की गयी। काशी पोई –1, काशी पोई –2 तथा काशी पोई –3 किस्मों को उत्तर प्रदेश में खेती हेतु विमोचित एवं अधिसूचित किया गया है। सहजन के उत्कृष्ट प्रभेदों वीआरएमओ–17, वीआरएमओ–16, वीआरएमओ–21, वीआरएमओ–9, वीआरएमओ–10, वीआरएमओ–12 एवं वीआरएमओ–14 में फल प्रति पौध प्रति वर्ष की संख्या 200 से ज्यादा पाई गयी।

समन्वित जीन प्रबंधन के वृहद् कार्यक्रम के अंतर्गत 44 मुख्य एवं अल्प उपयोगी सब्जियों के साथ–साथ उनके जंगली किस्मों को अनुरक्षित किया गया। कुल 74 विकसित प्रजनन सामग्रियों का आई सी क्रमांक प्राप्त किया गया। इस वर्ष 20 सब्जी फसलों के 253 प्रभेदों को एकत्रित कर जननद्रव्य संवर्धित किया गया। इसके अलावा सब्जी फसलों की 22 प्रजातियों के 1063 प्रविष्टियों को शोध हेतु विभिन्न संस्थानों को सामग्री हस्तांतरण समझौते के उपरांत दिया गया।

सब्जियों में बीज वृद्धिकरण की वृहद् कार्यक्रम के अंतर्गत 22 सब्जी फसलों के कुल 27075.53 किग्रा सब्जी बीज का उत्पादन किया गया। कुल बीज में भा.कृ.अनु.प.–भारतीय सब्जी अनुसंधान संस्थान के मुक्त परागित किस्मों का 23811.03 किग्रा टी.एल. बीज का उत्पादन किया गया तथा 1524.40 किग्रा के राष्ट्रीय मांग के सापेक्ष 3083.0 किग्रा प्रजनक बीज का उत्पादन किया गया। मुक्त परागित किस्मों के अलावा सब्जी किसानों हेतु बैंगन, टमाटर, मिर्च एवं नेनुआ के 151.4 किग्रा एफ–1 संकर बीज का भी उत्पादन किया गया। बीज गुणवत्ता अनुरक्षण एवं बीज विक्रय हेतु संस्थान एवं इसके उपक्रमों के 297 बीज नमूनों की बीज जाँच प्रयोगशाला में गुणवत्ता (अंकुरण प्रतिशत) की जाँच की गयी। संस्थान की 17 सब्जी फसलों की किस्मों के गृह वाटिका बीज के पैकेट तैयार किये गये एवं किसानों को बीज वितरित किये गये। क्षेत्रीय अनुसंधान केंद्र, सरगटिया पर 29482 किग्रा बीज एवं रोपण सामग्री तैयार की गयी जिसमें हल्दी एवं सूरन भी सम्मिलित थे। प्राइमिंग, कोटिंग, बीजाण्ड परिवर्तन एवं बीज वर्धन के अध्ययन के अंतर्गत यह पाया गया कि पोई साग के बीज को जिंक एवं आयरन नैनो कणों से प्राइमिंग करने पर सीसा की विषाक्तता प्रभावी रूप से कम करने में मदद मिलती है। सहजन में बीज विकास, परिपक्वता एवं शुष्कन के दौरान होने वालो बाह्य–जैव रासायनिक बदलावों के अध्ययन से यह ज्ञात हुआ कि परिपक्व अवस्था की ओर अग्रसर बीज की अंकुरण क्षमता अधिक होती है तथा फूल आने के 49 दिन बाद बीज में शुष्कन प्रतिरोध एवं अंकुरण क्षमता आ जाती है। सब्जी फसलों में मधुमख्खियों की सहायता से बीज संवर्धन हेतु किये गये परागण सम्बंधित अध्ययन में ज्ञात हुआ कि नेनुआ और लौकी में 5 प्रतिशत शर्करा + 5 प्रतिशत गुड़ + बहु–विटामिन + 200 पीपीएम नैनो जिंक ऑक्साइड का उपचार पूरे फसल अवधि में परागणकर्ताओं की अधिकतम संख्या को आकर्षित किया। सब्जी बीजों को सुखाने एवं भण्डारण सम्बंधित परियोजना के अंतर्गत यह पाया गया कि पेठा की किस्म काशी धवल के बीज में जिओलाइट बीड्स एवं सिलिका जेल जैसे शुष्ककों का उपयोग करने से प्रथम 24 घंटे के अन्दर ही अधिकतम नमी समाप्त हो जाती है। कुम्हड़ा की काशी हरित किस्म, मूली की काशी हंस किस्म तथा लोबिया की काशी निधि किस्म में जिओलाइट बीड्स एवं सिलिका जेल के साथ भण्डारण के मानकीकरण अध्ययन में यह पाया गया कि शीत भंडार गृह में जिओलाइट बीड्स के साथ भंडारित बीज में 12 महीने के बाद भी बीज की गुणवत्ता सार्थक रूप से विद्यमान रही।

सब्जी उत्पादन विभाग में प्राकृतिक रूप से हवादार पॉलीहाउस में किए गए अध्ययनों से पता चला कि टमाटर में दो–तना सधाई प्रणाली एनएस–4266 किस्म के लिए सबसे उपयुक्त है जिससे प्रति पौध 11.3 किग्रा उपज प्राप्त हुई। एनएस–4266 में पादप वृद्धि नियामकों (एनएए/15 पीपीएम + सैलिसिलिक अम्ल) के छिड़काव से उपज (10.63 किग्रा प्रति पौधा), फलों की लंबाई (4.78 सेमी), फल व्यास (5.63 सेमी) इत्यादि उत्तम पाया गया, जिसे जिब्रेलिक अम्ल + सैलिसिलिक एसिड द्वारा अनुसृत पाया गया। शिमला मिर्च में सधाई प्रणाली की पसंद बाजार पर निर्भर हो सकती है, क्योंकि दो तने की सधाई विधि से कम लेकिन बड़े फल मिलते हैं। इसी तरह, तीन तने की सधाई से थोड़े परंतु अच्छे आकार के फल प्राप्त होते हैं।

सब्जी आधारित फसल प्रणाली के अंतर्गत, 2017–18 के एक पूरे फसल चक्र के बाद, चावल के समतुल्य उपज के संदर्भ में उच्चतम कुल उत्पादकता (278.97 कुंतल/हे.) लोबिया–टमाटर–भिंडी के साथ प्राप्त हुई तथा भिंडी–टमाटर–लोबिया (271.98 कुंतल/हे.) दूसरे स्थान पर रहा। खरीफ–2018 में, बैंगन की फसल से सबसे अधिक चावल के समतुल्य उपज (177.57 कुंतल/हे.) प्राप्त हुई। रबी 2018–19 में, उच्चतम चावल समतुल्य उपज टमाटर (112.48 कुंतल/हे.) में दर्ज की गई। लौकी–गेहूं–चौलाई फसल पद्धति को सबसे अधिक लाभकारी पाया गया क्योंकि इसका लाभः व्यय अनुपात अधिकतम (2.43) था।

सब्जियों में सस्य क्रियाओं द्वारा जैव–सुदृढीकरण के उद्देश्य से किए गए अध्ययन में सोलेनेसी कुल और गोभी–वर्गीय फसलों

(टमाटर, फूलगोभी तथा पत्तागोभी) के लिए बनाए गए विशिष्ट सूक्ष्म पोषक तत्वों के संरुपण के पर्णीय छिड़काव से टमाटर, पत्तागोभी एवं फूलगोभी में क्रमशः 13.6–17.8 प्रतिशत, 11.9–18.5 प्रतिशत तथा 9.4–20.0 प्रतिशत तक उपज में वृद्धि पायी गयी। लोबिया के 18 और भिंडी के 41 प्रभेदों में सूक्ष्म पोषक तत्वों के प्रालेखन से ताम्र, लौह, जस्ता और मैंगनीज की मात्रा में इन फसलों में व्यापक विभिन्नता पाई गई।

सब्जियों की जैविक खेती में गोबर की खाद/नाडेप खाद 25 टन/हेक्टेयर या गोबर की खाद 10 टन/हेक्टेयर + केंचुआ खाद 3.5 टन/हेक्टेयर के प्रयोग से गाजर, मटर और कसूरी मेथी की पैदावार में क्रमशः 14.60, 36.39 और 81.21 प्रतिशत वृद्धि देखी गयी एवं पारंपरिक खेती की तुलना में लाभःव्यय अनुपात 1.99 से 6.17 के बीच पाया गया। टमाटर और ब्रोकोली में, पारंपरिक प्रणाली की तुलना में जैविक खेती के अंतर्गत प्राप्त उपज का स्तर मामूली रूप से कम (8.06 और 1.15 प्रतिशत) था। एस्कॉर्बिक अम्ल, कुल फिनोल और प्रति–ऑक्सीकारकों के संदर्भ में जैविक प्रणाली के अंतर्गत सब्जियों की गुणवत्ता, ब्रोकोली में क्रमशः 40.1, 43.4 और 16.8 प्रतिशत और कसूरी मेथी में 31.8, 48.8 और 14.96 प्रतिशत, पारंपरिक प्रणाली की तुलना में बेहतर थी। नाडेप खाद और गोबर की खाद 25 टन/हेक्टेयर के प्रयोग से मिट्टी में जैविक कार्बन सामग्री में क्रमशः, 17.63 और 22.42 प्रतिशत अभिवृद्धि हुई।

विभिन्न फसलों में ड्रिप सिंचाई के अंतर्गत किए गए अध्ययन में लोबिया (10.90 टन/हेक्टेयर), टमाटर (39.93 टन/हेक्टेयर), भिंडी (7.51 टन/हेक्टेयर), पत्तागोभी (53.19 टन/हेक्टेयर) और फूलगोभी (48.47 टन/हेक्टेयर) की अधिकतम उपज 100 प्रतिशत वाष्पोत्सर्जन पर प्राप्त हुई। तथापि, जल उपयोग दक्षता, जोकि 0.35–1.82 टन/हेक्टेयर सेमी के बीच थी, 75 प्रतिशत वाष्पोत्सर्जन पर अधिकतम देखी गयी।

अंर्तजातीय कलम–बंधन अध्ययन में, टमाटर की किस्म काशी अमन की उपज बैंगन के मूलवृंत आईसी–111056 और आईसी–354557 पर क्रमशः 28.67 प्रतिशत और 36.36 प्रतिशत अधिक रही। इसी प्रकार, शीर्ष पर अनिश्चितकाल तक बढ़ने वाली संकर टमाटर (एनएस 4266) से आईसी–111056 के मूलवृंत पर कलम बंधें होने पर 79.8 प्रतिशत अधिक फलों की उपज प्राप्त हुई। फलों के गुणवत्ता के संदर्भ में कुल घुलनशील ठोस की सर्वाधिक मात्रा *सोलेनम टोर्वम* x काशी अमन और सूर्या x काशी चयन में देखी गयी। इसी प्रकार, लाइकोपीन की उच्च मात्रा आईसी–354557 x काशी चयन एवं *सोलेनम लैनसिनेटम* x काशी आदर्श के संयोजन में देखी गई। फलों में एस्कॉर्बिक अम्ल की मात्रा आईसी–354557 x काशी चयन (31.25 मिलीग्राम/100 ग्राम) में अधिकतम थी तथा *सोलेनम एथियोपिकम* x काशी आदर्श (27.50 मिलीग्राम/100 ग्राम) दूसरे स्थान पर रहा।

लोबिया में खर–पतवार नियंत्रण संबन्धित अध्ययन में अधिकतम उपज (15.6 टन/हेक्टेयर), काली पॉलिथीन के पलवार के साथ दर्ज की गयी जिसे जैविक पलवार (14.8 टन/हेक्टेयर) द्वारा अनुसृत किया गया। खर–पतवारनाशी संबन्धित अध्ययन में अधिकतम उपज (12.3 टन/हेक्टेयर) पेंडिमेथलिन 750 ग्राम/हेक्टेयर (उद्भव–पूर्व) + इमैजैथेपायर (उद्भवोपरांत) के अनुक्रमिक प्रयोग से प्राप्त की गई।

राजमा में अधिकतम खर–पतवार नियंत्रण सूचकांक (डब्ल्यूसीआई) 98.9 प्रतिशत, काली पॉलिथीन के पलवार के साथ अभिलेखित किया गया। खर–पतवारनाशियों में अधिकतम डब्ल्यूसीआई (97.2 प्रतिशत), पेंडिमेथलिन/750 ग्राम/हेक्टेयर (उद्भव–पूर्व) + सोडियम एसीफ्लुओरफेन + क्लोडिनाफ़ोप 100 ग्राम/हेक्टेयर (उद्भवोपरांत) तत्पश्चात पेंडिमेथलिन 750 ग्राम/हेक्टेयर (उद्भव–पूर्व) + इमैजैथेपायर 100 ग्राम/हेक्टेयर (उद्भवोपरांत; 95.7 प्रतिशत) के अनुक्रमिक प्रयोग द्वारा पाया गया।

काली पॉलिथीन की पलवार लगाने से राजमा की उपज में उल्लेखनीय वृद्धि (16.9 टन/हेक्टेयर) अभिलेखित की गई। खर–पतवारनाशियों में अधिकतम उपज (13.4 टन/हेक्टेयर) पेंडिमेथलिन 750 ग्राम/हेक्टेयर (उद्भव–पूर्व) + सोडियम एसीफ्लुओरफेन + क्लोडिनाफ़ोप 100 ग्राम/हेक्टेयर (उद्भवोपरांत) के प्रयोग से प्राप्त हुई।

संरक्षण कृषि प्रणाली के अंतर्गत सब्जी आधारित खेती में अवशेष प्रतिधारण के साथ शून्य जुताई से हरे भुट्टे की अधिकतम उपज (13.0 टन/हेक्टेयर) प्राप्त हुई जिसे पारंपरिक जुताई के साथ अवशेष समावेश (12.6 टन/हेक्टेयर) द्वारा अनुसृत किया गया।

सब्जियों में तुड़ाई–उपरान्त प्रबंधन और मूल्यसंवर्धन पर किए गए अध्ययन से पता चला कि खीरे की निधानी आयु को 30 माइक्रोन के फ़्लेक्सफ्रेश उपांतरित वातावरणीय संवेष्टन (पैकेजिंग) में, 15° सेल्सियस पर 28 दिनों तक बढ़ाया जा सकता है। खीरे के भंडारण की गैसीय रचना (16.6–19.9 प्रतिशत ऑक्सीजन/3.2–3.7 प्रतिशत कार्बन डाइऑक्साइड) उपांतरित वातावरणीय भंडारण में 10 एवं 15° सेल्सियस पर भिन्न रही। कार्बन डाइऑक्साइड का बढ़ा हुआ स्तर (3.2– 3.7 प्रतिशत) श्वसन गतिविधि को कम करने के परिणामस्वरूप निधानी जीवन को बढ़ाने में सहायक था। भंडारण के दौरान खीरे में कुल फिनोल की मात्रा घट गई और यह कमी 28 दिनों के भंडारणोपरांत 10 एवं 15° सेल्सियस पर क्रमशः 58 प्रतिशत और 53.4 प्रतिशत रही।

भारतीय सब्जी अनुसंधान संस्थान द्वारा विकसित

प्रौद्योगिकियों के आर्थिक प्रभाव के आँकलन से पता चला कि 2007–08 से 2019–20 के दौरान लोबिया की काशी कंचन किस्म 29 राज्यों और 2 केंद्र शासित प्रदेशों के 443 जिलों के लगभग 90314.8 हेक्टेयर क्षेत्र में फैल चुकी है। अनुमानित कुल क्षेत्रफल का लगभग 65 प्रतिशत उत्तर प्रदेश और बिहार में सम्मिलित है। सात निजी बीज कंपनियों द्वारा काशी कंचन के व्यवसायीकरण से वर्ष 2013–14 से 2018–19 के दौरान 24.6 लाख रुपये प्राप्त हुये।

आर्थिक अधिशेष मॉडल के परिणामों से पता चला कि विगत 13 वर्षों में लोबिया की काशी कंचन किस्म का उत्पादन अधिशेष 38.5 करोड़, उपभोक्ता अधिशेष 128.4 करोड़ और कुल आर्थिक अधिशेष 166.9 करोड़ रुपये था। काशी कंचन उगाने से स्थानीय किस्म की तुलना में वर्षा ऋतु में शुद्ध लाभ 36406 रुपये और गर्मी के मौसम में 84942 रुपये था। काशी कंचन के लिए दोनों ही ऋतुओं में लाभः व्यय का अनुपात क्रमशः 3.26 और 3.04 था, जबकि स्थानीय किस्म के लिए यह अनुपात वर्षा ऋतु के दौरान किसान के खेत पर 1.43 था। स्थानीय किस्म की तुलना में काशी कंचन किस्म की आर्थिक पात्रता लगभग 86691 रुपये प्रति हेक्टेयर थी जोकि मुख्य रूप से इसे सहारा देने पर लगने वाले श्रम से बचती है क्योंकि यह एक बौनी किस्म है।

फसल सुरक्षा विभाग के अन्तर्गत विषालुता अध्ययन में थायोमेथक्साम, इमिडाक्लोप्रिड और डाईमेथोएट माहूँ के नियंत्रण हेतु अन्य कीटनाशकों तथा अनुपचारित नियंत्रण की तुलना में 68.05, 65.12 एवं 64.87 प्रतिशत अधिक प्रभावी पाये गये। सिन्ट्रानिप्रोल के उपयोग से डीबीएम जनसंख्या में अनुपचारित नियंत्रण की तुलना में 76.02 प्रतिशत कमी पायी गयी। विभिन्न कीटनाशी अकेरीसाइड्स में क्लोरफेनापिर और फिप्रोनील माइट्स और थ्रिप्स के जनसंख्या नियंत्रण हेतु क्रमशः 63.16 एवं 75.69 प्रतिशत ज्यादा प्रभावी रहे। इस्पिनोसाड, इंडोक्साकार्ब, क्लोरैट्रोनिप्रोल एवं एमामेक्टिन बेंजोएट लोबिया के फली छेदक (*मुरूका वीट्राटा*) के नियंत्रण में क्रमशः 87.37, 78.64, 77.73 तथा 73.53 प्रतिशत ज्यादा प्रभावी पाये गये तथा इनसे क्रमशः 142.47, 135.80, 134.77 एवं 120.27 कुन्तल/हेक्टेयर तक अधिक उत्पादन हुआ। इंडोक्साकार्ब, क्लोरैट्रोनिप्रोल एवं इस्पिनोसाड बथुआ लीफ वीवर (*स्पोलेडीया रिकरवेलीस*) के नियंत्रण हेतु क्रमशः 85.92, 84.73 एवं 80.03 प्रतिशत अधिक प्रभावी पाये गये। लीफ डिप नामक जैव परख विधि में अधिकतम लार्वा मृत्यु दर पायी गयी और नए कीटनाशक अणुओं की विषाक्तता निर्धारित करने के लिए यह विधि उपयुक्त पाई गई।

सूक्ष्मजीवीय जैव नियंत्रकों के 56 प्रभेदों को पृथक्कृत कर इनके शुद्ध संवर्धों को अगर संवर्धन में स्थापित किया गया। *ट्रा. हार्जिएनम* के तीनों प्रभेदों को जैव प्रभाविता को अन्तःपात्रे द्विसंवर्ध विधि द्वारा सब्जियों के मृदोढ़ रोगजनकों (*फ्यूजेरियम आक्सीस्पोरम, राइजोक्टोनिया सोलेनाई मैक्रोफोमिरना फेसियोलिना, स्कलेरोषियम रोल्फसाई, फ्यू. वर्टिसिलायड*) के प्रति परीक्षित किया गया। जिसमें प्रभेद टी.एच.–2 में कवकीय वृद्धि रोधन (42.85–100 प्रतिशत) हेतु प्रभाविता अत्यधिक पाई गयी इसके प्रभेद टी.एच.–3 (28.57–100 प्रतिशत) एवं प्रभेद टी. एच.–1 (14.28–100 प्रतिशत) प्रभावी पाये गये। जैव नियंत्रक घटकों के अन्तर्गत घटक (टी.–2) *बैसिलस सबटिलिस* आई. आई.वी.आर. प्रभेद सी.आर.बी.–7 (जड़ उपचार–1 प्रतिशत, मृदा उपचार– प्रभेद मिश्रित नाडेप 10 ग्राम प्रति किग्रा. एवं 1 प्रतिशत का 15 दिन के अन्तराल पर प्रयोग) टमाटर की उपज बढ़ाने हेतु अति प्रभावी पाया गया। जीवाणुवीय उकठा से संक्रमित बैंगन एवं मिर्च के पौधों से पृथक किये गये रोगजनक को संवर्धनीय लक्षणों एवं जैव रसायनिक परीक्षणों के आधार पर *रालस्टोनिया सोलेरालिएरम* के रेस–1/बायोवार III के रूप में पहचान गया।

रसायनों के प्रति संवेदिता के परीक्षण के आधार पर जीवाणुवीय रोगजनकों (*जेन्थोमोनास पी.वी. वेसिकटोरिया, रा. सोलेनासिटम एवं स्यूडोमोनाड्स*) को कॉपर ऑक्सीक्लोराइड 50 प्रतिशत डब्ल्यू.पी., एजोक्सीस्ट्रोबिन 23 प्रतिशत एस सी, स्ट्रप्टोमाइसिन सल्फेट + टेट्रासाइक्लिन हाइड्रोक्लोराइड, स्ट्रेपटोमाइसिन एवं निम्बीसिडिन के प्रति संवेदी पाया गया।

विभिन्न प्रकार के जैविक एवं रसायनिक उपचारों में *ट्रा. एस्पेरलम* (10 ग्राम प्रति लीटर) का टमाटर (किस्म काशी अमृत) में जीवाणुवीय झुलसा के प्रति प्रयोग करने से अधिक उपज (24. 76 टन प्रति हे.) प्राप्त हुई। नेनुआ के 106 जननद्रव्यों/किस्मों/संकरों/प्रजनक जननद्रव्यों को मृदुरोमिल आसिता के प्रति चयनित किया गया जिसमें रोग प्रतिक्रिया के आधार पर केवल 16 जननद्रव्य ही मध्यम रोगरोधिता की श्रेणी में वर्गीकृत किये गये।

विभिन्न प्रकार के जैविक रोग नियंत्रण के घटकों में घटक टी–2 टमाटर में अगेती पर्ण झुलसा के प्रबंधन एवं सर्वाधिक विपणन योग्य टमाटर की उपज हेतु प्रभावी पाया गया। विपणन योग्य टमाटर नहीं होने का कारण रोग ग्रसित फल (60 प्रतिशत), चिड़ियों द्वारा क्षति (20 प्रतिशत), फल छेदक एवं टूटा द्वारा क्षति (10 प्रतिशत) अजैविक कारकों द्वारा क्षति (10 प्रतिशत) होना था। रोग ग्रसित फलों में क्षति अगेती झुलसा (50 प्रतिशत), पछेती झुलसा (25 प्रतिशत), *राइजोक्टोनिया* (20 प्रतिशत), फल सड़न (5 प्रतिशत) एवं द्वितीयक रोगजनकों का संक्रमण होना था।

सौर्यीकृत पौधशाला की क्यारी में कवकीय रोगजनकों की संख्या (7.3×10^3) अनुपचारित (23.7×10^3) तुलना में कम पाई गयी। जबकि सौर्यीकरण की दशा में कम एक्टिनोमाइसीट्स (3.9×10^5) की संख्या अनुपचारित (6.6×10^5) की तुलना में कम थी। सौर्यीकृत पौधशाला की क्यारी में खरपतवारों में *सायप्रस रोटण्डस* अनुपचारित की तुलना में 95.1 प्रतिशत कम

अभिलेखित किया गया। सौर्यीकृत पौधशाला की क्यारी में फास्फोरस, गंधक, बोरान, जिंक एवं कापर की मात्रा भी बढ़त पाई गयी। नाडेप (5.3×10^3) की तुलना में वर्मीकम्पोस्ट में कुल कवकों की संख्या (1.18×10^4 सी एफ यू प्रति ग्राम) अधिक पाई गई। रोगजनक (*फ्यूजेरियम एवं पीथियम*) नाडेप कम्पोस्ट में नहीं पाये गये जबकि वर्मी कम्पोस्ट इन रोगजनकों से संक्रमित पाया गया। *ट्राइकोडार्मा एस्पेरलम* को नाडेप कम्पोस्ट में मिलाने पर इसकी संख्या व गुणन में कमी देखी गयी।

अन्तः पात्रे परीक्षण में यह पाया गया कि कवकीय कीट रोगजनक *बेउवेरिया बैसियाना, लेकानीसीलियम लेकानी* एवं *मेटाराइजियम एनीसोपली* कवकीय जैव नियंत्रक *ट्राइकोडर्मा* द्वारा संक्रमित हो जाते है। *ट्राइकोडर्मा* के 5 प्रभेदों को स्थापित कर इनकी जैव प्रभाविता को *ट्रा. एस्पेरेलम* (आई.आईवी.आर.–बी.ए.टी.एफ.–43) के सापेक्ष परीक्षित किया गया।

कद्दूवर्गीय सब्जियों में विषाणु जनित रोग के प्रतिरूपण एवं प्रबंधन हेतु उत्तर प्रदेश के 9 कृषि जलवायुवीय क्षेत्रों में सर्वेक्षण किया गया। सर्वेक्षण में मुख्य विषाणुओं में कुकुमो विषाणु (6.11 प्रतिशत), पाटी विषाणु (39.44 प्रतिशत), पोलेरो विषाणु (10 प्रतिशत), टोबैमो विषाणु (38.33 प्रतिशत) एवं अर्थ्रोयस्पो विषाणु (2.22 प्रतिशत) अभिलेखित किये गये। 64 विषाणु संक्रमित नमूनों में कई विषाणुओं के मिश्रित संक्रमण की पुष्टि की गई। देश में पहली बार तरबूज कली सड़न विषाणु का प्रविजन एवं आण्विक प्रतिरूपण के आधार पर संक्रमण को अभिलेखित किया गया। नेनुआ के बीजों से विषाणुओं को पृथक्कित कर डाट–आइ.बी.ए. एवं एस.एल.सी.वी. के परीक्षण द्वारा बेगोमो विषाणुओं के संक्रमण की पहचान की गई। बसेला में पर्ण कुंचन विषाणुओं के रूप में बेगोमो विषाणुओं एवं टमाटर के पर्ण कुंचन पालमपुर विषाणु के संक्रमण की पुष्टि की गई। बैंगन के पर्ण गुच्छा रोग के प्रबंधन हेतु रोपाई का उपयुक्त समय सितम्बर माह का प्रथम सप्ताह पाया गया। इसके प्रबंधन हेतु काले रंग वाली सिल्वर पलवार अत्यधिक प्रभावी पायी गयी जिसमें उपज (323.33 कुंतल/हे.) एवं रोग का संक्रमण 2.2 प्रतिशत अभिलेखित किया गया।

अन्तः पात्रे परीक्षण में *बैसिलस सबटिलिस* के प्रभेद सी.आर.बी.–7, एवं *बै. मारिसफ्लेवी* के प्रभेद सी.आर.बी.–2 को भिंडी के जड़ ग्रन्थि सूत्रकृमि *मिलायडोगाइन इनकोगनिटा* के प्रति प्रभावी पाया गया। भिंडी में इन प्रभेदों के उपचार से जड़ ग्रंथि सूत्रकृमि की संख्या में (सी.आर.बी.–7 62.5 एवं सी.आर.बी.–2 58.9 प्रतिशत), अण्डों की संख्या में (56.1 एवं 54.0 प्रतिशत), गाँठ सूचकांक (1.73 एवं 1.87) में कमी व उपज में (16.79 एवं 16.30 टन प्रति हे.) उपचार नियंत्रण की तुलना में वृद्धि अभिलेखित की गयी।

Division of Vegetable Improvement

MEGA PROGRAMME 1: INTEGRATED GENE MANAGEMENT

Programme Leader : Dr. P. M. Singh

Project 1.1: Genetic improvement of tomato

Promising tomato hybrid

A total of 36 hybrids having *Ty*-2 or *Ty*-3 genes were evaluated in main tomato growing season along with eight hybrids of private companies (Abhilash, NS585, Devika, Indam 14301, Sriram 121, Sampurna, Lucky and TO3150) and Arka Rakshak of public sector as commercial checks. Yield wise, hybrids VRT16-08 × VRT16-10, VRT16-01 × VRT16-10, VRT16-10 × VRT16-12 and VRT16-11 × VRT16-12 were top performers. With 116.3 tonnes/ha productivity, medium firmness with a pericarp thickness of 0.5-0.6 cm and average fruit weight of 80-110 g, VRT16-11 × VRT16-12 was found promising.

Pyramiding of disease resistance genes (ToLCV, RKN and LB)

Based on agro-horticultural characters and genotyping, 53 F_3 individual plants having *Ty2, Ty3, Ph2* and *Ph3* genes minimum in single dose were forwarded to next generation. Based on genotype information, 32 F_2 individual plants having *Ty2, Mi, Ph2* and *Ph3* genes minimum in single dose were forwarded to next generation.

Advancing segregating generations

Based on number of fruits and other visible horticultural characters, eighteen F_5 families out of 45 F_5 families with Ty_3 or $Ty_{3+}Ph_2$ *or* $Ty_{3+}Ph_3$ were advanced to next generation. Thirty-five F_6 families with Ty_3 gene were advanced to next generation.

Germplasm screening for Root Knot Nematode resistance

Five germplasms along with susceptible check were screened for root knot nematode (*Meloidogyne incognita*) resistance under pot condition by inoculating 2000 second stage infective juveniles per plant. Among, screened germplasms, EC-625645 showed resistance (GI: 2) against nematode.

Wide hybridization for heat stable root knot nematode resistance

Embryo rescued F_1 of Kashi Amrit and LA 2157 (*Solanum arcanum*) were screened against root knot nematode *Meloidogyne incognita* under pot condition by inoculating 2000 second stage infective juveniles per plant. LA 2157 and F_1 have shown immune reaction

Fig. 1: Screening of tomato lines against root knot nematode

Table 1: Performance of tomato advance lines grown in rainy season.

	25th July transplanting		8th October transplanting		Average
	Yield / plant	ToLCV incidence (PDI in %)	Yield / plant (kg)	TLCV incidence (PDI in %)	Yield / plant (kg)
VRT-20	2.40	10	3.80	5	3.1
VRT-16-1	4.0	5	4.8	0	4.4
VRT-30	3.40	10	5.6	0	4.5
VRT-32	3.13	10	4.5	0	3.8
VRT-34	4.29	5	5.5	0	4.8
H-86	1.2	75	3.4	25	2.3
Sel. 7	1.0	95	2.6	65	1.8
Kashi Aman	2.30	30	3.4	20	2.8
Kashi Chyan	3.40	5	4.5	2.5	3.9

Fig. 2: Promising tomato lines for rainy season.

while Kashi Amrit exhibited highly susceptible reaction (Fig. 1).

Evaluation of advanced lines for cultivation of tomato in rainy season (Tropical Tomato) Twenty two advance lines comprising of different generations from F_8 to F_{12} were evaluated for cultivation in rainy season (Transplanting in third week of July). Out of 22, five advanced lines showed ability to give high yield with low pressure of tomato leaf curl virus incidence in rainy season grown tomato (Table 1 & Fig. 2).

Evaluation of nutrition rich (high TSS, lycopene, β-carotene and acidity) segregating populations

Ten segregating populations comprising of F_6-F_7 generations were advanced.

Cherry tomato

Red fruited cherry tomato: Fourteen red fruited cherry tomato lines which comprised of F_6-F_7 generations were advanced in open field condition and the advanced lines superior in terms of total yield with high TSS (Table 2 & Fig. 3).

Fig. 3: VRCRT-2: A promising red fruited cherry type advance line.

Table 2: Performance of red fruited advanced cherry tomato lines in open field

Genotypes	FPC	FS	TSS	YPP (kg)
CRT-2	7-8	Round	7.6	2.80
VRCRT-8	5-6	Oval	7.2	2.09
VRCRT-14	5-6	Round	7.2	2.56
VRCRT-9	5-6	Oblong	7.2	2.12

YPP: Yield per plant, TSS: Total soluble solids

Yellow fruited cherry tomato: Eleven yellow fruited cherry tomato lines which comprised of F_6-F_7 generations were advanced in open field condition. Out of 11, the advanced lines superior in high yield with high TSS are mentioned in Table 3 & Fig. 4.

Table 3: Performance of yellow fruited cherry tomato advance lines in open field

Genotypes	TSS	YPP (kg)
VRCYT-3	5.4	2.87
VRCYT-6	6.1	3.62
VRCYT-10	5.6	1.89
VRCYT-9	6.5	2.05
VRCYT-11	5.5	1.85

YPP: Yield per plant,TSS: Total soluble solids

Figure 4: VRCYT-6 & VRCYT-9: Promising yellow fruited cherry type advance lines.

Generation Advancement: A total of 177 populations comprising F_2 to F_{12} were advanced.

Germplasm Maintenance: 218 germplasm comprising 200 cultivated and 18 accessions of seven wild species were maintained.

Entries under AICRP trials: Eleven entries viz. Kashi Tomato-8, VRToLCV-16, VRT-19, VRT-1, VRTToLCV-32, VRT-06, VRT-13, VRT-28, VRT-34, VRT-50 and VRT-51 are being tested in AICRP (VC) trials in different categories.

Project 1.2: Genetic Improvement of Brinjal

Management of Germplasm:

Augmentation: An exploration program to hilly and border area of Tripura was undertaken in collaboration with ICAR-NBPGR, New Delhi from 27-11-2018 to 06-12-2018, in which 299 germplasm of 36 crops including 253 accessions of 20 vegetable crops were collected. In this exploration program, 41 accessions of brinjal and related species were collected. One accession of *Solanum incanum* was also added to the germplasm of the institute.

Promising β-carotene lines

VRTKB-14: This has been developed through interspecific hybridization of WIR-3928 (*Solanum glandulosum*) X DVRT-2(*Solanum esculentum*) followed by single plant selection. Plants are of determinate in growth and yield 2.8-3.2 kg fruits/ plant. Fruits contain 6.34 mg/ g beta carotene and 1.34 mg/ g lycopene with TSS of 4.0-4.2° Brix.	
VRTKB-8: This has been developed through interspecific hybridization of H-86 XEC-520049 (*Solanum chemielwskii*) followed by single plant selection. Plants are of determinate growth habit with an average yield of 2.5-3.9 kg /plant. VRTKB-8 contains 4.78 mg beta carotene and 0.63 mg lycopene with TSS of 4.0-4.2° Brix.	
VRTKB-9: This has been developed by back cross of (DVRT-2xEC-528372) x EC-528372 followed by pedigree selection at ICAR-IIVR, Varanasi. Plants are of indeterminate growth habit with an average yield of 2.8-3.2 kg /plant. Fruits contain 3.11 mg beta carotene and 1.54 mg lycopene with TSS of 4.7-5.1° Brix.	
VRTKB-12: This has been developed through interspecific hybridization of EC-520074 (*Solanum pimpinellifolium*) x DVRT-2 (*Solanum esculentum*) followed by single plant selection. Plants are of indeterminate growth habit with an average yield of 3.8-4.2 kg /plant. Fruits contain 3.44 mg beta carotene and 0.99 mg lycopene with TSS of 3.4-3.8° Brix.	
VRTKB-5: This has been developed through interspecific hybridization of WIR-13706 (*Solanum cerasiforme*) X DVRT-2(*Solanum esculentum)* by single plant selection. Plants are of indeterminate growth habit with an average yield of 3.0-3.4 kg/ plant. Fruits contain 3.24 mg beta carotene and 0.92 mg lycopene with TSS of 4.0-4.2° Brix.	
VRTKB-10: This has been developed through interspecific hybridization of WIR-13706 X FLA7421 (*Solanum esculentum)* followed single plant selection. Plants are of indeterminate growth habit with an average yield of 4.0-4.2 kg /plant. VRTKB-10 contains 3.31 mg beta carotene and 0.94 mg lycopene with TSS of 4.0-4.2° Brix.	

Maintenance and Evaluation of germplasm: A total of 261 germplasm accessions including 236 cultivated and 25 accessions on 7 related species of brinjal were maintained at the research farm of the institute. 217 germplasm accessions were evaluated and were classified into following 18 different market segments.

Oval Light Purple

Earliness (days to 50% Flowering) DAT: IC-126898 (48.5), IC-602960 (53.5), IC-510447 (56.3), Swarnmani (c) (56), KS-224(c) (57)

Fruits/Plant (No.): IC-510447 (33.2), IC-126898 (23.4), IC-602960 (16.2), Swarnmani (c) (15.06), KS-224(c) (17.2)

Yield/Plant (kg): IC-510447 (8.3),IC-126898 (2.7),IC-602960 (2.1), Swarnmani (c) (3.26), KS-224 (c) (3.63)

Oval Dark Purple

Earliness (days to 50% Flowering) DAT: IC-136511 (43.3), IC-510419 (48.8), IC-127021 (52.3), IC-137674 (51.1), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-137674 (39.8), IC-127021 (36.2), IC-510419 (25.2), IC-136511 (22.8), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-127021 (3.5), IC-137674 (3.3), IC-510419 (3.2), IC-136511 (1.7), Swarnmani (c) (3.26),KS-224(c) (3.63)

Oval Green

Earliness (days to 50% Flowering) DAT: IC-144131(48.4), IC-99651 (52.2), IC-144157 (56.1), IC-89815 (56.7), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-89815 (57.2), IC-99651(44.4), IC-144157 (26.4), IC-144131 (25.2), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-99651 (6.1), IC-144157 (4.8), IC-89815 (4.2), IC-144131 (3.2), Swarnmani (c) (3.26),KS-224(c) (3.63)

Oval Spotted Green

Earliness (days to 50% flowering) DAT: IC-136107 (45.7), IC-112615 (52.3), IC-90969 (56.5), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-112615 (33.8), IC-136107 (25.2), IC-90969 (22.2), Swarnmani (c) (15.06), KS-224(c) (17.2)

Yield/Plant (kg): IC-112615 (6.5), IC-90969 (4.1), IC-136107 (2.6), Swarnmani (c) (3.26), KS-224 (c) (3.63)

Oval White

Earliness (days to 50% flowering) DAT: IC-126914 (43.4), IC-112901 (52.6), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-112901 (39.5), IC-126914 (22.8), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-112901 (5.2), IC-126914 (4.1), Swarnmani (c) (3.26), KS-224(c) (3.63)

Spotted Purple White

Earliness (days to 50% flowering) DAT: IC-126880 (51.3), IC-510420 (51.5), IC-112636 (54.4), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-112636 (39.8), IC-510420 (31.8), IC-126880 (31.8), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-510420 (3.3),IC-112636 (3.1), IC-126880 (2.5), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

White

Earliness (days to 50% flowering) DAT: IC-90978(54.2), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-90978 (43.2), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-90978 (2.8), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Round Light Purple

Earliness (days to 50% flowering) DAT: IC-510414 (48.2), IC-136490 (48.2), IC-169761 (48.4), IC-112786 (51.2), IC-127144 (54.1), IC-136122 (54.6), IC-136100 (55.2), IC-127150 (55.3), EC-316264 (55.8), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-169761 (39.6), IC-112786 (39.4), IC-510414 (39.4), IC-136490 (36.6), IC-136122 (33.2), IC-127144 (22.8), IC-136100 (19.8), IC-127150 (19.8), EC-316264 (12.6), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-510414 (7.7), IC-169761 (7.3), IC-136122 (6.8), IC-136490 (5.7), IC-127150 (3.9), IC-112786 (3.5), IC-136100 (3.4), IC-127144 (3.2), EC-316264 (1.9), Swarnmani (c) (3.26), KS-224 (c) (3.63)

Round Dark Purple

Earliness (days to 50% flowering) DAT: IC-89949 (48.2), IC-136123 (48.6), IC-90126 (51.2), IC-14399 (51.6), 600615 (53.2), IC-136213 (54.3), IC-510445 (54.3), IC-0602978 (54.6), IC-127150 (54.7), IC-90090 (54.8), IC-11065 (55.1), IC-IC-99682 (55.5), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-89949 (40.8), IC-136213 (40.8), IC-14399 (40.8), IC-99682 (40.2), IC-136123 (39.7), IC-90126 (39.4), IC-0602978 (33.1), IC-510445 (27.6), IC-127150 (25.8), IC-11065 (25.2), IC-600615 (21.4), IC-90090 (21.1), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-136123 (7.1), IC-89949 (6.6), IC-90126 (5.9), IC-0602978 (5.5), IC-510445 (5.4), IC-11065 (5.04), IC-136213 (4.9), IC-99682 (4.8), IC-127150 (4.4), IC-90090 (3.8), IC-14399 (3.5), IC-600615 (2.4), Swarnmani (c) (3.26), KS-224 (c) (3.63)

Round Spotted Green

Earliness (days to 50% flowering) DAT: IC-89911 (48.6), IC-510435 (52.3), IC-111010 (52.5), IC-90934 (54.2), Swarnmani (c) (56), KS-224 (c) (57)

Fruits/Plant (No.): IC-510435 (45.3), IC-89911 (42.2), IC-90934 (32.4), IC-111010 (18.6), Swarnmani (c) (15.06), KS-224 (c) (17.2)

Yield/Plant (kg): IC-89911 (7.3), IC-90934 (6.1), IC-510435 (5.0), IC-111010 (2.0), Swarnmani (c) (3.26), KS-224 (c) (3.63)

Oblong Light Purple

Earliness (days to 50% flowering) DAT: IC-89909 (44.3), IC-316277 (46.2), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-316277 (43.2), IC-89909 (33.2), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-316277 (9.8), IC-89909 (8.1), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Oblong Dark Purple

Earliness (days to 50% flowering) DAT: IC-111415 (45.3), IC-510461 (46.1), IC-89955 (52.4), IC-510476 (55.3), IC-136191 (56.6), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-89955 (41.4), IC-510476 (28.8), IC-111415 (28.8) ,IC-510461 (22.8), IC-136191 (19.2), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-89955 (7.3), IC-510461 (5.9), IC-510476 (5.6), IC-111415 (4.9), IC-136191 (2.1), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Oblong Green

Earliness (days to 50% flowering) DAT: IC-112300 (55.5), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-112300 (21.4), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-112300 (2.3), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Oblong Spotted Green

Earliness (days to 50% flowering) DAT: IC-113006 (48.5), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-113006 (27.5), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-113006 (5.1), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Oblong Green Spotted Purple

Earliness (days to 50% flowering) DAT: IC-144145 (55.3), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-144145 (43.8), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-144145 (2.8), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Long Light Purple

Earliness (days to 50% flowering) DAT: IC-112339 (43.1), IC-510417 (43.2), IC-305013 (43.4), IC-510416 (43.5), IC-144021 (43.5), IC-169763 (51.2), IC-90975 (51.2), IC-126711 (51.3), EC-316277 (51.3), IC-112989 (51.6), IC-126906 (51.6), IC-600502 (51.8), IC-89822 (54.2), IC-111311 (54.3), IC-111328 (54.9), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-305013 (52.8), IC-112339 (51.2), IC-126711 (49.8), IC-126906 (46.8), IC-600502 (45.4), IC-144021 (40.8), IC-510417 (39.5), IC-510416 (39.1), IC-169763 (40.8), IC-112989 (39.2), IC-111328 (30.6), EC-316277 (25.2), IC-89822 (25.2), IC-111311 (24.6), IC-90975 (13.2), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-144021 (7.6), IC-510417 (6.5), IC-112339 (5.6), IC-305013 (5.2), IC-510416 (4.1), IC-126711 (3.7), IC-169763 (3.6), IC-126906 (3.6), IC-600502 (3.5), IC-111328 (3.2), EC-316277 (3.0), IC-112989 (3.0), IC-111311 (3.0), IC-90975 (2.2), IC-89822 (2.1), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Long Dark Purple

Earliness (days to 50% flowering) DAT: IC-112779 (51.3), EC-169769-A (51.3), IC-126886 (51.8), IC-127239 (54.2), IC-99665 (54.4), IC-104095 (54.7), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-104095 (59.4), IC-99665 (38.4), EC-169769-A (36.6), IC-126886 (35.4), IC-112779 (23.4), IC-127239 (10.8), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-104095 (4.6), IC-99665 (3.7), EC-169769-A (3.1), IC-112779 (2.5), IC-126886 (2.4), IC-127239 (1.2), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Long Green

Earliness (days to 50% flowering) DAT: IC-144073 (43.7), IC-126937 (46.5), IC-603133 (51.2), IC-144131 (51.5), IC-112627 (51.5), IC-74233 (51.7), IC-144093 (54.3), Kashi Taru (c) (52.0), Punjab Sadabahar (c) (54.0)

Fruits/Plant (No.): IC-126937 (47.4), IC-144073 (45.6), IC-144131 (45.4), IC-603133 (39.1), IC-144093 (37.8), IC-74233 (28.8), IC-112627 (27.1), Kashi Taru (c) (26.6), Punjab Sadabahar (c) (31.83)

Yield/Plant (kg): IC-144131 (5.1), IC-144073 (5.0), IC-126937 (4.5), IC-603133 (4.1), IC-144093 (4.0), IC-74233 (3.2), IC-112627 (3.0), Kashi Taru (c) (3.36), Punjab Sadabahar (c) (3.43)

Screening of germplasm: Thirty two germplasm lines were evaluated under field conditions for resistance to little leaf disease in brinjal. During screening, these lines were categorized as immune (14 lines), resistant (15 lines) and moderately resistant (3 lines). Due to minimum disease incidence, lines need to be screened again during next season.

***Documentation*:** Indigenous collection (IC) numbers of twenty four elite germplasm accessions, released varieties and parental lines of hybrids ranging from IC-0628867 to IC 0628889 and IC 628075 (Kashi Himani) were obtained from ICAR-NBPGR, New Delhi.

Evaluation of hybrids. 28 F_1 hybrids targeting various market segments were evaluated. Among round ones (HRB/B3 to HRB/B3-24) HRB/B3-17 (IVBHR-19) was best performer. Among long ones

IVBHR-19 *IVBHL-23*

Fig. 5: Promising hybrids of brinjal identified for multi-location testing

(HRB/B3-25 to HRB/B3-40), HRB/B3-26 (IVBHR-23) was best performer (Fig. 5). These hybrids were submitted for multi location testing through AICRP (VC).

Evaluation of advance lines: Among advance lines, CHBR-2 x BCB3-1 (IVBR-20) in round fruited type and Uttara x JB-7 (IVBL-28) in long fruited type were evaluated for two years and identified as promising for entry in AICRP (VC) trials (Fig. 6).

IVBR-20 *IVBL-28*

Fig. 6: Promising advance lines of brinjal identified for multi-location testing

New Variety released: Kashi Himani (IVBL-26; SLW; IC 628075) released for cultivation in Uttar Pradesh by CVRC vide notification number S.O. 692(E) dated 5th February, 2019.

New crosses attempted: 72 new crosses (20, 51 and 1 in round, long and oblong fruit shapes, respectively) were attempted in this season. The F_1 seeds obtained from the crosses have been harvested and shall be used for evaluation of hybrids in next years.

Generation Advancement: 406 segregating populations (30 : F_1 to F_2; 52 : F_2 to F_3; 103 : F_3 to F_4; 58 : F_4 to F_5; 25 : F_5 to F_6; 31 : F_6 to F_7; 10 : F_7 to F_8; 50 : F_8 to F_9; 47 : F_9 to F_{10}) were advanced to next higher generation. Promising lines have been selected and seeds have been harvested from single plant for evaluation of promising lines in the next season.

Phenotyping of RILs: Phenotyping of the inter-specific mapping population of 144 RILs developed using Ramnagar Giant (*S. melongena*) and W4 (*S. incanum*) was done for 33 traits including 20 qualitative and 13 quantitative agri-horticultural traits. The data shall be used for mapping of the agri-horticultural traits in brinjal.

Maintenance Breeding: Seeds of Kashi Sandesh (500 g), Kashi Taru (500 g), Kashi Komal (200 g), Kashi Prakash (400 g), Kashi Himani (500 g) and Kashi Uttam (400 g), PR-5 (300 g) have been multiplied for distribution and multi-location demonstration. Parental lines of hybrids were also multiplied.

Project 1.3: Genetic Improvement of Chilli

Utilization and maintenance of germplasm: Three hundred ninety accessions, including 360 of chillies and 30 accessions of sweet pepper were maintained. The chilli collections included 282 cultivated chillies, 35 stuff pickle type chillies, 10 paprika lines, 22 wild accessions, two genetic and nine sets of cytoplasmic-genetic male sterile lines and other germplasm.

Seed Multiplication: Nucleus seeds of Kashi Anmol (500 g), Kashi Gaurav (300 g), Kashi Sinduri (200 g), Kashi Abha (300g) and Pusa Jwala (300 g) and sufficient amount of elite parental lines were produced.

Germplasm augmentation/creation: A total of 109 recombinant inbred lines (RILs) derived from the cross of BS-35 and Kashi Sinduri in F_6 advanced generation were characterized for their morphological traits and disease resistance to ChiLCVD. The population exhibited wide range of variability for various traits like fruit length (3.1 – 11.8 cm), fruits per plant (3-78), ten fruit weight (16 - 115 g) and disease reaction (highly resistant to highly susceptible). The fruit colour varied from light green to dark green with erect or pendant orientation of fruits on the plant.

The RILs *viz.* IIVRC-GT-113-3-3-3-3, IIVRC-GT-46-5-2-4-1, IIVRC-GT-183-2-1-4-2, IIVRC-GT-191-1-5-1-1, IIVRC-GT-197-1-8-4-1, IIVRC-GT-191-2-2-4-2, IIVRC-GT-109-2-4-9-4, IIVRC-GT-144-1-2-7-2, IIVRC-GT-137-3-3-3-4, IIVRC-GT- 115-2-5-2-2 were found promising for resistance to ChiLCV disease both under field and molecular screening with universal begomovirus primers (Fig. 7). These lines will be further screened through grafting and challenged inoculation for confirmation of resistance.

IIVRC-GT-191-2-2-4-2 **IIVRC-GT-183-2-1-4-2**

Fig. 7: Highly resistant lines derived from Kashi Sinduri x BS-35

Spontaneous Chilli mutants identified: Two unique types of chilli mutant plants obtained amongst the germplasm were identified as 'leafy rosette' forming mutant and 'undifferentiated inflorescence' (Fig. 8). The rosette forming mutant with very short internodes, have huge potential to study genetics of various

morphological traits like plant height, internodes length, floral orientation etc. The other mutant with undifferentiated inflorescence may be useful for floral development studies in chillies. To understand mutated genes and their genetics, various crosses have been attempted in rosette forming mutant with genotypes having contrasting characters.

Leafy rosette LCA -235 Undifferentiated inflorescence

Fig 8: Spontaneous mutants in chill with leafy rosette and undifferentiated inflorescence

Evaluation and development of hybrids

A total of 56 F_1 hybrids including nine commercial hybrids from the private seed sectors were evaluated for various characters. The hybrids exhibited wide variability for different traits like fruit length (3.38 – 12.46 cm), fruit width (0.84 – 4.14 cm), fruits per plant (12-70) and ten fruit weight (23 - 290 g). The evaluation of the hybrids revealed that A1 x EC-519625, PBC-535 x NMCA-4008, California Wonder x EC-519636, Kashi Gaurav x Pasighat-6, A1 x VR-339 manifested superior yield potential of 184, 163, 151, 147 and 145 quintals of green fruits per hectare. Fruit length was found better in the cross combinations of PBC-535 x NMCA-4008 (12.46), Pusa Jwala x NMCA-4008 (11.90), A1 x EC-519625 (11.64), R-line x Pasighat-2 (10.76), A7 x EC-519625 (10.14). Regarding fruit number per plant the hybrids A7 X FS-112 (105), Eagle-151 (104), A4 x VR-339 (95), Kashi Anmol x J. Longi (89), VR-338 x EC-790571 (88) were found promising (Fig 9). Hybrid A7 X EC 519625 and A1 X VR 339 were found promising consecutively in 2nd year of testing and VR 339 emerged as superior combiner for yield and disease resistance in many hybrids e.g. GMS-3 x VR339 *etc.*

A7 x FS-112 A1 x EC-519625

Fig 9: Promising CMS-based F_1 hybrids of chilli

A total of 40 new hybrid combinations utilizing elite lines including wild relatives as pollen parent were developed on the cytoplasmic male sterile and other potential combiners. These F_1 hybrids will be evaluated for their yield potential along with other desirable traits such as disease resistance and qualities.

Screening and identification of Chilli leaf curl virus resistant lines: Chilli leaf curl virus (ChiLCV) disease is one of the most threatening viruses of chilli causing considerable yield losses to the farmers and currently there is lack of resistant cultivar against this disease. A population has been developed using resistant line BS-35, a natural interspecific derivative of *C. frutescens* and *C. chinense* and paprika variety Kashi Sinduri. In order to explore the resistance, the population of 109 families in F_6 generation was screened for the reaction of ChiLCVD caused by whitefly transmitted begomovirus. A total of 2208 individual plants of all 109 F_6 families were screened for disease on 0-4 score (assigned based on the symptom appearance on the plants under field condition) at 60 and 120 days after transplanting. Results revealed that 4% (95) plants scored 0, 39% (864) plants scored 1, 33% (726) plants scored 2, 16% (358) plants scored 3 and 7% (165) plants scored 4 for the disease depicting a typical normal distribution for the disease reaction. Individual families/progenies were marked and DNA was isolated for molecular screening with universal primer. Sixty five individual plants showing symptomless response (0 score) were screened with the universal primer which resulted in 23 virus free plants. Out of 23 plants, 10 plants *viz.*, IIVRC-GT-113-3-3-3-3, IIVRC-GT-46-5-2-4-1, IIVRC-GT-183-2-1-4-2, IIVRC-GT-191-1-5-1-1, IIVRC-GT-197-1-8-4-1, IIVRC-GT-191-2-2-4-2, IIVRC-GT-109-2-4-9-4, IIVRC-GT-144-1-2-7-2, IIVRC-GT-137-3-3-3-4, IIVRC-GT- 115-2-5-2-2 (Table 4) were also found free from β satellite DNA particle after molecular screening with Roja's universal primer. Similarly, at 120 days after transplanting, again 95 plants scored in 0 category. 10 plants were found free from β satellite DNA particle after molecular screening with Roja's universal primer. The population is further being monitored for the expression of ChiLCVD and efforts are on to develop resistant chilli pepper lines.

In the line development programme, a total of 30 F_3 families were advanced to F_4 and 25 F_4 families to F_5. In F_6 generation, 250 families of a cross Pusa Jwala x IIVRC-452 and 109 families of Kashi Sinduri x BS-35 have been advanced to F_7 generation. Over 270 families of F_7 generation and 160 families of F_8 generation were furthered to subsequent generations.

Some of the promising lines with respect to fruit quality parameters, yield and disease resistance were identified in advanced generations and their characteristic features have been recorded (Fig. 10). These lines exhibited wide variability for various traits like fruit length (4.8 – 11.56 cm) fruits width (0.94 – 1.68 cm), number of fruits per plant (20-107.5) and ten fruit weight (31 - 130 g) and good disease resistance against viruses. The fruit colour varied from light green to dark green with erect or pendant orientation of fruits on the plant. Depending upon the seed availability, these lines would be identified for multi-location testing in next season.

VR-338 x Taiwan-2, F_8 VR-338 X BC-2-2, F_8

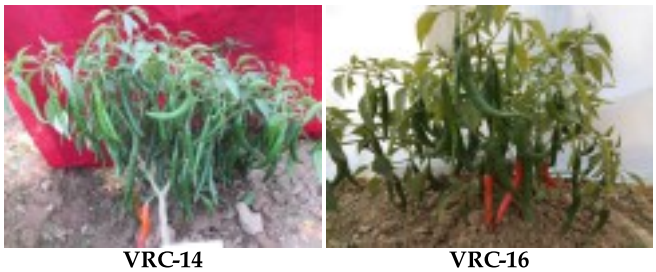
Fig 10: Promising advanced lines chillies for superior yield and resistance

Regarding line development in sweet pepper, inbred lines or varieties were crossed in order to create variability in capsicum. In that sequence, the F_4 generation of 14 crosses/hybrids were screened for different traits and advanced to next generation (F_5).

Release and notification of Chilli variety and hybrids: One OP variety *viz.* Kashi Abha and two F_1 hybrids *viz.* Kashi Tej and Kashi Ratna have been recommended by the SVRC (UP) and notified by the CVRC vide S.O. 692(E) dated Feb., 05, 2019 for cultivation in UP.

New Entry of chilli for multilocation testing under AICRP (VC)

Two entries VRC-14 and VRC-16 were included in Chilli Varietal IET of AICRP (VC) trials from the ICAR-IIVR, Varanasi centre based on two year performance in station trial. (Fig. 11). Another high yielding, pungent and chilli leaf curl viruses resistant entry IIVRC -18132 (Fig. 12) has been proposed for inclusion in AICRP (VC) trials.



VRC-14 VRC-16

Fig 11: performance of VRC-14 and VRC-16 in Field.

Project 1.4: Genetic improvement of Pea

Creation of genetic variation through hybridization: A total of 43 F_1s crosses were attempted to create the genetic variation for edible podded type by utilizing the parents' *viz.*, VRPD-1, VRPD-2, VRPD-3, Swarna Mukti, Arka Sampoorna, *Mithi Phalli* and others. Similarly, 117 F_1s were also made by utilizing the parents like PC-531, Arka Ajeet, Arkel, Kashi Ageti, Kashi Samridhi, HUDP-15, Kashi Samridhi to combine the resistance for powdery mildew and rust.

Screening of germplasm for high temperature tolerance for early (October) and late sowing seasons (January): A total of 60 genotypes including the released cultivars were evaluated for tolerance to high temperature during early (October, 2018) and late sowing seasons (January, 2019) for which sowing were done on 10th October and 28th January, 2018-19, respectively (Fig.13). For early season, one line *viz.*, 'VRPE-109' found promising and picking was ready on 1st week of December. The average low and high temperature for the growing period was 11.9 to 28.9°C. However, for late sowing, two edible podded lines *viz.*, VRPD-2 and VRPD-3 were found good for pod bearing that continue up to last week of March when the average low temperature and average high temperature were 16.1 °C and 31.0 °C, respectively.

Fig. 12: IIVRC-18132: a high yielding, pungent and resistant chilli line

Fig.13: (a) Field evaluation of 60 genotypes of peas grown during October; (b) promising genotype VRPE-109 for early pod setting; (c) pod bearing in VRPD-3 during March end, 2019

Fig. 14: Field expression of VRPM-901-5, (a) Appearance of five flowered peduncle; (b) Plant bearing five-pods and four-pods on single peduncle at multiple reproductive nodes and (c) Multi-podded peduncle at seed-maturity.

Table 4: Mean performance of 'VRPM-901-5' genotype over triple, double and single podded cultivars using Tukey-Kramer's HSD test

Genotypes	DTF	TFP	BPP	PL	PPP	APW	SPP	PH	YPP
VRPM-901-5	54.0^{b}	59.2^{a}	2.8^{a}	9.3^{a}	48.8^{a}	6.7^{b}	6.0^{c}	111.7^{b}	290.8^{a}
VRP-500	49.3^{c}	31.7^{b}	2.3^{a}	8.0^{b}	25.6^{b}	5.8^{c}	6.9^{b}	69.0^{c}	130.7^{b}
PC-531	47.0^{c}	22.0^{c}	2.3^{a}	9.5^{a}	18.5^{c}	8.2^{a}	8.0^{a}	58.0^{c}	141.5^{b}
VL-8	70.0^{a}	31.5^{b}	1.3^{b}	6.5^{c}	25.0^{b}	5.6^{c}	6.7^{bc}	115.5^{b}	132.5^{b}
NO-17	49.5^{c}	29.0^{bc}	2.5^{a}	6.0^{c}	21.0^{bc}	3.4^{d}	4.9^{d}	160.0^{a}	72.1^{c}
LSD (5%)	**0.89**	**2.70**	**0.18**	**0.16**	**1.74**	**0.19**	**0.28**	**4.86**	**7.92**
R^2	**98.9**	**95.7**	**88.7**	**98.8**	**97.5**	**98.5**	**93.0**	**98.3**	**98.8**

Days to flower (DTF; days), total flower produced (TFP; No.), branches/plant (BPP; No), pod length (PL; cm), pods/plant (PPP; No), average pod weight (APW; g), Seeds/pod (SPP; No), plant height (PH; cm) and yield/plant (YPP; g).

Performance of multi- podded lines: Stability and performance for multi-flowered genotype 'VRPM–901–5' was assessed during the year with other triple, double and single podded cultivars. VRPM–901–5 was found promising for the pod yield/plant, which was significantly higher than both double-podded cultivars PC–531 and VL-8 and single podded genotype NO-17 (Fig. 14 & Table 4). The higher yield potential of VRPM–901–5 could be attributed to the formation of more number of flowers (48-52) and pods/plant (32-48) in multi-podded line than in the double or single-podded lines. In addition, 100-seed weight in this genotype was found to vary from 45-50g with 50-52 shelling (%).

Inheritance of multi-flower and multi-pods: To analyze the inheritance pattern of the multi-flowering and to identify the segregants, a total of 9 F_2 population were grown along with the F_1s and parents. The F_1s and parents were grown at normal row to row spacing of 30 cm and plant to plant spacing of 10 cm whereas, all F_2 s were space planted at 60 × 30 cm so as to observe the plants individually. Data was recorded on around 1200 plants and segregation was recorded for single, double and multi-flowered plants. Segregation ratios obtained in the resistance inheritance study were compared by Chi-square test. The plants were found to segregate in the ratio of 3(double flower):1 (triple flower) in two crosses 'VRP-386 × VRP-500' and 'VRPM-501 × VRP-386' indicating the monogenic recessive inheritance of multi-flowering. However, in other three crosses *viz.*, 'N0-17 × VRPM-901', 'VRP-500 × N0-17' and 'VRPM-501 × N0-17', the plants were found to segregate in 12 (double flower): 3 (single flower):1 (triple flower) indicating effect of dominant epistasis.

Fig. 15: The promising genotype, (a): VRPE-29; (b): VRP-16 × VRP-25 and (c): VRP-22 × DARL-404

Identification of promising lines of peas for early maturity group: Among the early maturity group, three advance breeding lines *viz.* VRPE-29, VRP-16 × VRP-25 and VRP-22 × DARL-404 were found promising for earliness and pod yield/plant over the standard check Kashi Nandini (Fig. 15 & Table 5). The genotype VRPE-29 was found superior for days taken to 50 % flowering and days to first picking.

Table 5: Mean comparison of promising genotypes with Kashi Nandini for early maturity using Tukey-Kramer's HSD test

Genotypes	Days to 50% flowering	Days to first picking	Pods/plant (No)	Average pod weight (g)	Pod length (cm)	Seeds/pod (No)	Yield/plant (g)
VRPE-29	31.0^{b}	61.2^{b}	11.3^{ab}	6.5^{b}	8.4^{a}	6.7^{b}	70.77^{a}
VRP-16 × VRP-25	36.0a	65.8^{ab}	10.1^{b}	8.4^{a}	8.4^{a}	7.2^{ab}	80.83^{a}
VRP-22 × DARL- 404	36.0 a	67.3^{a}	13.34^{a}	7.1^{b}	9.0^{a}	8.0^{a}	93.83^{a}
Kashi Nandini(C)	33.0 ab	63.8^{ab}	8.6^{b}	7.2^{b}	8.4^{a}	6.8^{b}	70.60^{a}
R^2	**81.2**	**69.5**	**79.85**	**83.21**	**44.08**	**75.37**	**55.4**
LSD	**1.0**	**1.1**	**0.87**	**0.31**	**0.28**	**0.29**	**8.53**

Table 6: Performance of VRPE-66 and VRPE-60 for various horticultural traits

Genotypes	Days to 50% flowering	Pod Length (cm)	Pod Weight (g)	Pods/plant (No)	Seeds/pod (No)	Pod Yield/plant (g)
VRPE-66	37.0^{a}	11.47^{a}	11.0^{a}	8.87^{b}	9.06^{a}	93.20^{ab}
VRPE-60	35.0^{a}	11.47^{a}	10.0^{a}	12.53^{a}	9.5^{a}	113.33^{a}
Kashi Nandini (C)	33.0^{a}	8.43^{b}	7.23^{b}	8.60^{b}	6.8^{b}	70.60^{b}
LSD (5%)	**1.49**	**0.59**	**0.61**	**1.01**	**0.28**	**12.5**

Table 7: Mean comparison of promising genotypes with Kashi Shakti using Tukey-Kramer's HSD test

Genotypes	Days to 50% flowering	Pod Length (cm)	Pod Weight (g)	Pods/plant (No)	Seeds/pod (No)	Pod Yield/plant (g)
VRP-7×PC-531	52.0^{a}	11.6^{a}	8.2^{a}	21.9^{ab}	9.6^{a}	166.8^{a}
PMPM-1 × VRPMR-11	53.0^{a}	11.3^{a}	8.1^{a}	19.3^{bc}	9.2^{a}	165.0^{a}
PC-531 × PMR-32	56.0^{a}	8.5^{b}	7.5^{a}	18.2^{bc}	8.8^{a}	150.8^{a}
PC-531× DARL-404	55.3^{a}	8.1^{b}	7.0^{a}	24.2^{ab}	8.8^{a}	145.5^{a}
VRP-500	55.1^{a}	8.2^{b}	5.2^{b}	28.3^{a}	6.2^{b}	145.1^{a}
Kashi Shakti (C)	53.3^{a}	8.8^{b}	7.2^{a}	13.3^{c}	8.4^{a}	94.0^{b}
R^2	**34.2**	**94.9**	**83.4**	**81.2**	**87.6**	**88.23**
LSD (5%)	**1.98**	**0.34**	**0.44**	**2.27**	**0.41**	**8.81**

Identification of genotype for long pod in early group: Two Lines *viz.*, VRPE-66 and VRPE-60 were identified for long pod having pod length of 11.47 cm and found significantly superior over the standard check Kashi Nandini (Table 6). The genotype VRPE-60 also found superior for high pod yield.

Identification of promising lines in mid maturity group: Among the mid- maturity group, five advance breeding lines *viz.* VRP-7×PC-531, PMPM-1 × VRPMR-11, PC-531 × PMR-32, PC-531× DARL-404 and VRP-500 were found promising for pod yield per plant over the standard check Kashi Shakti (Table 7). All these lines were found superior for pod yield over the standard check Kashi Shakti. In addition, the lines *viz.*, VRP-7×PC-531 (VRPE-107), PMPM-1 × VRPMR-11 were found superior for pod length while VRP-500 for high number of pods/plant. One other genotype 'PMPM-1× AP-3' was identified with broad pods having pod width of 2.0 cm.

Screening germplasm for powdery mildew: A total of 172 germplasm lines that includes newly augmented 16 lines (from Banaras Hindu University, Varanasi) were screened for powdery mildew resistance by adopting the scale of Tiwari *et al.* (1997). Scoring was done under normal field conditions and scale ranged between 0–4 was classified as resistant whereas, scale ranged between 5–9 was classified as susceptible (Fig. 16). Out of 172 lines screened, 03 lines were found immune to the disease *viz.*, IC-296678, BHU-26 (EC865944) and BHU-57 (EC865975) with 0 PDI score. Thirty-two other lines were also found resistant *viz.*, EC-6621, BHU-11 (EC865929), BHU-7 (EC865925), BHU-25 (EC865943), BHU-64 (EC865982), BHU-114 (EC866032), VRP-147, VRP-186, EC-71944, VRP-322, VRP-351, VRP-345, VRP-314, VRP-343, VRP-310, VRP-304, VRP-370, VRP-358, VRP-306, VRP-311, NDVP-12, VRP-90, VRP-27, VRPD-3, VRPD-2, IC208366, IC-208378, No-17, Kashi Samridhi, Arka Sampoorna, Arka Karthik and Kashi Samrath.

Fig. 16: Phenotypic screening for powdery mildew under field conditions, a & b: a close view to resistant genotype 'EC865975' grown with susceptible genotype under huge disease pressure

Evaluation of edible podded lines: Two genotype *viz.,* VRPD-2 and VRPD-3 were found potential for edible pod type with absence of parchment layer. The genotypes had longer and broader pods along with resistance to powdery mildew.

Generation advancement of breeding material: Among total 143 advanced lines grown, 40 lines were advanced to F_2 population, 09 lines to F_3, 35 lines to F_4,13 lines to F_6, 20 to F_7, 6 to F_8 and 20 to F_9. Twenty-two other lines were also grown and advance to their successive generation.

Entries in AICRP trials: A new entry 'VRPE-903' was submitted for IET (mid) of AICRP (VC) trial.

Maintenance breeding : A total of 172 germplasm lines were grown and maintained during the cropping season. The maintenance breeding was done through true to type single plant selection of pea varieties viz. Kashi Uday, Kashi Nandini, Kashi Ageti, Kashi Mukti, Kashi Samrath, Kashi Shakti, and Kashi Samridhi.

Germplasm documentation: A total of 09 lines were allotted with IC Numbers from NBPGR, New Delhi *viz.,* VRPE-101 (IC-0626394), VRPE-103 (IC-0626395), VRPE-107 (IC-0626396) VRPE-109 (IC-0626397), VRPM-903 (IC-0626398), VRPM-905 (IC-0626399), VRPM-909 (IC-0626400), VRPM-911 (IC-0626401) and VRPSel-1 (IC-0626402).

Project 1.5: Genetic improvement of Cowpea

Maintenance of cowpea germplasm: Three hundred and eighty four cowpea genotypes were maintained.

Germplasm Documentation: Eleven advanced breeding lines of vegetable cowpea were submitted to NBPGR and IC number was obtained viz. VRCP-111-2 (IC628892), VRCP-115-3 (IC628893), VRCP-119-1 (IC628894), VRCP-121-3 (IC628895), VRCP-126-2 (IC628896), VRCP-128-5 (IC628897), VRCP-131-4 (IC628898), VRCP-134-2 (IC628899), VRCP-142-1 (IC628900), VRCP-143-2 (IC628901) and VRCP-148-3 (IC628902)

Hybridization: Based on yield, quality and cowpea golden mosaic resistance of parental lines, a total of 23 F_1 cross combinations were made in vegetable cowpea.

Advancement of generation: A total of 23 F_1, 23 F_2, 16 F_3, 16 F_4, 10 F_5, 10F_6, 9 F_7 and 9 F_8 cross combinations were advanced to next generation and SPS were done.

Evaluation of advance lines and IC allotment :

Eight advanced breeding lines were selected based on yield and horticultural traits during 2018-19 (Table 8).

Maintenance breeding of cowpea varieties: Five varieties of cowpea *i.e.,* Kashi Kanchan, Kashi Nidhi, Kashi Gauri, Kashi Shyamal and Kashi Unnati were maintained by multiplication of nucleus seed every season.

Table 8: Performance of advanced lines of cowpea

Cowpea Advanced breeding line	Pods/plant	10 Pod wt(g)	Pod length (cm)	Yield/plant (g)
VRCP 218-1	31.40	155.00	44.60	486.70
VRCP 227-2	32.20	125.00	49.80	402.50
VRCP 227-4	37.20	110.00	35.60	409.20
VRCP 228-5	28.20	100.00	39.20	282.00
VRCP 233-2	30.00	130.00	34.60	390.00
VRCP 68-2	35.20	160.00	35.60	563.20
VRCP 71-1	29.20	140.00	31.40	408.80
VRCP 188-3	29.40	150.00	33.80	441.00
Kashi Kanchan	31.00	110.00	31.00	341.00
CV (%)	9.36	16.49	16.77	19.44

Project 1.6: Genetic improvement of Indian bean & French bean

Indian bean (*Dolichus* bean) :

Generation Advancement: A total of 177 populations comprising F_4 to F_{10} were advanced and selected superior segregants in F_4 (82 Sps), in F_5 (VRBSEM-123-sps-2), in F_7 (VRBUSEM-104, VRBSEM-100, VRBSEM- 106 SPS-1, VRBSEM-109), in F_8 (VRBUSHSEM-75) in F_9 (VRBUSHSEM-202) and F_{10} (VRBUSHSEM-1, VRBUSHSEM-15, VRBUSHSEM-313, VRBSEM-19 (pot culture).

Seed Multiplication: Seven entries of bush type Indian bean and three released and notified varieties were multiplied for supply of seeds to varietal testing centers. The quantity of seeds are VRBSEM-3 (7 kg), VRBSEM-8 (5 kg), VRBSEM-9 (6 kg), VRBSEM-14 (7 kg) VRBSEM-18 (18 kg), VRBSEM-207 (3 kg), VRBSEM-202 (3 kg), Kashi Haritima (4 kg), Kashi Khushaal (3 kg) and Kashi Sheetal (4 kg).

Germplasm Maintenance: Maintained 146 germplasm comprising 130 pole type and 16 bush type.

Notification and Release of Varieties: Two varieties Kashi Khushaal and Kashi Sheetal of pole type were released and notified for commercial cultivation in Uttar Pradesh. (Fig. 17)

Kashi Khushaal (IC 555592) Kashi Sheetal (IC 555769)

Fig. 17 : Kashi Khushaal & Kashi Sheetal

Kashi Rajhans (IC 0622784) Kashi Sampann (IC 0622783)

Fig. 18 : Kashi Rajhans & Kashi Sampann

French bean

Notification and Release of Varieties: Two varieties Kashi Rajhans and Kashi Sampann of Vegetable type French bean were released and notified for commercial cultivation in Uttar Pradesh (Fig. 18).

Maintenance of Germplasm: 23 genotypes of bush type and 12 pole type along with one scarlet bean genotype were maintained.

New Germplasm collected & evaluated: 19 new genotypes of French bean were collected and evaluated.

Hybridization: 5 F_1 combinations were made during winter season of 2018-19.

Advancement of generations: 11 F_2s and 3 F_3s of Bush type French beans along with 7 F_2s of pole type French bean were advanced to next filial generation

Project: 1.7: Genetic improvement of seed propagated gourds

Bitter Gourd

Characterization of germplasm: During the year, 6 germplasm collected from different region of the country were again evaluated and among them, accession number BT-3-C gave maximum yield (2.769). Minimum yield was recorded in DVBTG-4 (0.802 kg/plant) (Fig. 19 & Table 9).

Table 9: Performance of germplasm characterized during 2018-19

Genotypes	Germination (days)	Colour of fruit	50% Flowering-female (days)	Node of first female flower	No. of Fruits/ plant	Fruit Length (cm)	Fruit circum. (cm)	Fruit weight (g)	Yield/Plant (kg)
VRBTG-23-1	9	White	72	9.67	17.33	13.8	13	55	1.01
DVBTG-4	8	Green	72	11	15	11.5	13.7	61.7	0.80
VRBTG-23	9	Green	69	11.3	15.67	11.3	14.3	83.3	1.30
B.B.G.S-09-1	8	Green	68	12.7	15.67	12.3	12.5	55	0.99
BT-3-C	8	Green	68	12.3	21.33	14	18.3	117	2.76
IC 391819	11	White	68	8.33	25.33	11.6	8.67	40	1.01

Fig. 19: DVBTG-4, (IC-3911819)

Fig. 20: VRBTG- 37, VRBTG- 11-1, VRBTG-47-1 & VRBTG-10

Evaluation of advance lines and promising genotype identified: Twelve promising advance lines (7 green and 5 White) along with 21 segregating lines were evaluated for various horticultural traits. Among these, the advance lines VRBTG-47-1 and VRBTG-10 were found promising having major variation in colour, tubercles and shape. In white fruited lines, VRBTG- 37 and VRBTG- 11-1 were found promising in term of yield and quality attributes. These lines were maintained through selfing and further selected for next generation (Fig. 20). Among the segregating population, these 4 advance lines (from F_7 and F_8) were selected for identification in AICRP (VC).

Evaluation of hybrids: Twenty-seven F_1 hybrids involving fifteen diverse parents were evaluated during kharif season of 2018. Sagar and Mohini hybrids were used as commercial check. The hybrid VRBTG-5 x VRBTG-2-1 (4.10 kg/plant) was highest yielder among all hybrids followed by VRBTG-10 x VRBTG-47-1 (3.76 kg/plant) and VRBTG-23 x VRBTG-4-1 (2.80 kg).

Development of Gynoecious based cross combinations: During the year, different cross combinations (Gyno-34 x VRBTG-10, Gyno-34 x BT-1A, Gyno-34 x VRBTG-8, Gyno-34 x IC212504, Gyno-34 x VRBTG-29, Gyno-34 x DVBTG-3, Gyno-34 x VRBTG-5 and Gyno-34 x VRBTG-4-1-1) have been developed using gynoecious line as female parent. The evaluation of these hybrids will be done in next year.

Screening of bitter gourd germplasms for root knot nematode resistance: Thirteen genotypes screened for resistance against root knot nematode *Meloidogyne incognita* during 2017-18 under pot condition were

Table 10: Screening of bitter gourd germplasm against root knot nematode resistance

Bitter gourd Germplasms	Number of Root Galls (Mean ± SE)	Gall index (1-5 Scale)	Resistance reaction (HS/S/MR/R)
IC-44428	3.3 ± 0.54	2.0	R
IC-44438	5.7 ± 0.72	2.0	R
IC-212504	16.0 ± 2.20	3.0	MR
VRBTG-10	13.3 ± 1.65	3.0	MR
VRBTG 11-1	21.7 ± 4.45	3.0	MR
VRBTG 47-1 (SC)	103.7 ± 3.81	5.0	HS
Kalyanpur Baramasi (SC)	107.0 ± 3.85	5.0	HS
VRBTG-26	76.7 ± 5.04	4.0	S
VRBTG-2-1	46.3 ± 5.70	4.0	S
VRBTG-15	45.3 ± 3.06	4.0	S
VRBTG 1-1	60.0 ± 3.68	4.0	S
VRBTG-12	110.0 ±2.49	5.0	HS
VRBTG-23-1	139.0 ± 2.05	5.0	HS
SE(m)	**3.8**		
CD	**11.3**		

screened again to confirm root knot nematode resistance. A pot experiment was conducted including susceptible checks *i.e.* VRBTG-47-1 and Kalyanpur Baramasi. Each germplasm was screened at inoculation level 2000 second stage infective juveniles per replication or plant under screen house condition (Table 10). The results revealed that, among thirteen germplasms, two germplasms *viz.* IC44438 and IC44428 shown resistance to root knot nematode *Meloidogyne incognita,* three germplasms *i.e.* IC212504, VRBTG-10 and VRBTG11-1 were found moderately resistant and remaining seven germplasms were found to be susceptible to root knot nematode which confirms the previous results.

Collection of germplasm: During the year, an exploration programme was conducted with ICAR-National Bureau of Plant Genetic resources, Regional Station, Plandu (Ranchi) covering Banka, Jamui and Gaya districts of Bihar and total of 238 accessions of various vegetables were collected.

Bottle gourd

Characterization of germplasm: During the year, 6 germplasm (VRBG-15-1, VRBG-67, DRAG-3, VRBG-9-1-1, IC-594545 and IC-594544) were evaluated and among them accession number DRAG-3 yielded maximum (8.091 kg/plant) but took maximum days (10) for germination.

Evaluation of hybrids (F_1): During the year, total 20 hybrids in long fruited group pertaining to different horticultural traits were evaluated. Among the hybrids, cross combination VRBG-1 x VRBG-3 and VRBG-8 x VRBG-6 (Fig. 21) yielded maximum of 12.10 and 12.52 kg/plant, respectively. Other combinations found promising are VRBG-3 x VRBG-6 and VRBG-61-1 x VRBG-59 which yield 11.358 and 11.556 kg/plant, respectively. In round bottle gourd, 6 hybrids (F_1) were evaluated for different horticultural traits. Among the hybrid cross combinations, VRBG-27 x VRBG-34 and VRBG-4 x VRBG-59 were found promising with respect to yield *i.e.* 18.914 and 10.578 kg/plant, respectively which was higher than the national check Pusa Sandesh (9.833 kg/plant) and Kashi Kiran (8.125 kg/plant), respectively.

In flatty round fruited bottle gourd hybrids, only two cross combinations were developed and both could not surpass the national check. Oblong fruited type bottle gourd is the demand of the market. Only combination *i.e.* VRBG-11-1 x VRBG-18 gave maximum yield of 10.578 kg/plant with the earlier node number (9) for female flower development. Fruits are very

Fig. 21: Long fruited hybrid VRBG-8 x VRBG-6

attractive of this cross combination and having longer period storage. In small fruited "Gutka Type" two hybrids were developed using cut leaf line. Out of this, the hybrid cross combination VRBG-67 (n) x VRBG-61(c) gave maximum yield of 9.067 kg/plant, though both the hybrids could not surpass national checks.

Evaluation of advance lines: Under evaluation of advance line (after F_8) in long (VRBG2-1 and VRBG-67), round (VRBG-9-1-1), VRBG-61 (cut leaf gutaka type) and VRBG-61-3 (cut leaf round) were selected and characterized. During the year 10 (F_1 to F_2), 18 (F_2 to F_3), 14 (F_3 to F_4), 9 (F_4 to F_5), 7 (F_5 to F_6) and 4(F_6 to F_7) populations were advanced for next generation.

Evaluation of winter fruited bottle gourd: A total of 3 advance lines were evaluated along with Kashi Ganga and one hybrid for yield and horticultural traits. Among 3 lines 2 most promising lines have been identified for state release for winter season cultivation in two different segments *i.e.*; gutka type and oval round.

New varieties released

Kashi Kirti: This is suitable for winter as well as normal season and recommended from state variety release committee and notified for Uttar Pradesh. The fruit colour is green, shape cylindrical, size small (800-900 g) at edible maturity. Yield potential is 375-425 q/ha, better edible and keeping quality and tolerant to downey mildew.

Kashi Kundal: This is suitable for winter season and recommended from state variety release committee and notified for Uttar Pradesh. The first harvesting starts at 90-95 days after sowing, and seed maturity on 186 days after seed sowing. The fruit colour is light green, shape oval, size medium (13-1.5 kg) at edible maturity. Yield potential is 375-410 q/ha and having better keeping quality.

Ash gourd

Evaluation of segregating lines of ash gourd: Ten selected lines of wax gourd including wax less lines in F_6

generation along with 3 released varieties were planted. The variation was observed in fruit shape and size. The weight of wax less lines ranged from 2.3-6.9 kg. The storability of wax less lines was at par with the waxy lines.

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

Project 1.8: Genetic Improvement of Luffa

Varieties/hybrids released:

Kashi Shreya (VRSG-194; IC 627485): This variety (Fig. 22) has been developed through selection from a germplasm collected from the eastern Uttar Pradesh. It has a medium viny (3.5-5.50 m) with fruiting at every node. Fruits are dark green, long straight (20-25 cm on the flatbed, up to 32 cm on bower) and with 3-3.75 cm diameter. Fruits are harvested in 50-55 days after sowing date. Yield ranges from 150-200 q/ha. Resistant to *Sponge Gourd Mosaic Virus* and downy mildew disease under field condition. Identified during XXXVI Group Meeting of AICRP (VC) in 2018 and notified by the CVRC notification no S.O. 692(E) dated 05.02.2019 for cultivation in zone-IV (Punjab, Uttar Pradesh, Bihar and Jharkhand).

Kashi Jyoti (VRSG-1-17; IC 627486): This variety has been developed through hybridization followed by selection. It is medium viny (3.5-5.50 m) with fruiting at every node. First male and female flowers appear at node number 5-10 and 14-20, respectively. Fruits are light green, long straight (20-25 cm on flat bed up to 30 cm on bower) and with 2.5-3.0 cm diameter. Fruit weight ranges from 100 g to 140g. Fruits are harvested in 50-55 days after the date of sowing (Fig. 23). Yield ranges from 140-180 q/ha. Resistant to *Sponge Gourd Mosaic Virus* and tolerant to downy & powdery mildew under field condition. Released by SVRC and notified by the CVRC notification no S.O. 692(E) dated 05.02.2019 for cultivation in Uttar Pradesh and adjoining area.

Fig. 23: Kashi Jyoti

Kashi Rakshita (VRSGH-1; IC 627487): It is medium viny (3.5-5.50 m) hybrid with fruiting at every node. Fruits are dark green, long straight (20-25 cm on flat bed and may on up to 30 cm on bower) and with 3-4 cm diameter. Fruits can be harvest at 48-52 days after sowing. Yield ranges from 200-250 q/ha (Fig. 24). Resistant to *Sponge Gourd Mosaic Virus* and downy mildew disease under field condition. Identified during XXXVI Group Meeting of AICRP (VC) in 2018 and

Fig. 22 Kashi Shreya

Fig. 24: Kashi Rakshita

notified by the CVRC notification no S.O. 692(E) dated 05.02.2019 for cultivation in zone-IV (Punjab, Uttar Pradesh, Bihar and Jharkhand).

Kashi Saumya (VRSGH-3; IC 627490): It is medium viny (3.5-5.50 m) hybrid with dark green foliage. First male and female flowers appear at node number 5-10 and 15-24, respectively. Fruits are green, long straight (20-25 cm on flat bed up to 32 cm on bower) and with 3.0-3.5 cm diameter. Fruit weight ranges from 140 g to 150g (Fig. 25). Fruit is harvested in 45-50 days after sowing. Yield ranges from 180-200 q/ha. Resistant to *Sponge Gourd Mosaic Virus* and tolerant to downy & powdery mildew under field condition. Released by SVRC and notified by the CVRC notification no S.O. 692(E) dated 05.02.2019 for cultivation in Uttar Pradesh and adjoining area.

Fig. 25: Kashi Saumya

Promising germplasm

Sponge gourd: Out of 80 germplasms of sponge gourd (73+7 new collection) 12 *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 (Fig. 26) were found promising for horticultural traits. These lines except VRSG-7-17 were free from *Sponge Gourd Mosaic Virus* (SGMV) disease symptoms under field conditions.

Aromatic line VRSG-7-17: A special aroma like 'Basmati Rice' has been noticed in leaves, vines, flower and fruits. The aroma test analysis of leaves and fruits justify that the whole fruit of VRSG-7-17 showed the presence of high concentration of Hexenal and 3 Octanone, which is either absent or found in very low concentration in the control sample 'Kashi Shreya' (VRSG-194). Other common volatile identified using GCMS were cis-3 hexenol, 1-octane-3-ol, 1-hexenol and Limonene etc. Moderately susceptible to *Sponge Gourd Mosaic Virus* and tolerant to downy mildew disease under field condition.

Fig. 26: Promising germplasm of sponge gourd (VRSG-7-17)

Promising Advance Breeding Lines: Among the 32 advanced breeding lines of sponge gourd, VRSG-17-1, VRSG-17-2, VRSG-17-3, VRSG-17-4, VRSG-17-5, VRSG-17-6, VRSG-17-10, VRSG-17-11, VRSG-17-12 and VRSG-17-15 were found promising for various horticultural traits and showed tolerance against *Sponge Gourd Mosaic Virus and* downy mildew disease under field conditions.

Development and evaluation of F_1 genotypes: A total of 60 F_1 cross combinations were developed by using the 12 Lines × 5 Testers. Among the 60 F_1(s) of sponge gourd 10 *i.e.* VRSG-136 x Pusa Supriya, VRSG-2-12 × Kashi Shreya, VRSG-57× Kashi Shreya, VRSG-214 × VRSG-1-12, Kashi Jyoti × VRSG-7-17, VRSG-136 × VRSG-2-12, VRSG-2-12 × VRSG-136, VRSG-1-12 × VRSG-214 , VRSG-17-10 × Pusa Sneha, and VRSG-57×VRSG-7-17 were found promising for various horticultural traits over the checks *i.e.* Priya (Golden Seeds), Utsav (Clause Seeds), KSP-1125 (Kalash Seeds), VNR Alok (VNR Seeds) and showed tolerance against downy mildew and virus disease under field conditions.

Generation advancement: Under the generation advancement program, 11 populations were advanced from F_{11} to F_{12}, 14 populations from F_{10} to F_{11}, 13 populations F_9 to F_{10}, 4 populations F_8 to F_9, 5 populations F_7 to F_8.

RILs programme: one population of *Luffa cylindrica sin. Luffa aegyptiaca x Luffa acutangula* var. Satputia syn. *Luffa hermaphrodita* advanced from F_5 to F_6 (45 plants).

Germplasm documented: Under the germplasm conservation and documentation program, a total of 8 germplasm/lines/hybrids were documented during 2018-19 in NBPGR, New Delhi with IC 627485 to IC 627491.

Ridge gourd

Germplasm collection and evaluation of ridge gourd: Out of 60 germplasm (52 old and 8 new collection) of ridge gourd, 10 *i.e.* VRRG-26, VRRG-35, VRRG-110, VRRG-7-2016, VRRG-6A, VRRG-1-16, VRRG-8-17, VRRG-12-10, VRRG-42-2016 and VRRG-46-2016 were found promising (Fig. 27) for horticultural traits and were free from *Sponge Gourd Mosaic Virus* (SGMV) and downy mildew disease symptoms under field conditions.

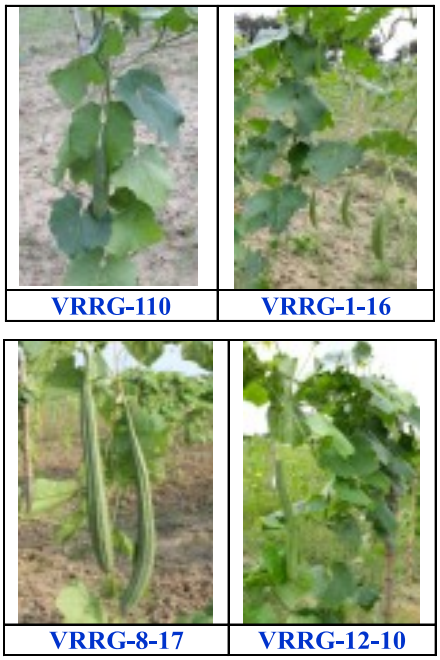


Fig. 27: Promising germplasm of ridge gourd

Promising genotypes/hybrids under multi-location testing of AICRP (VC) trials: One OP improved genotypes *i.e.* VRRG-6A in AVT-I and 2 F_1 hybrids namely, VRRGH-1 and VRRGH-2 in IET, are under multi-location testing of AICRP (VC) trials.

Generation advancement of Ridge gourd: Under the generation advancement program, 15 populations of ridge gourd were advanced from F_2 to F_3.

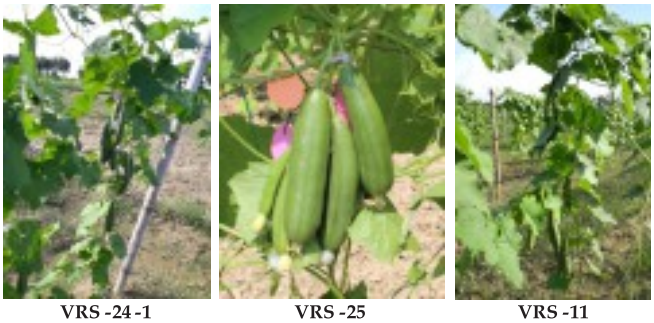


Fig. 28: Promising germplasm of Satputia.

Satputia: Out of 38 germplasms (37 old + 1 new collection) of Satputia 5 i.e. VRS-24-1, VRS-25, VRS-20, VRS-36 and VRS-11 were found promising for horticultural traits (Fig. 28).

Project 1.9: Genetic Improvement of Pumpkins and Cucumber

Pumpkin

Evaluation and maintenance of germplasm; Eighty eight germplasm have been evaluated for yield and quality attributes. A total of 110 lines including identified/released varieties were maintained as active collections. Fruit yield per plant ranged between 1.1 kg per plant (Pumpkin V-4) to 5.47 kg/plant (VRPK-Sel.-11-6-5). Number of fruits per plant varied between 1.0 (N. Agrim) to 4.56 (VRPK-Sel-11-6-5). Individual fruit weight ranged from 0.8 kg (VRPK-5-01) to 2.55 kg (G-81) at edible green mature stage. All the lines have been maintained through selfing/sibbing for their further utilization.

Evaluation of advance lines: Five advance breeding lines have been evaluated for important horticultural traits. Maximum yield per plant was reported in VRPK-9-01(6.63 kg/plant) followed by VRPK-222 (6.60 kg/plant). Whereas, maximum individual fruit weight was observed in VRPK-18-01 (2.05 kg) followed by VRPK-222 (2.0 kg) at green edible stage. On the basis of overall performance, VRPK-9-01, VRPK-222-2-1 and VRPK-18-01 were found promising (Table 11).

Table 11: Performance of pumpkin advance lines

Genotype	No of fruits/plant	Average fruit weight (g)	Yield/plant (kg)
VPPK-230	3.71	1.48	5.51
VRPK-9-01	3.68	1.80	6.63
VRPK-222-2-1	3.00	2.00	6.00
VRPK-18-01	2.62	2.05	5.36
VRPK-310	1.93	1.30	2.51

Isolation and maintenance of inbred: A total of 10 inbred from advance lines have been selected for hybridization in mottle green and flat round/round segment. The selected inbred have been maintained for purity through selfing.

Development and evaluation of hybrids: Crosses were made among selected parents during summer, 2017 and developed F_1 hybrids along with check Kashi Shishir evaluated for their yield and yield attributing traits during summer season, 2018. Maximum green fruit yield per plant was recorded in hybrid Kashi Shishir (10.08kg) followed by VRPKH-17-10 (9.63kg). None of the hybrid found better in respect of yield over check variety Kashi Shishir (10.08kg).

Advancement of breeding material: A total of 36 segregating lines which includes F_3 (10), F_4 (08), F_5 (06), F_6 (5), F_7 (3) and F_8 (04) were evaluated; selfed and further selection were made to advance as next generation.

Notification of hybrids

Kashi Shishir: This is early maturing hybrid recommended from state variety release committee and notified for Uttar Pradesh. The fruit colour is mottled green, shape flat round, size small (2-2.25kg) at edible maturity. First fruit harvesting starts on 58-62 days and duration of crop from seed to seed is 100-105 days after sowing and yield potential is 400-450 q/ha & 385-400q/ha in rainy and summer season, respectively.

Maintenances and evaluation of advance lines of summer squash

Five promising advance lines, and one check of *Cucurbita pepo* (summer quash) and 65 segregating lines includes (5 F_4, 7 F_4 and 53 F_5) were evaluated. Among four advance lines, VRSS-65 and VRSS-66 were found promising in terms of yield and quality. The segregating lines of summer squash have major variation in colour and shape. The segregating lines in F_5 generation have tolerance against the fruit fly and have tolerance against sucking insects. These lines were advanced through selfing and further selected for next generation. Among the segregating population, one line VRSS-17-05 has shown the stability towards high frequency femaleness. The high frequency female lines have been maintained by sibing/selfing.

New variety released

Kashi Subhangi: This is medium maturing, bushy in growth recommended from state variety release committee and notified for Uttar Pradesh. The fruit colour is dark green, shape elongated, size medium (800-900 g) at edible maturity. Most suitable sowing time of this variety is September to November and early in spring season (maximum temperature upto 30^{0}C). Yield potential is 600-650 q/ha and resistant to downey mildew.

Multiplication and maintenance of seeds of released varieties: Two kg seeds of Kashi Harit variety of pumpkin were produced and 50 SPS were selected for maintenance of the variety. Similarly, summer squash variety Kashi Subhangi seed was also multiplied and 1 kg seed has been produced.

Cucumber

A total of 80 germplasm/genotypes including 7 released varieties of different organization were evaluated for flowering, yield and related traits (Table 12). The results indicated that the fruit length ranged from 13.00 (VRCU-Sel-12-03) to 17.25 (VRCU-Sel-19-19) and fruit diameter ranged from 11.95 (VRCU-13-06) to 14.00 (VRCU-18-01). The average fruit weight among the genotypes ranged from 120 to 210 g. Yield per plant ranged from 588.46 (VRCU-Sel-12-02) to 763.60 (VRCU-Sel-19-03).

Table 12: Performance of cucumber genotypes

Genotype	Fruit length (cm)	Fruit diameter (cm)	Fruits/plant	Average fruit weight (g)	Yield/plant (g)
VRCU-12-03	13.00	12.25	4.60	166.0	763.60
VRCU-13-05	15.00	12.50	5.80	128.0	742.40
VRCU-18-01	16.00	14.00	3.92	180.0	706.15
VRCU-13-13	16.00	12.25	4.70	150.0	705.00
VRCU-Sel-19-19	17.25	12.50	5.43	120.0	651.43
VRCU-13-06	17.00	11.95	4.20	146.0	613.20
VRCU-Sel-12-02	16.50	12.75	3.92	150.0	588.46
PCUC-9 (Check)	13.67	12.33	2.95	200.0	589.47

Table 13: Performance of cucumber hybrids

Hybrid	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/plant	Average fruit weight (g)	Yield/plant (g)	Fruit colour
VRCUH-16-01	19.56	4.48	6.84	210.52	1680.50	Light green striped
VRCUH-16-02	22.44	4.56	6.87	198.32	1430.25	Light green striped
VRCUH-16-03	15.65	4.26	6.23	165.25	1155.50	Green, non-striped
VRCUH-16-08	21.25	4.93	7.00	158.62	1220.35	Light green striped
VRCUH-16-09	18.75	4.12	6.00	125.22	710.00	Green, non-striped
VRCUH-16-10	17.86	4.25	6.50	135.65	815.60	Light green striped
VRCUH-16-13	16.58	4.32	4.63	137.22	600.80	Light green striped
VRCUH-16-15	14.95	4.05	6.28	165.22	1015.30	Light green striped

Table 14 : Yield and contributing traits of advance lines of cucumber

Hybrids	Fruit length (cm)	Fruit diameter (cm)	No. of fruit/plant	Average fruit weight (g)	Yield/plant (g)
VRCU- Sel- 12-03	19.80	4.8	6.25	250.00	1450.25
VRCU- Sel- 12-02	20.21	4.4	6.50	200.00	1220.45
VRCU- Sel-13-19	14.30	4.7	6.50	160.00	985.85
VRCU-Sel-09-36	20.36	3.25	6.25	115.00	725.50
VRCU.Sel.12-01	18.50	3.85	6.00	100.50	600.25
PCUC-09	20.25	4.65	6.65	170.00	1050.25

Development and evaluation of hybrids: Twenty hybrids along with parents of cucumber have been evaluated for yield and yield contributing traits. Among the evaluated hybrids one were identified and included for multiplication testing. The mean performance of promising hybrids are presented in table 13.

Evaluation of advance lines: A total of 10 advance lines along with checks PCUC-09 have been evaluated for yield and its contributing traits in mottle green segment. Fruits of these lines were non-bitter in taste. The best performing lines based on the fruit colour, appearance and yield were VRCU-Sel.-12-03 followed VRCU-Sel.-12-02 based on yield data (Table 14).

Advancement of breeding material: A total of 36 segregating lines which includes F_2 (16), F_6 (8), F_7 (6), and F_8 (05) were evaluated, selfed and further selections were made to advance as next generation.

Screening of cucumber germplasms for Root knot nematode resistance: Nine germplasms of cucumber along with susceptible check Swarna Ageti were screened for root knot nematode (*Meloidogyne incognita*) resistance under pot condition by inoculating 2000 second stage infective juveniles per plant. Observations were recorded by using gall index 1-5 scale. Among screened germplasms, none of them found resistance to root knot nematode and all were susceptible or highly susceptible to root knot nematode *M. incognita*.

New hybrid released

Kashi Nutan: This hybrid is recommended from state variety release committee and notified for Uttar Pradesh state. The fruit is cylindrical long, medium in size, dark green and average fruit weight 200-225g at edible maturity. First fruit harvesting starts on 52-55 days and duration of crop from seed to seed is 100 days after sowing and yield potential is 175-180 q/ha.

Project 1.10: Genetic Improvement of Melons

Muskmelon

Status of germplasm: A total of 180 accessions of muskmelon were maintained at IIVR which include genotypes of various fruit shapes *i.e.,* round, flaty round, oval and oblong and flesh colour *i.e.,* yellow, white, orange and green flesh. A total of 41 accessions of 2 different related wild species of muskmelon were also maintained at IIVR. During 2018-19, fourteen *C. melo var agrestris* and eight *C. callosus* accessions were collected from Odisha.

Evaluation of *Cucumis melo* var *agrestris* and *C. callosus* germplasm: A total of 41 accessions of *Cucumis melo* var *agrestris* and *C callosus* were evaluated for various horticultural traits. There was sufficient genetic variability reported for the traits under consideration. Taste of the fruits of these CWR species was sour and they are monoecious in nature with respect to sex form. Among these wild accessions, the genotype RCM/PK/45 remained free from downy mildew disease under field condition.

Evaluation of advance lines:

A total of fifteen advance lines of muskmelon were evaluated for various traits of economic importance. Sex form of these advance lines was either andro-monoecious or monoecious. In monoecious segment all the advance lines were round fruited with orange or white flesh. There was considerable amount of genetic variability reported for the horticultural traits under consideration (Fig. 29). Among these evaluated 15 genotypes, VRMM-170 (Yield: 3.87 kg/plant; TSS: 10° Brix) and VRMM-186(Yield: 3.53 kg/plant; TSS: 9.33° Brix) were found to be most promising.

Generation advancement: During 2018-19, 10 cross combinations were attempted and seeds harvested for the evaluation in next season. Seven F_1, four F_2 and two F_3 were advanced to subsequent generation. Besides, promising genotypes were also self pollinated for the development of inbred lines.

Maintenance of seeds of released variety: Half kg seeds of Kashi Madhu variety of muskmelon were produced for maintenance of the variety.

Watermelon

Collection, characterization and evaluation of germplasm: Sixty-six lines were evaluated for yield and quality attributes and a total of 70 lines including

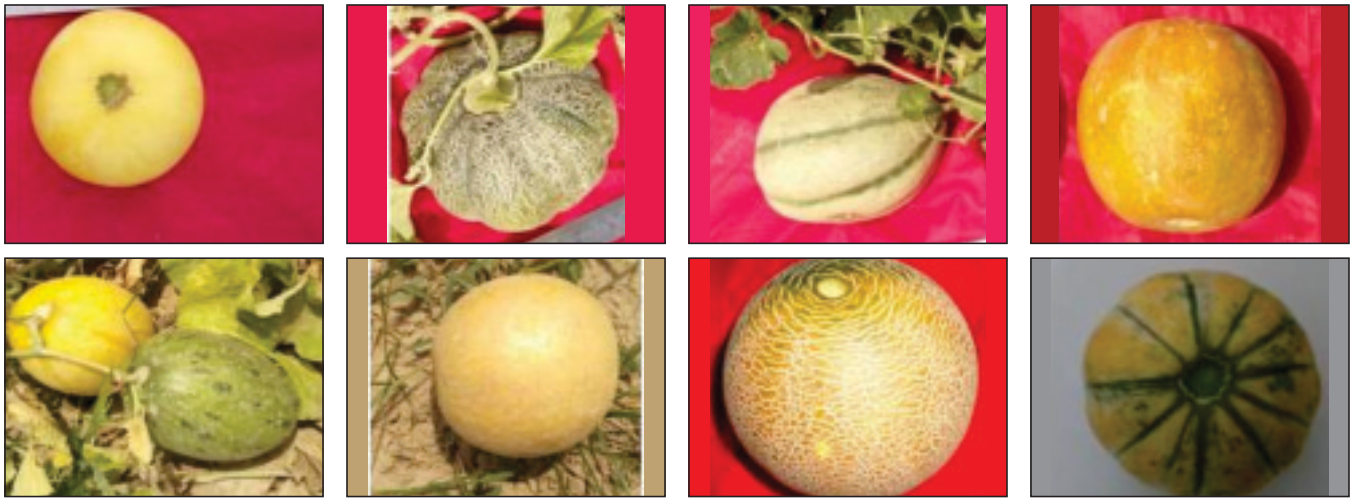


Fig.29: Variation in fruit traits

wild/identified/released varieties were maintained and multiplied. Under augmentation programme, four germplasm were introduced from Jodhpur, Rajasthan; one from Kushinagar and one from Sasaram, Bihar which are being multiplied for evaluation and further use in breeding programme.

Maintenance of inbreds and generation advancement: The selected inbreds have been maintained for purity through selfing. A total of 43 segregating lines which include F_2 (10), F_3 (7), F_4 (7), F_5 (5), F_6 (3), F_7 (3), and F_8 (8) were evaluated, selfed and further selection were made to advance as next generation.

Evaluation of advance lines: In summer season, there was severe incidence of thrips, tospovirus/*Watermelon Bud Necrosis Virus* under open field conditions. Hence, the fruiting was very poor which affected yield and quality parameters. Ten advance lines under poly house at main campus and twenty-one germplasm at RRS, Sargatia having various flesh colour (red, scarlet red, canary yellow, Salomon yellow, orange and white) were evaluated for several economic traits. Among these, the potential yielder (Fig. 30) with high TSS are VRW-514, VRW-514-1, VRW-516 and VRW-511 (Mini segment <3.5 kg, scarlet red flesh/pink); VRW-14-1 and VRW-9-1 (Yellow skin with yellow/red fleshed); VRW-12-3-1 (Matera), VRW-10, VRW-55 VRW-58 (Orange fleshed), VRW-53 (yellow striped) and VRW-53-1 (Ice-box segment 3-5.5 kg). Maximum yield per plant and average fruit per plant was observed in VRW-514-1 (11.5 kg/plant) followed by VRW-514 (10.8 kg/ plant). An andromonoecious plant from segregating population of previous years was identified which was further maintained through inbreeding and become stable. It produced round, orange-fleshed fruits having light grey rind matured in 70-75 days after sowing, weighing 3.0-3.5 kg fruit with 11.20-12.30% TSS and thick rind (0.9-1.3 cm). The developed material (VRW-10) possesses a unique trait *i.e.* stable andromonoecious sex form with orange flesh and white seed with black tip.

VRW-12-3-1 **VRW-514-1** **VRW-514**

Fig. 30: Promising genotypes of watermelon VRW-514, VRW-514-1 and VRW-12-3-1

Two promising advance lines, VRW-514-1 and VRW-12-3-1 under different segment in F_7 and F_8 generation were selected for high yield and better fruit quality. The selected lines shall be used for yield trial at station before submitting it for multi-location testing in AICRP (VC). Twenty one germplasm were evaluated at RRS, Sargatia also. Among them VRW-10, VRW-511, VRW-14-1 & VRW-9-1 were highest yielders (8.6 to 9.71 kg/plant).

Identification of unique inbred line (VRW-14-1): During Summer 2016, few plants showing yellow vein true leaves were identified among the segregating population of VRW-3 x VRW-9 in F_4 generation. The skin of fruit is yellow which can be easily identified right from ovary stage of flower. At the time of harvesting, fruits of some plants had yellow flesh with black seeds which was in contrast to their parents. Further, these plants have been advanced to successive generation (F_8 generation) by selfing to achieve the stability. This line may be utilized as a morphological marker in hybrid/triploid/resistant breeding programme for identification of hybrid

Field screening of watermelon germplasm for *Watermelon Bud Necrosis Viruses*: Among sixty four (64) germplasm screened, no line was found immune, only 2 were found resistant (VRW-27 and VRW-24), 8 others (VRW24-1,VRW-8,VRW-52-2,VRW-52-1,VRW-32,VRW-12-3,VRW-40, VRW-63)-1) moderately resistant and twenty one were moderately susceptible to the virus. The remaining 33 lines ranged from susceptible to highly susceptible to the tospo virus.

Round melon

Ten lines were evaluated for yield and quality attributes, maintained as active collections and multiplied. There was a severe incidence of thrips, and viruses resulting in poor fruiting in open field condition. Eight improved lines maintained and multiplied during *kharif* 2018 under poly house resulted into healthy crop. Maximum yield was found in VRM-1 (1.12 kg/plant) followed by VRM-5 (1 kg/plant) and VRM-11-1(0.89 kg/plant) which has medium green colour and flatty-round to round fruit shape (Fig. 31). VRM-11-1 has the characteristic of late seed development, which attract the preference of consumers and farmers. All these lines are susceptible to viruses under field condition. These lines were advanced through selfing and further selected for next generation.

VRM-11-1 2 VRM-1 VRM-11-1

Fig. 31: Promising roundmelon genotypes

Long melon

Collection, characterization and evaluation of germplasm: Forty (40) diverse genotypes were evaluated for different horticultural traits and maintained through selfing. Two germplasm of long melon were collected from Aurangabad, Bihar which will be multiplied for evaluation.

Early flowering was observed in VRLM-05 (24 days after sowing) followed by VRLM-29-1 (26 days after sowing). Maximum fruit length was recorded in VRLM-01 (52 cm) and minimum in VRLM-24-1 (25 cm). The genotypes VRLM-01 (Fig. 32), VRLM-40, VRLM-24-1, VRLM-28 and VRLM-29-1 were found to be superior for yield and quality attributes All the lines are being maintained through selfing.

Fig. 32 : Promising genotype of Long melon (VRLM-01)

A promising advance line, VRLM-01 in F_7 generation was selected for high yield (1.62 kg/plant) and better fruit quality. This selected line shall be used for yield trial at station before submitting it for multi-location testing.

Full exploitation of the genetic potential of germplasm needs systematic characterization with molecular interventions to identify and evaluate the important horticultural traits. With this view, the study to investigate the genetic diversity was planned through molecular characterization of long melon (Armenian cucumber) varieties. Thirty-six diverse genotypes of Armenian cucumber, collected from various parts of the country as well as abroad, were subjected to profiling using Eighty SCoT markers. The screening and results are under progress.

Project 1.11: Genetic Improvement of Okra

Status of germplasm: In okra 680 germplasm accessions were maintained including bush type, thin fruited, ridge less, five to nine ridged, red fruited, cut leaf, YVMV and ELCV resistant genotypes. ICAR-IIVR also maintained 94 accessions of 10 different related wild species of okra *viz*., *Abelmoschus caillei* (15), *A. tuberculatus* (10), *A. ficulneus* (12), *A. tetraphyllus* (30), *A. moschatus* (20), *A. enbeepeegearense* (1), *A. crinitus* (1), *A. angulosus* (2), *A. manihot* (1) and *A. moschatus* subsp. *tuberosus* (1). In 2018-19, a total of 47 new accessions were also augmented from wester Uttar Pradesh and Odisha.

Evaluation of hybrids: A total of ninety F_1 hybrids were developed using eighteen different parents (VRO-109, VRO-112, Parbhani Kranti, VRO-102, SB-8, OK-99-335, VRO-6, VRO-110, Kashi Kranti, VRO-113, VRO-178, 416-10-1, VRO-111, VRO-114, HRB-55, VRO-115, OK-99-318 and No.315) during spring summer season of 2018 and were evaluated during *kharif* season for yield, fruit quality, YVMV and ELCV disease reaction along with four checks Kashi Bhairav, VNR-999, Navya and ZH-1044. Out of ninety, 10 best performing hybrids were identified and among them, VRO-178 × 416-10-1 (Fruit yield/plant: 523.00g; YVMV PDI: 3.33; ELCV PDI: 0.00), VRO-110 × Kashi Kranti(Fruit yield/plant: 469.20g; YVMV PDI: 0.00; ELCV PDI: 0.00) and OK-99-335 × VRO-109(Fruit yield/plant: 405.60g; YVMV PDI: 0.00; ELCV PDI: 0.00) were found most promising (Fig. 33).

VRO-178 × 416-10-1

VRO-110 × Kashi Kranti

Fig. 33: Promising okra hybrids developed

Evaluation of advance lines: Forty advance lines were evaluated during *kharif* season for yield, dark green fruit, devoid of seed bulging and reaction to viral disease like YVMV and ELCV. Genotype VRO-120 (Fruit yield/plant: 300g;) and VRO-125 (Fruit yield/plant: 360g;) identified as most promising genotypes for fruit yield, fruit quality and disease resistance during field evaluation of advance lines (Fig. 34).

VRO-120

VRO-125

Fig. 34: Promising advance lines of okra

Identification and transfer of Genetic Male sterility (GMS): In the summer season of 2018-19, male sterile plants were identified from segregating population of a GMS based hybrid. The male sterile plants were characterized by dropping of the flowers without setting fruits, withering and dropping of flower

buds prior anthesis, devoid of fruits in the lower and middle nodes, presence of single fruits on the upper nodes etc. Staining ability of the pollen grain of fertile and sterile plants were also studied (Fig. 35). To transfer this GMS, sterile plants were crossed with VRO-109, VRO-110, VRO-112-1, Kashi Lalima, VRO-120, VRO-125 and No. 315 and crossed seeds were harvested. In the rainy season these GMS based crosses were grown and back crossed with the recurrent parent.

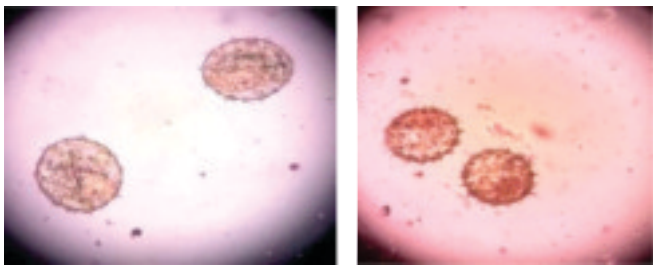


Fig. 35: Sterile and fertile pollen

Generation advancement and characterization of $F_{2:5}$ RILs of VROR-156 × VRO-5: In the summer season of 2018, seeds of 260 $F_{2:4}$ RILs were sown and F_5seeds were harvested from 255 RILs. In the rainy season, all the 255 $F_{2:5}$ RILs were sown for generation advancement to F_6 generation and phenetic characterization. Out of 255 $F_{2:5}$ RILs 115 were green, 106 red and 27 were still segregating (Fig. 36). Plant height varied from 55 cm to 173 cm.

Fig. 36: Growing plants and fruits of $F_{2:5}$ RILs

Screening of wild relatives of okra for YVMV and ELCV diseases: Ninety four accessions of wild relatives of okra which include *A.caillei* (15), *A.ficulneus* (12), *A. tuberculatus* (10), *A. angulosus* var *grandiflorus* (2), *A. tetraphyllus* (30), *A. manihot* (1), *A. crinitus* (2), *A. moschatus* (20), *A.moschatus* subsp. *tuberosus* (1) and *A.enbeepeegearense* were evaluated for various descriptor traits and YVMV and ELCV disease reaction. Among these 24, 31 and 14 accessions showed resistance to YVMV, ELCV and both the diseases, respectively. *A.enbeepeegearense, A. crinitus, A. angulosus* var *grandiflorus*, *A. moschatus* subsp *tuberosus* (IC-470750), *A. manihot* and *A. moschatus* (collected from Gujarat) showed immune type reaction to both YVMV and ELCV disease under field condition.

Reaction of interspecific hybrids to viral diseases (YVMV & ELCV): A total of ten interspecific hybrids *viz.*, VRO-109 × *A. caillei* (Susthira *caillei*), VRO-115 × *A. caillei* (*caillei*-1), VRO-115 × *A. caillei* (*caillei*-2), VRO-113 × *A. caillei* (caillei-1), VRO-115 × *A. tuberculatus*, VRO-109 × *A. tetraphyllus*, VRO-112-1 × *A. tetraphyllus*, VRO-6 × *A. tetraphyllus*, Kashi Kranti × *A. tetraphyllus*, *A. moschatus* × *A. moschatus* subsp. *Tuberosus* were screened against YVMV and ELCV infestation. All the interspecific crosses showed resistance to both YVMV and ELCV except VRO-6 × *A. tetraphyllus*. In cross VRO-115 × *A. tuberculatus*, resistance reaction may be due to the VRO-115 (resistant line) as *A. tuberculatus* is completely susceptible to these viral diseases.

Interspecific hybrids with ornamental value and free form fruit borer: *A. moschatus* × *A. moschatus* subsp. *tuberosus* is a cross of yellow flower and red flower *Abelmoschus* and produces large scarlet red flower as like china rose though out the year and is perennial in nature. On the other hand, VRO-115 × *A. tuberculatus* remain free from fruit borer as the fruits of this cross were characterized by presence of tubercle and dense trichome and can be utilized for the development of pre-breeding lines for fruit borer resistance in okra (Fig. 37).

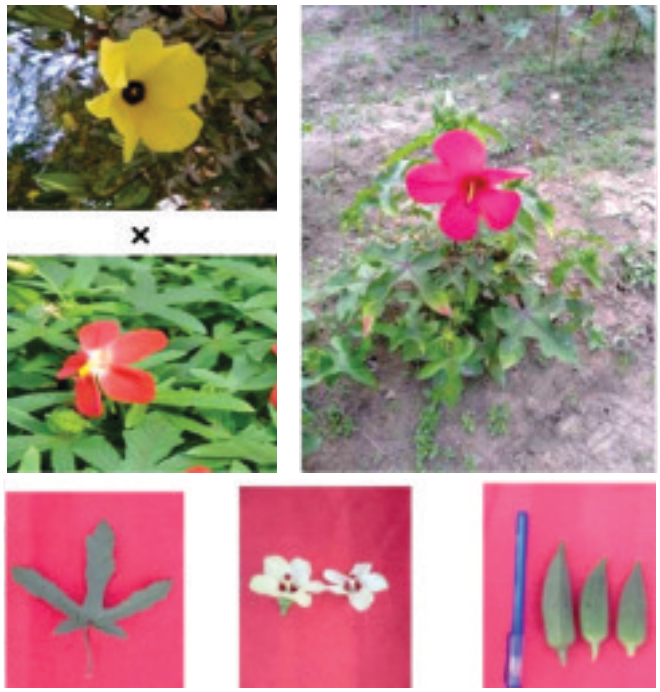


Fig. 37: Interspecific hybrids with ornamental value and free form fruit borer

Induction of colchiploidy in interspecific hybrids: It has been reported that interspecific hybrids produce

fruits without viable seeds. To overcome this problem, 10 interspecific hybrids were treated with 0.2% colchicine at the time of true leaf formation. 80% survivable ability was observed in the colchine treated interspecific hybrids. On sefing and backcrossing, sufficient seeds were harvested in colchicine treated plants as compared to plants without treatment and were advanced to subsequent generation.

Confirmation of YVMV and ELCV resistance in wild relatives using begomo virus specific primer: Wild relatives of okra *viz.*, *A. manihot, A.enbeepeegearense, A.crinitus, A. caillei, A. moschatus, A. moschatus* subsp. *tuberosus* and $C_2$106-Mizo-1 which showed immune type of reaction to YVMV and ELCV while one accession each of *A. ficulneus* and *A.tetraphyllus* which showed susceptible reaction to YVMV and ELCV, were artificially screened along with susceptible and resistant check samples. There was no amplification reported from the sample which showed immunity against YVMV and ELCV under field condition and susceptible accessions showed amplification with begomovirus specific primer.

Screening of okra germplasms for Root knot nematode Resistance: A total of twenty two accessions including both cultivated and wild relatives, were screened against root knot nematode. Among these 22 accessions, 13 were reported as either highly susceptible or susceptible, while nine accessions reported to form less number of gall or no gall which need to be confirmed further.

Varieties and hybrid notified

Kashi Chaman (IC 0610502): It is a yield potential variety developed through pedigree selection from Kashi Kranti × Punjab Padmini. It is almost free from YVMV (PDI: 1.62) & OELCV (PDI: 1.12) disease under field condition as compared to check VRO-6 which has YVMV and ELCV PDI of 42.26 and 38.87, respectively. Plants are medium tall with short internodes along with double or triple branch attached in narrow angle with the main stem. First flowering occurred 42-44 days after sowing and having fruiting period of 48-105 days. Fruits are dark green in colour; length and diameter of fruit is 12-15 cm and 1.4-1.5 cm, respectively. This variety had yield potential of 15.0-16.0 t/ha which is 21.66% more than the national check VRO-6 (Kashi Pragati). It is suitable for growing in both summer and rainy season (Fig. 38).

Kashi Lalima (IC 628076): It is first reddish purple fruited yield potential variety in India. It is developed through pedigree selection from IC-93892 × VROR-150

Fig. 38: Kashi Chaman

and tolerant to YVMV (PDI: 3.34) and ELCV (PDI: 8.97) disease under field condition as compare to check. Plants are medium tall with short internodes along with double or triple branch attached in narrow angle with the main branch. It is suitable for both summer and rainy season with high fruiting potential and having a yield potential of 140-150 q/ha which is 15.68% more than the check. Besides, it has antioxidant potential due to anthocyanin and phenolics content (Fig. 39).

Fig. 39: Kashi Lalima

Kashi Shristi (IC 628085): It is an F_1 hybrid developed by crossing (Kashi Kranti × VRO-102). This hybrid is tolerant to YVMV disease (PDI: 2.87) under field condition as compared to check which has YVMV PDI of 38.88. It produces medium-tall plant with short internodes along with double or triple branch attached in narrow angle with main branch. First flowering is recorded 40-42 days after sowing and fruiting period is 45-105 days. It is suitable for both summer and rainy season with high fruiting potential. Fruit colour, length and Diameter of this hybrid is dark green, 12-15 cm and 1.4-1.5 cm, respectively (Fig. 40).

Fig. 40: Kashi Shristi

Yield potential is reported to be 180-190 q/ha which is 20.55 % more than the check.

IC Number of advance lines and varieties and their licensing: Seed of six genotypes of okra which include variety, hybrid and advance lines were submitted to gene bank of ICAR-NBPGR and IC number was obtained for these lines *viz.,* Kashi Lalima: IC 628076, Kashi Shristi: IC 628085,VRO-110:IC-0629867, VRO-112-1:IC-0629868, VRO-120:IC-0630302 and VRO-125:IC-0630303.

Generation advancement of breeding material: A number of progeny families in various stages (F_2 to F_{10} generations) of inbred development were grown, single plants selection was done for dark green fruit colour, small fruit size, YVMV/ OELCV resistance/ tolerance and seeds were collected for further advancement of generation.

Validation of performance of wild *Abelmoschus* derived genetic materials from Thrissur: A total of 40 cultivated okra × *A. mizoramensis sp. Nova* which was identified during 2017-18 for YVMV and ELCV resistance were validated for viral disease resistance and ability to set fruit during winter months. All the 40 *A. mizoramensis sp. Nova* derived lines confirmed their resistance to viral disease during 2018-19 also. Four genotypes were reported to set fruit during winter months (November-January). These promising pre-breeding lines were self pollinated and seed were harvested.

Maintenance breeding: The maintenance breeding of different okra varieties released by ICAR-IIVR *viz.* Kashi Kranti, Kashi Pragati, Kashi Sathdhai, Kashi Lila, Kashi Vibhuti, Kashi Vardaan and Kashi Chaman were done through true to type single plant selection. For self pollination, okra rose bud nets were used which were easy to use, observed high percentage of fruit set and may reduce labour requirement as compared to the use of butter paper bags . Besides, hybrid seeds of Kashi Bhairav were produced and its parental lines were also maintained by selfing.

Project 1.12: Genetic improvement of cole and root crops

Cole crops

In cauliflower, seventy-eight genotypes including varieties / promising lines / germplasm / accessions / hybrids with different maturity groups, forming curds at 13-30°C were evaluated and characterized for various traits of horticultural importance. The genotypes promising for curd yield were VRCF-75-1 and VRCF-86 in mid-October maturity (22-32 °C); Kashi Gobhi-25, VRCF-102, VRCF-27, and VRCF-32 in late-October to mid-November maturity (16-28 °C); and VRCF-104, VRCF-202 and VRCF-22 in late-November to mid-December maturity group (11-22 °C). The genotypes VRCF-75-1 and VRCF-86 realized better marketable yield potential of 160-180 q/ha during 2nd fortnight of October having small frame size of 45-50 cm, short duration of 60-70 days, net curd weight of 300-325 g, marketable curd weight of 340-370 g, gross plant weight of 750-850 g, curd size of 9.5-11.0×11.5-12.5 cm, and medium-compact cream-white curds free from riceyness and leafiness. Additionally, VRCF-102 and VRCF-27 realized marketable yield potential of 190-210 q/ha during first fortnight of November having net curd weight of 410-440 g, marketable curd weight of 490-525 g, 990-1150 g gross plant weight, curd size of 10.5-11.5×12.0-13.5 cm, maturity period of 65-75 days, and medium compact to compact off-white curds free from riceyness and leafiness. Moreover, VRCF-104 and VRCF-202 realized better yield potential of 220-240 q/ha during 1st fortnight of December possessing net curd weight of 460-500 g, marketable curd weight of 550-580 g, gross plant weight of 1100-1200 g, curd size of 10.5-12.0×12.5-13.5 cm, maturity period of 65-80 days, and self-blanched curd having compact and white curds.

New variety released: A variety ready to harvest during 1st fortnight of November 'Kashi Gobhi-25 (VRCF-50)' has been released and notified for UP state (Fig. 41). Nucleus seed of Kashi Gobhi-25 (2.0 kg) has been produced in flexible nylon-net cage for further seed multiplication.

Fig. 41: Kashi Gobhi-25

On the basis of beta carotene content (0.75-1.50 mg/100 g FW) and orange colour intensity (light orange to dark orange), orange curd genotypes possessing '*Or*' gene have been grouped in four categories and population has been advanced (Fig. 41a). Seven plants having green curd have been identified and seed multiplied for further evaluation. Five best performing genotypes namely VRCF-86, VRCF-50, VRCF-102, VRCF-104 and VRCF-202 are in multi-location testing under AICRP-VC.

Fig. 41 a : Orange cauliflower

CMS in tropical cauliflower: With respect to transfer of CMS system in tropical cauliflower, 18 BC population have been advanced (BC_1F_1-BC_5F_1) in different curd maturity/colour groups (Early/Mid/Mid-late maturity, and white/orange curd) through back-crossing. Among these, three Ogura-CMS lines *i.e.* VRCF-41, VRCF-131 and VRCF-110 were found to be very similar to their respective maintainer lines. The CMS line VRCF-41 develops curd at about 28-30 °C temperature *i.e.* 2nd fortnight of October, semi-spreading plant type, marketable curd weight of 350-375 g, hemispherical curd, cream-white curd colour, medium curd compactness and initiates flowering during last week of November. Moreover, another Ogura-CMS line VRCF-131 forms curds at 25-27 °C temperature *i.e.* 1st fortnight of November, semi-erect plant type, marketable curd weight of 500-525 g, hemispherical curd, off-white curd colour, medium curd compactness and initiates flowering during mid-December. Third Ogura-CMS line VRCF-110 forms curds at 21-25 °C temperature *i.e.* 2nd fortnight of November, semi-erect plant type, marketable curd weight of 550-625 g, hemispherical curd, off-white curd colour, compact curd and initiates flowering during mid-January. By utilizing these lines, five best promising CMS-based hybrids expressing 15-25% heterosis and developing curds at different temperature have been identified *i.e.* VRCF-41×VRCF-75-1 (28-30 °C), VRCF-41×VRCF-50 and VRCF-131×VRCF-86 (25-28 °C), and VRCF-110×VRCF-50 and VRCF-110×VRCF-104 (20-25 °C) (Fig. 42); and the parental lines are ready for commercial use.

VRCF-41×VRCF-75-1 VRCF-41×VRCF-50 VRCF-110×VRCF-50

Fig. 42: Promising CMS based hybrids

Kale

Tropical kale genotype 'VRKALE-1' (Fig. 43) induces bolting and flowering, sets seeds in the North Indian plain and doesn't require any vernalization. This genotype initiates bolting and flowering during third week of February in North Indian plain. Bolting percentage is continuously increasing i.e. 2.5%, 23.6%, 40.6%, 61.7%, 74.6% and 91.5% respectively during 2013-14, 2014-15, 2015-16, 2016-17, 2017-18 and 2018-19; and test weight (1000 seed weight) also showed increasing pattern i.e. 1.512 g, 1.502 g, 1.555 g, 1.746 g, 1.832 g and 2.450 g. The leaves are ready for first picking in 23-30 days after transplanting and thereafter at 7-10 days interval. It has leaf yield potential of about 40-50 t/ha. A variant of kale possessing trichomes on leaf surface has been identified in population and seed multiplied for further evaluation.

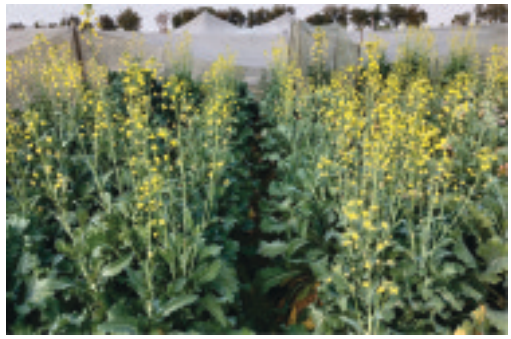


Fig. 43 : VRKALE-1

Cabbage and broccoli

Six genotypes of tropical cabbage and seven of tropical broccoli which induce robust bolting/flowering at 12-22 °C have been evaluated for various traits, especially head shape, size and compactness, and advanced to next generation. As like Indian/tropical cauliflower, back-crosses have been made in seven backgrounds to transfer Ogura-CMS system in cabbage/broccoli (BC_1F_1) (Fig. 44).

Fig. 44: Tropical cabbage

Genotypes documentation with NBPGR: Sixteen genotypes of tropical cauliflower have been documented with NBPGR, New Delhi whose IC number are 0626345 (VRCF-22), 0626346 (VRCF-34), 0626347 (VRCF-50), 0626348 (VRCF-51), 0626349 (VRCF-75), 0626350 (VRCF-75-2), 0626351 (VRCF-86), 0626352 (VRCF-101), 0626353 (VRCF-102), 0626354 (VRCF-103), 0626355 (VRCF-105), 0626356 (VRCF-112), 0626357 (VRCF-113), 0626358 (VRCF-114), 0626359 (VRCF-120) and 0626360 (VRCF-201). A sum of 87 genotypes/accesions, including 73 of cauliflower, 6 of cabbage, 7 of broccoli and 1 of kale are being maintained.

Carrot

Eighty-four genotypes (varieties/promising lines/germplasm/hybrids) of tropical carrot, having different root colour (red, black, orange, yellow, cream and rainbow) (Fig. 45) were evaluated and characterized. The most promising genotypes with better quality traits (self-coloured core, fewer secondary roots, lesser root scars) and higher root yield are VRCAR-186, VRCAR-201, VRCAR-185 and VRCAR-109 (red root); Kashi Krishna, VRCAR-124 and VRCAR-89-1 (black root); VRCAR-91-1 and VRCAR-91-2 (orange root); VRCAR-153, VRCAR-127 and VRCAR-178 (yellow root); VRCAR-160 (cream root); and VRCAR-107-1, VRCAR-107-2 and VRCAR-171-1 (rainbow-type root). Red carrot genotypes such as VRCAR-186 (Kashi Arun) and VRCAR-185 outperformed (>98% uniformity for root shape and colour) with root yield potential of 350-375 q/ha & 335-350 q/ha, root weight of 140-160 g and 130-140 g, root length of 22-25 cm & 21-23 cm, marketable roots of 90-94% and 90-92% and self-coloured roots of 92-95% and 90-92%, respectively; and both entries are in multi-location testing.

Fig. 45: Red, orange, rainbow, yellow and black carrots

New variety released: Kashi Krishna (VRCAR; IC 0623130-126), a black colour genotype has been released and notified for UP state having potential yield of 220-240 q/ha, root weight of 115-125 g, root length of 20-22 cm, marketable roots of 88-90% and self-coloured roots of 92-94%. It is good source of antioxidants and rich in anthocyanins (265-285 mg/100 g) *i.e.* able to produce anthocyanins to the tune of 60-65 kg/ha.

Maintenance breeding of varieties Kashi Krishna and Kashi Arun are being done by producing nucleus seed (3 kg each) in flexible nylon-net cage. Furthermore, ten population of cross between temperate and tropical carrot has been advanced in next generation to combine the traits of temperate carrot (dark orange colour, smooth and scar free roots) in tropical genotypes. Total 84 genotypes/accesions of various coloured carrots are being maintained at this institute. To transfer petaloid-CMS system for facilitating heterosis breeding, 15 back-cross populations have been advanced to various stages (BC_1F_1-BC_4F_1) in red, black, orange, rainbow and yellow coloured carrots.

Radish

Seventy-two promising lines/varieties/germplasm/hybrids have been evaluated and characterized for various traits such as leaf morphology (lyrate, sinuate and entire), root colour (white, red and purple), root shape (tapering and blunt), heat tolerance and flower colour (white, purple and dark purple). During winter season, the following eleven genotypes were found to be promising for yield and root quality traits *i.e.* Kashi Mooli-40 (VRRAD-203, IC-0625066), VRRAD-200, VRRAD-202 and VRRAD-216 (white root); Kashi Lohit (VRRAD-131-2, IC-0619131), VRRAD-170, VRRAD-171 and VRRAD-173 (red root); and VRRAD-131, VRRAD-134 and VRRAD-151 (purple exterior). However, in summer trial (2018), amoung six genotypes and three hybrids, highest root yield (220-350 q/ha) were harvested for VRRAD-200, Kashi Mooli-40, VRRAD-13×VRRAD-200 and VRRAD-201×VRRAD-200 during mid-April to May harvesting. Additionally, Kashi Mooli-40 showed delayed bolting habit during winter season and spring trials. Two varieties namely Kashi Lohit (Red root) (Fig. 46) and Kashi Mooli-40 (Heat tolerant) have been released and notified for Uttar Pradesh state. Kashi Lohit is a variety with attractive red coloured root, biomass yield potential of 600-700 q/ha), high in anthocyanins (39.9 µg/g FW) and phenolic content (30.3 mg/100g FW), good source of vitamin-C (32.3%), and high antioxidant activity (99.4%). Kashi

Fig. 46: Kashi Lohit (VRRAD-131-2)

Mooli-40 develops root at 38-42 °C temperature, hence suitable for summer sowing having higher root yield (22-26 t/ha) during mid-April to mid-May harvesting. Roots are attractive white in colour, long and icicle in shape, ready to harvest in 40-50 days after sowing, and tolerant to pithiness and bolting i.e. suited to longer field stay after root development.

CMS and hybrids in radish: For developing robust Ogura-CMS lines in radish, 17 back-cross population have been advanced to various stages (BC_1F_1-BC_6F_1) in different backgrounds (leaf morphology, root colour, root shape and heat tolerance) to harness heterotic potential. Four Ogura-CMS lines *i.e.* VRRAD-11, VRRAD-13, VRRAD-198 and VRRAD-201 have been developed through back-crossing which are very similar to their respective maintainer for leaf morphology; plant growth habit; colour and shape of root; flowering; and seed maturity. Six best promising CMS-based F1 hybrids namely VRRAD-11×VRRAD-203 (Fig. 47), VRRAD-201×VRRAD-203, VRRAD-201×VRRAD-216, VRRAD-201×VRRAD-90, VRRAD-13×VRRAD-200 and VRRAD-201×VRRAD-200 with different leaf morphology, root shape, sowing season and yield potential have been identified and the parents are ready for commercial use.

Maintenance breeding of four varieties (Kashi Shweta, Kashi Hans, Kashi Lohit and Kashi Mooli-40), and four CMS lines/Maintainers are being done by producing nucleus seed (100-2000 g each) in flexible nylon-net cage. Total 98 genotypes/accesions of white/red/purple radish are being maintained at this institute.

Fig. 47: CMS based F1 Hybrid (VRRAD-11×VRRAD-203)

Project 1.13: Biotechnological interventions

Optimization of *Agrobacterium* -mediated genetic transformation of cauliflower (*Brassica oleracea L. var.botrytis*): Seeds were surface sterilized by rinsing with 70% (v/v) ethanol for 2 min followed by treatment with 0.1% (w/v) mercuric chloride for 1min. and inoculated onto half-strength and incubated in darkness at 25 ± 2°C for germination. Shoot induction was observed on MSB5 medium supplemented with 4.5 µM TDZ with 0.5 µM NAA. 10-12 days old seedling derived leaves were used as explants for transformation. Leaves were cut approximately 1 cm^2 avoiding the mid-vein with a cut edge on each side and were cultured as abaxial side facing the medium. The factor which influence genetic transformation and the overall gene transfer efficiency such as effect of explant age, different regimes of plant growth regulators, initial selection pressure, preculture period, *Agrobacterium* cell density in the inoculum and co-cultivation period were optimized. The first two parameters have been standardized during regeneration study. Calli were induced from leaf explants grown on MSB5 medium supplemented with 9.1 µM TDZ with 0.5 µM NAA (Fig. 48). In order to determine the appropriate concentration of selection agent for effectively screening transformed shoots, leaf explants were cultured on callus induction medium (CIM) supplemented with different concentrations of kanamycin (25-100 mg/l). For screening of each concentration of kanamycin, 50 explants were used. At 25 mg/l, 30% and at 50 mg/l, 18% callus induction was noted. Further increase in kanamycin concentration (100 mg/l) completely inhibited callus induction. The effect of pre-culture (1- 6 days) on the frequency of transformation in *B. oleracea* was examined on MS medium supplemented with 9.1 µM TDZ with 0.5 µM NAA. On bacterium inoculation, preculture for one day resulted in 96% death of explants. Two days of pre-culture improved to some extent, but 80% explants turned to necrotic after five days of culture. Similarly, three days resulted in 70% death of explants Four days of pre-culture resulted in survival of 45% explants after inoculation. Five or six days of preculturing resulted into bulging at the cut ends of explants which might have inhibited incorporation of *Agrobacterium*. Thus, four days of pre-culturing of explants was found to be favorable for transformation. The duration of the co-cultivation period with bacteria

a) Leaf explants on SIM b) Shoot elongation on SIM

Fig. 48: Shoot induction in 9.1 µM TDZ with 0.5 µM NAA and kanamycin

affected the infection frequency. Optimum no. of days (1-6) required for the co-cultivation of explant for transformation was optimized. Extended cocultivation (4-6 days) increased the transformation efficiency and longer co-cultivation periods frequently resulted in *Agrobacterium* overgrowth and subsequent death of explants. Co-cultivation for four days was found to be suitable for the genetic transformation.

Assessment of cross transferability of cotton (*Gossypium* spp.) SSR markers in okra (*Ablemoschus* spp.): To access the magnitude of cross transferability of the cotton SSR in okra, the SSR markers from cotton was chosen for validation. A total of 65 SSRs showing amplification across all the species of cotton was selected from the Yu *et al*. 2012. These primers were amplified through PCR as per the specifications provided by Yu *et al*. 2012. The cotton was also used a source of DNA for checking the proper functioning of the synthesised primers. All the primers showed amplification on cotton DNA, while only 4 of the primers amplified in okra, giving around 6% of cross transferability of cotton SSRs in okra. This low rate of transfer of SSRs from cotton to okra suggest that there is a need for development of SSR markers specific to okra, that too should be derived from its own genome.

Molecular characterization of Okra Enation Leaf Curl Virus

Infectivity of partial tandem repeats (VA and Vβ) of OELCV Varanasi: Partial tandem repeats of OELCV Varanasi (OVA) (GenBank Accession MK728952), and OELCB (OVβ) were constructed in pCambia 2300 vector separately and were mobilized into *Agrobacterium tumefaciens* (strain EHA-105). Okra plants co-inocluated with OVA and OVβ exhibited symptoms like leaf crinkling and enation on underside of leaves after 25 dpi (Fig 49).

Mock OVA OVA + OVβ

Fig 49: Symptom expression in test plants okra (*Abelmoschus esculentus*) seedlings following inoculation with OELCV Varanasi (OVA) alone and with associated betasatellite (OVA + OVβ). The photographs were taken at 35 dpi.

Detection of Viral DNA by real-time PCR: Real-time PCR assay was performed to detect and quantify the virus in agro-inoculated okra plant.

In okra plants, amplification plot exhibits C_T value 21.18 when inoculated with OVA alone and viral copy number was found to be $1.43x10^4$ per 100 ng of total DNA. While okra plants inoculated with OVA + OVβ, C_T value was observed 20.69 with viral copy number $2.55x10^4$ per 100 ng of total DNA. Hence, OVA when co-inoculated with OVβ caused significant increase in accumulation of helper virus produce symptoms compared to the plant inoculated with OVA alone.

RNA interference-based resistance in transgenic okra plants against Okra *Enation Leaf Curl Virus* (OELCV) and its associated betasatellite: The clone of *Okra enation leaf curl beta* was used as template for PCR amplification of βC1 gene for further analysis.

Primer Designing

a) The sequence of the OELCV βC1 gene was retrieved from OELCB full sequence

b) *Primer3 i.e.* Primer designing tool used to design the primers of interest.

Forward and reverse primers were tagged with *Bam* H1 site and *Sal* 1 site at the 5'ends and 3'ends respectively. These primers were synthesized from IDT.

Cloning of βC1 gene of OELCB in pJET 1.2 and pENTR1A vector vector: Further, for gateway cloning, the PCR amplified products cOELβC1 and nOELβC1, were cloned into pJET1.2 vector through PEG mediated ligation and transformed in *E.coli* DH10β competent cells. The confirmed pJET:cOELβC1 and pJET:nOELβC1 clones were separately double digested with restriction endonuclease enzymes, *BamHI* and *Sal I* and were introduced independently between att site (*attL1* and *attL2* recombination sites) of pENTR1A vector. The true colonies were obtained due to the disruption of the ccdB gene and chloramphenicol resistance marker of pENTR1A vector. The recombinant clones pJET:cOELβC1 and pJET:OELβC1 were confirmed by PCR and sequencing.

Recombinational cloning of βC1 gene in gateway binary vectors ; The gateway expression clones pGWB408:cβC1 with 6xHis tagged at its c-terminal were obtained by recombinational cloning between pENTR1A:cβC1 and pENTR1A:cβC1 with pGWB408 vector using clonase enzyme. Similarly, the gateway RNAi clones pANIC8B:cβC1 with GUS linker were obtained by recombinational cloning between pENTR1A:cβC1 and pANIC8B vector using clonase enzyme. Further, the orientation and presence of cβC1

insert was confirmed by PCR using 35sCMV forward primer and gene specific reverse primer (Fig. 50). All clones pGWB408:cβC1 and pGWB409:nβC1 were independently transformed in *A. tumefaciens*.

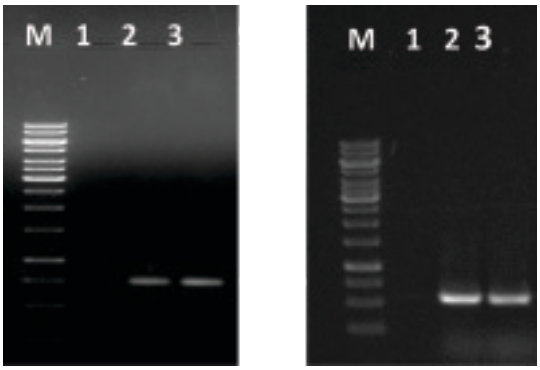


Fig.50: Recombinational cloning of c-terminal βC1 genes in pGWB destination vectors. Colony PCR amplification of cBβC1 from pGWB408:cBβC1 (Lane 2) and pGWB441:cBβC1 (Lane 3) from the positive clones

Expression of βC1 gene in *model plant:* The βC1 gateway expression clones, pGWB408:cβC1 and pGWB409:nβC1, were Agro-inoculated in *N. benthamiana* alone and with their respective wild helper virus OELCV. OELCB was also co-inoculated with their respective helper virus OELCV as control through agro-infiltration. The plants co-inoculated with helper virus OELCV + pGWB408:cβC1 and OLCV + pGWB409:nβC1 separately showed similar symptoms crumpling of leaves, upward curling of leaves, vein clearing, vein thickening, and stunted growth like those plants inoculated with wild type (OELCV+OELCB). Disease symptoms on these inoculated plants appeared at 7th dpi as crumpled leaves and symptom progressed with time. Hence, the symptoms induced by transiently expressed βC1 effector inoculated with its helper virus showed similar appearance and severity as the plants inoculated with wild betasatellite and its helper virus. The plants inoculated separately with only gateway expression clones pGWB408:cβC1 and pGWB409:nβC1 showed no viral disease symptoms although some plants develop deformities on leaves at the 7th dpi which gradually disappears after the 17th dpi. The result also showed that the c-terminal and n-terminal effector has no distinct effect on the symptom induction or determination indicating that the middle portion of the effector plays an important role as a determinant of symptom induction. The result confirms that βC1 effector acts as a symptom determinant in Okra enation leaf curl disease (Fig. 51). The RT-PCR amplification detected βC1 in all the combination irrespective of the presence of its helper virus. This implies that *βC1* was constitutively expressed in the plants and that it requires helper virus for systemic symptom induction.

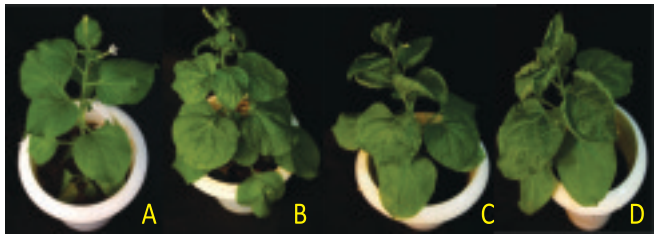


Fig. 51: Transient expression of βC1 gene of OELCB in *N. benthamiana*. (A) Mock plants; (B) Plants co-inoculated with viral DNA (OELCV) and its associated betasatellite, OELCB. Plants co-inoculated in combination of wild helper virus with (C) pGWB 408:c*βC1* and (D) 409:nβC1 clones. Photographs taken at 35th dpi.

DNA probes for rapid detection of OELCV in host plants

PCR conditions: DNA was extracted from okra plants with modified CTAB protocol (previously reported) was used for okra DNA extraction. Extracted DNA of plant was used to detect the presence of viral DNA by PCR. A pair of degenerate primers OlmVF (GATCGACGACCGACAGATAAAC) and OLmVR (GTACCGATCCCTATGCATGTTC) were used. PCR reaction was set in 25 µl of total reaction mixture which was consist of 2.5 Units of Taq polymerase, 2 µl 10x PCR reaction buffer, 1 µl of 10 mM dNTPs, 0.2 µl of reverse and forward primers rest of 25 µl volume maintained by sterilized distilled water (SDW). PCR products about 105bp were observed on 1% agarose gel on transilluminator by comparing 100bp ladder (Fig. 52).

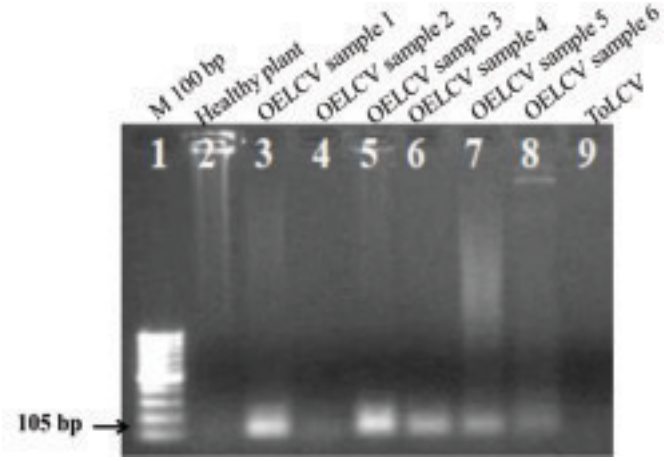


Fig 52: Ethidium bromide stained 1% agarose gel electrophoresis showing amplification of OELCV using specific primers. Lane1 100bp DNA ladder Lane 2, -ve control Lane 3-8 contains OELCV samples and Lane 9 ToLCV

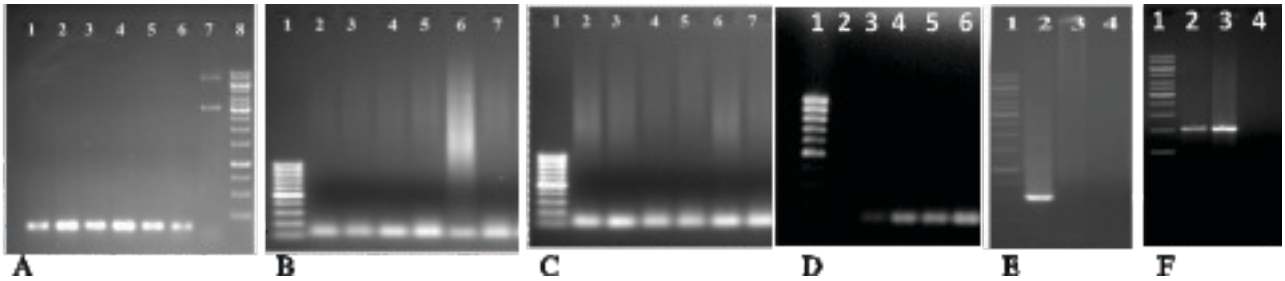


Fig 53: Ethidium bromide stained 1% agarose gel electrophoresis showing PCR amplification of begomovirus using species specific primers. (A) *Chilli Leaf Curl Virus* specific primer; (B) *Tomato Leaf Curl Gujarat Virus* specific primer; (C) *Tomato Leaf Curl New Delhi Virus* specific primer; (D) *Tomato Leaf Curl Karnataka Virus* specific primer: (E) *Tomato Leaf Curl Palampur Virus* specific primer (F) *Radish Leaf Curl Virus* specific primer

PCR based detection of ChiLCV, ToLCGV, ToLCNDV, ToLCKV, ToLPMV and RalCV in host plants; For PCR based detection of ChiLCV, ToLCGV, ToLCNDV, ToLCKV, ToLPMV and RalCV in host plants the specific primers of respective viruses are been designed. To confirm the presence of respective viruses in plant the total DNA was isolated. A pair of virus specific primer were used. The amplified PCR product was run on 1% agarose gel with 1kb ladder and bands appearance were examined on trans-illuminator (Fig. 53).

***In-planta* transformation in okra:** Independent, in-planta transformation of okra in the cultivar Kashi Kranti was repeated. For *Agrobacterium* mediated in-planta transformation, a vertical cut was made at the junction of cotyledonary leaves, superficially along the length of the shoot apex, partially bisecting the shoot tip and exposing meristem cells, without damaging the apical meristem. A total of 89 seedlings were raised from 3 T1 events in pots under containment proof insect house and 20 days old seedlings were sprayed with 100 mg/l of kanamycin. 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 and subjected to PCR for confirmation of *npt II* gene using *npt II* specific primers. None of the events showed any amplification with *npt II* specific primers only positive control amplified. Hence, 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 2500 seedlings transformed and the presence of *npt II* gene confirmed in 20 T0 events.

Genome editing in Okra: CRISPR/Cas9 mediated genome editing work in okra was undertaken to progress the work towards the development of coat protein construct for plant transformation. The guide RNA construct targeting replicase (rep) and coat protein (cp) gene of *Okra Enation Leaf Curl Virus* (OELCV) was artificially synthesized. The target region of replicase and coat protein gene was identified manually from a conserved sequence by multiple sequence alignment of major strains of OELCV to achieve broad spectrum resistance. Complementary gRNA oligonucleotide pairs will be annealed and cloned into pORE-04 vector by Ligation (Fig 54).

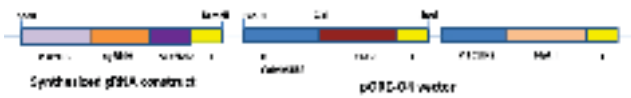


Fig. 54: Complete construct in pORE-O4 vector

Genome editing in tomato; To create durable resistance in tomato against ToLCV disease, two host genes were targeted for genome editing by using CRISPR/Cas-9 technology. The prediction site *http://crispor.tefor.net/* was used to design gRNA sequences targeting coding sequences near the 5' ends of the target genes. For each gene, two gRNAs were designed. Complementary gRNA oligonucleotide pairs will be annealed and cloned into pCR3-EF / Pentr-Topo vector by Golden Gate Ligation.

Construction of high-density genetic linkage map using mapping population of RILs in eggplant (*Solanum melongena* L.): From the previous studies for detection of polymorphic markers between Ramnagar Giant (*S. melongena*) and W-4 (*S. incanum*), total 1,443 different molecular markers (23 RAPD, 10 ISSR, 37 SCoT, and 212 SSR) were screened out of which 282 were confirmed to be polymorphic. These markers were further genotyped for the mapping population of 114 F_8-RILs. Based on genotyping information, a genetic linkage map with LOD threshold ≥4 spanning 1,165 cM of the eggplant genome with an average marker density of 4.13 cM was constructed using JoinMap 3.0 software.

The linkage map was clustered into 12 tentative linkage groups (LGs), and the map distances were calculated using the Kosambi map function. The results obtained from this study shall be used in mapping QTLs for traits of horticultural importance in eggplant. All the markers sufficiently covered entire eggplant genome to ensure that no effective QTLs would be missed in future studies. Moreover, the molecular markers used in the present study exhibit great potential for linkage mapping and their association with qualitative as well as quantitatively inherited characters in eggplant.

Diversity analysis and validation of powdery mildew linked markers in pea germplasm: With the objectives to assess the diversity present in pea genetic resources at IIVR, a set of 88 SSR markers were adopted from literature covering the various linkage group. Among these 88 markers, 45 markers were found to show monomorphic banding pattern, however the markers *viz*., *PSMP5, AA205, PEA 251, PEA 402, c5DNA met, AnMtL6, PSMPA9, PEA120, PEA132, PEA143, Psat7598, AA92, AA372, AD83, AA 339, AA135, AA90, AA206, AA5, Fw_Trap_480, Fw_Trap_340, AD 73, AD60* and *AB146* were found polymorphic and were able to distinguish the 48 genotypes of garden peas at molecular level. Further, several DNA markers (*PSMPSAD60, PSMPSAA374, PSMPA5* and *ScX171400* etc.) have been found linked to powdery mildew resistance genes *er*1 and *er*-2. The validation work of these markers is in progress.

Project 1.14: Genetic Improvement of Underexploited and Future Vegetables

Winged bean

Germplasm augmentation characterization and seed multiplication: With the aim to identify the Winged bean germplasm lines suitable for vegetable purpose, a total of 8 new accessions of winged bean *viz.* EC-918081, EC-918082, EC-918083, EC-918084, EC-918085, EC-918086, EC-918087, and EC-918088 were augmented from USA. These lines were characterized for various horticulture traits and seeds were multiplied for next season. Genotypes EC-918085 and EC-918086 could not survived. Remaining genotypes were characterized for different horticultural traits *viz*., pod colour (light green, green, dark green, purple-green colour and dark purple colour), average number of pod per cluster (2- 2.3), days anthesis (76-106), days to anthesis (15-21), pod length (13.6 -24.0 cm), average pod weight (13.1-26.1g), average pods per plant (20.0-49.0) pod yield per plant (375.0-1170.0 g) and dry weight per pod (1.3-3.6 g). The genotype EC-918082 identified as promising for pod length and dark purple colour (Fig. 55-57)

Fig 55: Genotype - EC-918082 –dark purple fruit

Fig 56:Variability in flowers

Fig 57: Genotype-EC-918087-green fruit

In addition to newly augmented germplasm lines a total of 153 germplasm lines of winged bean (Fig. 58) were also characterized for different horticultural traits *viz*., pod colour (light green, green, dark green, purple-green colour and dark purple colour), average days to anthesis (65-77) , days to edible maturity (15-21), pod length (15.3 -21.3 cm), pod weight (11.95-33.75 g), pod per cluster (1-2.7), pods per plant (85.33-170.0), yield per plant (1050.0-2685.0 g), dry weight per pod (2.5-5.48 g), tuber length (12.2 -26.8 cm), tuber width (1.35 – 2.68 cm), number of tuber per plant (3-14) and tuber yield per plant (300 -1200 g). The genotypes *viz*., VRWB- 29, VRWB- 45, VRWB- 46, VRWB- 56, VRWB- 57, VRWB- 60, VRWB- 71, VRWB- 77, VRWB- 91 and VRWB- 94 were identified as promising for pod yield and genotype VRWB-69 adjudged as promising for tuber traits (Fig. 59).

Fig 58: Overall variability in pods of winged bean

Hybridization: A total of 55 F_1 crosses were attempted to target the traits *viz*., earliness, more

Fig 59: Genotype-VRWB-69- Big size of tuber

number of pods 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-1, EC-918083 X EC-918084, EC-918082 X EC-918081, EC-918082 X EC-918083, EC-918083 X EC-918087 VRWB -24 X VRWB-25, VRWB-16 X VRWB-17, VRWB-4 X VRWB-12, VRWB-28 X VRWB-29, VRWB-9 X VRWB-10, VRWB-69 X VRWB-71, VRWB-13 X VRWB-14, VRWB-42 X VRWB-43, EC-918081 X VRWB-16, EC-918084 X EC-918087,VRWB-47 X VRWB-49, VRWB-21 X VRWB-23, VRWB-29 X VRWB-31, VRWB-5 X VRWB-6, VRWB- 5 X VRWB-7, VRWB-32 X VRWB-33, VRWB-68 X VRWB-69, VRWB-41 X VRWB-42, VRWB-26 XVRWB-27.

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

Molecular characterization of winged bean germplasm through SCoT markers: A total of Seventy five start codon targeted (SCoT) markers were used to assess genetic diversity and population structure of winged bean germplasm lines which were morphologically diverse. Among these, 39 were polymorphic, 25 monophorphic and 11 were not amplified. The validation of polymorphism and associated work is under progress.

Cluster bean

Germplasm collection and evaluation; During 2018-19, three genotypes of cluster bean used for vegetable purpose were collected from South Gujarat. A total of 155 genotypes (including 3 newly augmented genotypes) of cluster bean were evaluated during *kharif* 2018-19 for high yield, earliness, better pod quality and resistant/tolerant to viruses. All genotypes were characterized for important horticultural traits. Significant variation was observed among all the genotypes for plant height (49.3-108.0 cm), number of clusters per plant (4-32.5), number of pods per cluster (3.3-19.2), yield per plot (50-2250 gm) and pod length (4.9-14.2 cm). Highest yield per plot was recorded in VRCB-105 (2250 gm) while maximum clusters per plant were observed in VRCB-24 (32.5). Some of the promising genotypes were VRCB-95, VRCB-96, VRCB 105, VRCB-128 VRCB-47, VRCB-48, Avani-117 and Dilojan 3 for different horticultural traits and disease resistance (Fig 60).

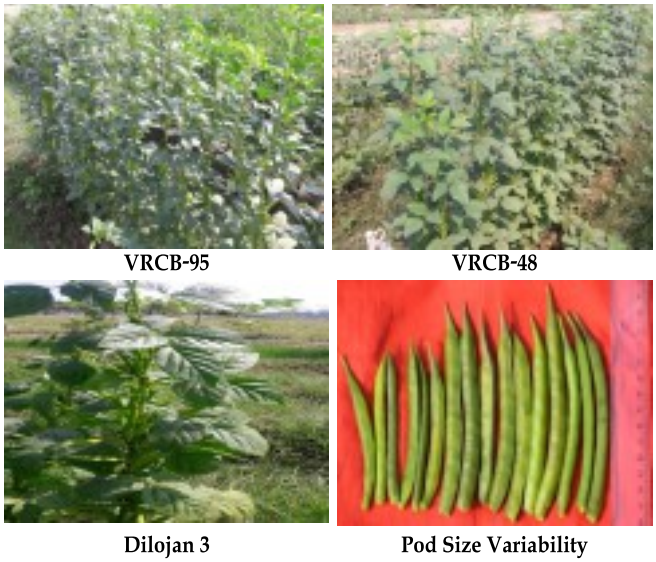


Fig 60: Some promising genotypes of cluster bean and variability for pod size

Population development: 17 F_1 cross combinations developed during in previous season were advanced to F_2 generation for varietal development. These F_1were also characterized for horticultural traits and disease resistance. Apart from this, 20 new F_1 hybrids have been made combining parents for high yield and disease resistance .

Faba Bean

Germplasm evaluation: A total of 115 Faba bean genotypes including one new augmented line (Cherry) were evaluated in augmented design during rabi 2018-19 for yield and horticultural traits. All genotypes were characterized traits like early maturity, high yield, better pod quality and resistant/tolerant to disease. Wide range of variability was observed for all the recorded traits such as days to 50% flowering (58-90 days), plant Height (32-97 cm), number of pods per plant (1-69), pod length (3.74-11.66 cm), pod width (0.64-3.32 cm) and single pod weight (2.4-18.4 g). Maximum number of pods per plant was observed in EC-628934 (97.0) while maximum pod weight was recorded in EC-841555 (18.4 g). EC841533 was earliest flowering genotype (58 days)

Fig 61: Variability for pod size

and EC-841617 had longest pod (11.66 cm). Some promising genotypes were Muradabad-103, EC- 628941, EC- 628921, EC-841776, Cherry, EC-841609, ET-3160 and ET-1107 for yield, varietal purity and disease tolerance (Fig 61). All the genotypes were maintained true to type using nylon bag and successfully harvested.

Vegetable Soybean

Germplasm augmentation and seed multiplication: With the aim to identify the soybean germplasm lines suitable for vegetable purpose, a total of 15 new accessions of vegetable soybean were augmented from World Vegetable Regional Center for South Asia, ICRISAT, Hyderabad. These lines were further characterized for various horticulture traits and seed were also multiplied.

Hybridization: A total of six cross combinations were attempted by utilizing the parental lines viz., AGS-406, *Swarna Vasundhara*, AGS 465, BS-26 and SLB by targeting the traits *viz.*, Non hairiness/less hairs on pod, higher number of pods per plant, yellow mosaic virus (YMV) resistance and low trypsin inhibitors.

Germplasm characterization: A total of 125 genotypes of vegetable soybean were grown and characterized for various horticultural traits during July, 2018. The lines *viz.*, EC-170, EC-172, AGS-339, AGS-406, AGS-447, AGS-457, AGS-459, AGS-460, AGS-461, EC-174, EC-205, EC- 213, EC-218, EC-226, EC-221, EC-227, AGS-328, AGS-423, AGS-429, AGS-430, AGS-456, AGS-466, AGS-469, AGS-472, EC-182, EC-195, EC-202, EC-221, EC-224, EC-227 and EC-219 found earliest for days to flowering (≤35 days). A wide range of genetic variation was observed among genotypes for other horticultural traits. Pod length was found to vary from 2.83 to 5.2 cm, pod width from 0.8 to 1.5 cm, average pod weight from 0.5 to 2.2g, pods per plant from 20.3 to 133.2 (No), 100-green seed weight from 11.9 to 65.1g, plant height from 18.3 to 44.9 cm, and pod yield from 16.9 to 95.8g per plant. Based upon overall performance the genotypes *viz.*, *Swarna Vasundhara*, EC-148, AGS-406, AGS-447, EC-215 and AGS-429 were found superior for pod yield per plant.

Phenotypic Screening for YMV Resistance: In a collaboration programme with ICRISAT, Hyderabad, F_2 population derived from the cross 'AGS-461× SL-95' was grown for YMV screening. Individual plant were tagged for scoring and leaf samples were collected for DNA extraction and marker based screening. However, due to disease escape, phenotypic scoring was deferred to higher generation for which seeds were harvested as single plant progenies.

Water chestnut

Germplasm augmentation and multiplication: With the aim to identify promising water chestnut germplasm lines suitable for vegetable purpose, a total of 6 new accessions viz. VRWC-5, VRWC-6, VRWC-7, VRWC-8, VRWC-9 and VRWC-10 were augmented from different part of the country. These lines were characterized for various horticulture traits and multiplied for next season (Fig. 62).

Fig. 62: Flowering and fruit variation in water chestnut

Germplasm characterization: Ten genotypes of water chestnut grown in Institute were characterized for different horticultural traits *viz.*, average number of leaves per plant, average number of fruit per plant, average leaf length (cm), average leaf width (cm), average fruit pedicel length (cm), number of spine per fruit, average fresh fruit weight (g), average shelled fruit weight (g), dry weight (g), dry matter content (%), TSS (^{0} Brix) and fruit yield /pond (kg). Variation was

observed for many traits *viz.* average number of leaves per plant (26.8-36.4), number of fruit per plant (4-4.8), average leaf length (3.75 - 4.47 cm), average leaf width (5.45- 6.75 cm), average fruit pedicel length (4.5 -5.8 cm), number of spine per fruit (0 - 2.0), average fresh fruit weight (10.75-18.5 g), average shelled fruit weight (5.5 - 12.5 g), dry fruit weight (0.45- 2.7 g), dry matter content (8.18-21.6 %), TSS (1.4- 2.6 ^{0} Brix), and fruit yield per pond (20.5-28.50 kg). Among all genotypes VRWC-1 adjudged as promising genotype for dry matter content and fruit yield. Genotype VRWC-5 was found as spineless and green in colour while genotype VRWC- 6 was found as spineless and red in colour (Fig. 63).

Genotype VRWC-5 Genotype VRWC-6

Fig 63: Variability in water chestnut genotypes

Lotus

Germplasm augmentation and characterization: With the aim to identify the suitability of lotus cultivation in this region, 3 new germplasm lines were augmented from different parts of the country. VRL-1 genotype was found promising for different horticultural traits (Fig. 64). Nursery was raised in pots and lotus plants were planted in pond.

Standardization of vegetative propagation of lotus through stem cutting: Lotus is usually propagated by the seed or division of enlarged rhizomes. Vegetative propagation allows the cloning of superior individuals and enables nurseries to supply uniform planting stock to growers. 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 laborious, and the buds often break vigorously 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. Thus, rigorous studies were undertaken to determine whether lotus could be propagated through some other plants parts than seeds or rhizomes and also their survival rate evaluation. Large number of plants could be raised by stem cuttings for vegetative propagation (Fig. 65). Through this method, we could produce true to characters as of source material within a very short period of time and plant survival rate was also found to be 90%. The present finding encourages for rapid multiplication technique of lotus and proven as easy and most effective method of propagation of lotus over seed / rhizome propagation methods.

Water spinach

Germplasm augmentation: With the aim to identify the promising genotype of Water spinach, 03 new germplasm lines *viz.* VRWS-23, VRWS-24, VRWS-25 were augmented from different parts of country. These lines were characterized for various horticultural traits and crop plants were multiplied for next season.

Germplasm characterization : A total of 25 germplasm lines of water spinach were characterized

Lotus plant in pond | Harvested lotus rhizome | Rhizome harvesting | Ripened seed of lotus | Anther and stigma of lotus

Fig. 64: Different plant parts of lotus (VRL-1)


Cutting -preparation


Planting of cutting


Plants developed through stem cutting


Flowered plant propagated by stem cutting

Fig 65: Lotus propagation technique of Stem cutting

for different horticultural traits *viz.*, leaf length (3.28-10.5 cm), petiole length (3.5-5.0 cm), leaf width (1.5- 7.5 cm), number of vine/plant (3.0- 4.8), vine length (50.0-90.0 cm), internodal length (3.0 -7.5 cm), number of nodes / vine (8-14), number of cuttings /month (2-3) and fresh weight of 50 leaves (35.0- 75.0 g). The genotypes VRWS-1 (Fig. 66), VRWS-4, VRWS-8, VRWS-9, VRWS-23, VRWS-24 and VRWS-25 were found to be promising for different horticultural traits. Result on field cultivation of water spinach was found encouraging (Fig. 67).


Fig. 66: Promising genotypes of water spinach (VRWS-1)

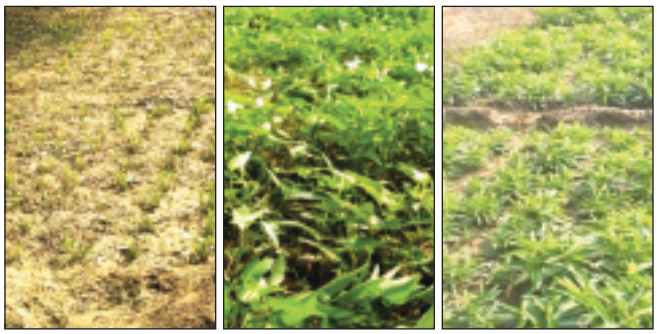


Fig 67: Cultivation of Water spinach in field condition.

Baby corn and Sweet corn

Germplasm maintenance: Thirty six sweet corn inbreds and fifty six baby corn inbred lines were maintained.

Hybridization programme: Crosses were made to develop ten baby corn and ten sweet corn hybrids. Resistant breeding programme for banded sheath and leaf blight disease (BSLB) was initiated by crossing resistant line IIVRBC-13 with susceptible sweet corn and baby corn inbred lines. Around 15 F_2 plants of baby corn hybrid were advanced to F_3 generation.

Biochemical analysis of BSLB resistant and susceptible inbred lines; Biochemical analysis was done in IIVRBC-13 (resistant), CML-323 (moderately resistant) and in IIVRBC-19 (susceptible) inbred lines. Resistant inbred line (IIVRBC-13) contains the highest and susceptible line (IIVRBC-19) contains the lowest total phenol content. The phenol content in moderately resistant line (CML-323) was slightly higher than inbred line IIVRBC-19 and considerably lesser than IIVRBC-13.

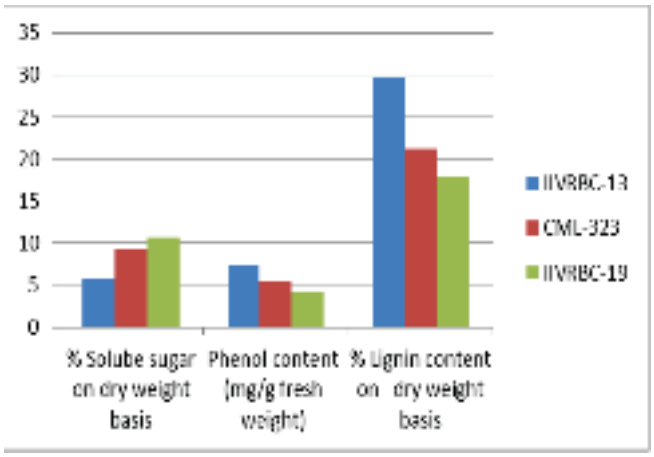
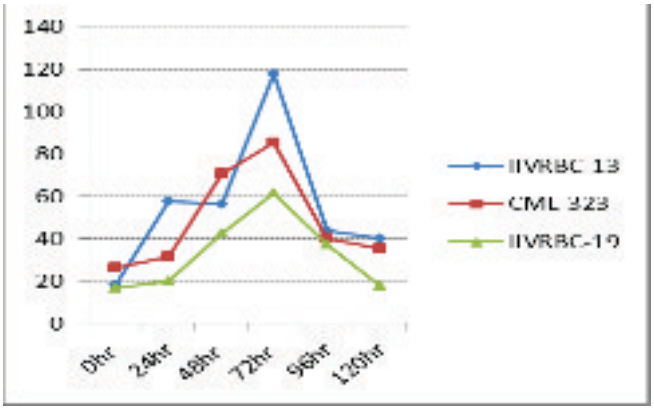


Fig. 68: Variation in total phenol, lignin and sugar contents in the three inbreeds namely IIVRBC-13, CML-323 and IIVRBC-19

Similarly, IIVRBC-13 contains the highest amount of % lignin content among the three lines tested. The lignin content in moderately resistant line (CML-323) was higher than susceptible inbred line IIVRBC-19 and lesser than resistant inbred IIVRBC-13 (Fig. 68). Higher total phenols and lignin content in the resistant line may be contributing towards resistance against banded sheath and leaf blight pathogen. The susceptible germplasm (IIVRBC-19) has the highest content of total sugar. This may favour better and quick establishment of the pathogen in IIVRBC-19.

Response of defence related enzymes peroxidase and polyphenol oxidase: After infection, Peroxidase activity increases with time up to 72 or 92 hrs post inoculation then its activity starts declining. Relative increase in enzyme activity is higher in resistant IIVRBC-13 and lesser in susceptible IIVRBC-19. But the quantum jump in increase is very high in resistant and moderately resistant germplasm in comparison to susceptible. Similar is the response of the polyphenol oxidase activity but the increase is quit linear in comparison to the peroxidase enzyme activity (Fig. 69).



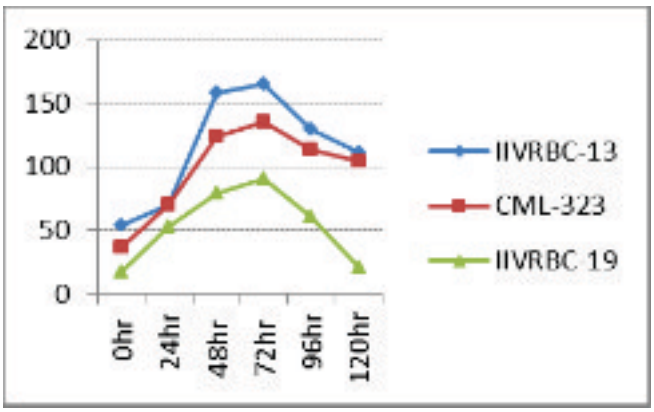


Fig 69: Peroxidase activity (µmol min^{-1} mg^{-1}) & Polyphenol oxidase activity (µmol min^{-1} mg^{-1})

Protein content: In inoculated condition, percent protein on dry weight basis was very low in susceptible genotype IIVRBC-19 in comparison to other genotypes in the study. During disease progression with time the resistant and the susceptible genotype showed opposite trend in percent protein on dry weight basis. In both resistant and moderately resistant genotype the protein content showed upward trend whereas in susceptible genotype a downward trend was observed (Fig. 70).

Electrolyte leakage: During the initial infection period electrolyte leakage increased in all the inbred lines and its increase was continuous in the susceptible genotype. Forty eight hours after inoculation, resistant germplasm started recovery and electrolyte leakage reduced considerably (Fig. 71).

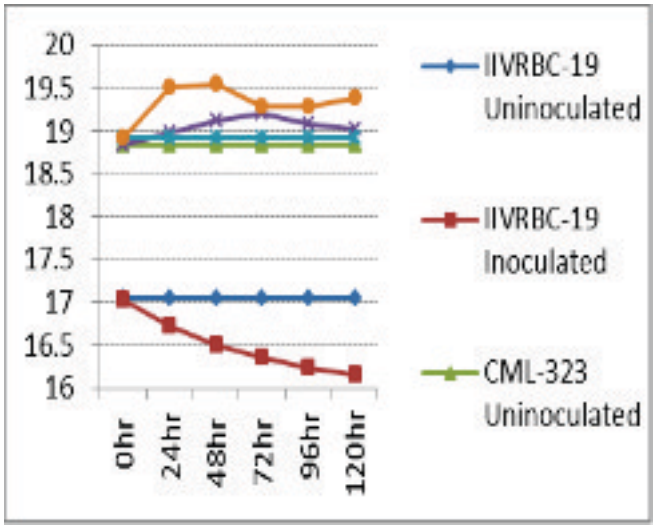


Fig. 70 : Variation in percent protein on dry weight basis and changes in its content with time after disease inoculation.

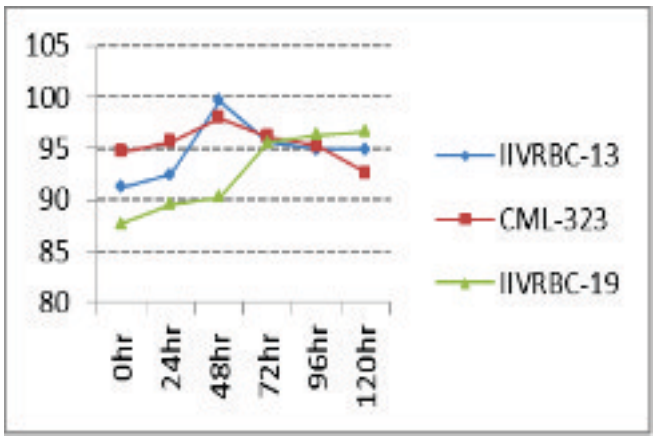


Fig 71. Electrolyte leakage (conductivity- µS/cm)

Bathua (Chenopodium album)

Seven genotypes/varieties of leafy chenopods were evaluated. Biomass yield of three varieties namely Kashi Bathua-2 (VRCHE-2, green leaves), Kashi Bathua-4 (VRCHE-4, purplish-green leaves) (Fig. 72), and Pusa Bathua-1 (purplish-green leaves) was realized 390, 458 and 349 q/ha, respectively in five pickings. The corresponding plant growth of Kashi Bathua-2, Kashi Bathua-4, and Pusa Bathua-1 at different stages was measured 21.3, 21.7 and 19.3 cm at 40 DAS; 42.5, 48.1 and 40.7 cm at 80 DAS; 143.5, 151.7 and 128.4 cm at 120 DAS; and 190.4, 221.7 and 175.3 cm at 160 DAS.

Fig. 72: Kashi Bathua-4

Fig. 73: VRPLK-2

Two varieties i.e. Kashi Bathua-2 (VRCHE-2) and Kashi Bathua-4 (VRCHE-4) have been released and notified for UP state, and both entries are also in the multi-location varietal trial (AVT-II) of AICRP-VC. Kashi Bathua-2 is nutritionally rich and high yielding (36.7 t/ha) variety having luxuriant plant growth, green leaf and petiole colour, waxy leaf pubescence, 15.2% dry matter, and excellent source of vitamin C (21.2% higher), phenolics (30.0% higher) and antioxidants (43.1% higher). Maintenance breeding is being done by producing basic seed of both varieties (5-6 kg of each). Further, Kashi Bathua-4 is a high yielding (40.7 t/ha) variety having luxuriant plant growth; purplish-green leaf and petiole colour; waxy leaf pubescence; green stem along with pink pigmentation on nodes at early stage of growth, and stem colour turns to complete pink at flowering stage; 16.1% dry matter; excellent source of vitamin C, vitamin A, folic acid and minerals; and good source of vitamin C, phenolics and antioxidants.

Beet leaf (*Beta vulgaris* var. bengalensis)

Twelve genotypes/varieties of beet leaf (Palak) were evaluated for morphological traits and seed multiplied for further evaluation. Biomass yield potential in main season ranged from 345-722 q/ha and 310-624 q/ha during 2017-18 and 2018-19, respectively. The best performing genotype 'VRPLK-2' was compared with popular variety i.e. All Green in three dates of sowing namely late-August, late-September and late-October. The biomass yield of VRPLK-2 (Fig. 73) was harvested 914 q/ha in late-August, 885 q/ha in late-September and 624 q/ha in late-October sowing correspondingly in 9, 8 and 6 cuttings which is 65.2%, 36.9% and 54.4% higher than check variety All Green, respectively. Further, VRPLK-2 showed delayed bolting habit i.e. 25-30 days late as compared to All Green. Seed of VRPLK-2 are being multiplied (15 kg) for multilocation testing. A sum of 19 accesions of beet leaf are being maintained.

Amaranth

Evaluation of germplasm: During 2018-19, a total of 165 germplasm including checks (Pusa Lal chaulai, Pusa Kirti and Pusa Kiran) were evaluated in augmented block design. Each germplasm was maintained through selfing using three ring muslin cloths. Observations were recorded for 16 horticultural traits. Based on growth habit the germplasm can be classified into two types *i.e.* erect and prostrate. Based on stem colour, it can be classified into four classes i.e. light green, light purple, medium purple and purple. Based on leaf colour these genotypes can be grouped in six classes i.e. light green, green, dark green, light purple, purple and dark purple (Fig 74). Vigour scoring ranged from 1-5; indicated low to high vigour and insect scoring ranged from 1-4 indicating low to high damage by leaf eating insects. The promising genotypes with low insect damage were AM-4A, AM-5, AM-6, AM-9, AM-10, AM-11, AM-13, AM-20, AM-21, AM-27, AM-32, AM-36, AM-41, AM-42, AM-43, AM-61, AM-131, AM-141 and AM-148. Leaf margin among these germplasms are either erect or undulated. Regarding stem and leaf pubescence

Fig 74. Leaf colour variation among the Amaranth germplasms

some of the genotypes were having conspicuous stem pubescence, while in most of them it is absent. In case of leaves, only few possessed pubescence that too on the lower surface of leaves. Days to flowering ranged from 29-90 days. The promising genotypes which are very late in flowering were AM-1, AM-7, AM-8, AM-17, AM-18, AM-19, AM-20, AM-23, AM-28, AM-42, AM-44, AM-45, AM-62 and AM-64A. Leaf length ranged from 3.26 to 12.32 cm. The promising genotypes for leaf length were AM-1, AM-7, AM-14, AM-23, AM-26, AM-28, AM-61, AM-64A, AM-129, AM-131 and AM-376. Similarly, the leaf width ranged from 2.0 to 9.08 cm and the promising genotypes were AM-1, AM-2A, AM-8, AM-9, AM-10, AM-17, AM-18, AM-27, AM-28, AM-42, AM-44, AM-45, AM-61, AM-64A, AM-375. The green leaf yield was also quantified for these genotypes. The yield on per meter row basis ranged from 1.65-6.01 kg. The promising genotypes for this trait were AM-2, AM-2A, AM-8, AM-32, AM-42, AM-44, AM-64, AM-64A, AM-131 and AM-133. The wild and related species of *Amaranthus tricolor* i.e. *A. magnostenus, A. blitum, A. dubious, A. cruentus, A. hypochondriacus, A. Viridis, A. tristis and A. blitumvaroleraceous* were also maintained (Fig 75).

For carrying out the diversity analysis, hybridity test and identification of true to type plants 10 SSR primers namely; AMM-013, AMM-032, AMM-051, AMM-071, AMM-078, AMM-099, AMM-105, AMM-123, AMM-129, AMM-132, AMM-136 and AMM-137 were synthesised from grain amaranth and were validated in our leaf amaranth germplasm. All the grain amaranth SSR primers were showing amplification in the leafy amaranth germplasms giving a transferability rate of 100 % from grain to leafy amaranth.

Fig 75. Morphological characteristics of different Amaranth species

Quinoa

In quinoa a total of 12 genotypes viz. VRQ-1, VRQ-2, VRQ-3, VRQ-4, VRQ-5, VRQ-6, VRQ-7, VRQ-8, VRQ-9, VRQ-10, VRQ-11, VRQ-12 were grown with three rows each. The data for days to 50% flowering, panicle length, number of branches per plant and five plant yield was recorded. All the quinoa genotypes started flowering at 40 days after sowing. Maximum panicle length was recorded in VRQ-1 followed by VRQ-7. The maximum number of branches was observed in VRQ-7 followed by VRQ-11. Maximum five plant yield was recorded for VRQ-1 followed by VRQ-2.

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

Pointed gourd

Status of germplasm: In pointed gourd 122 accessions were maintained at IIVR which included genotypes of various fruit shapes and colour *i.e.,* round, oval, epitical and oblong; green fruited, light green fruit colour; fruits with or without white stripes on the surface and seeded, less seeded or seedless. A total of 10 accessions of 4 different related wild species of pointed gourd were also maintained at IIVR. During 2018-19, nine accessions were collected including three accessions of wild relatives from Odisha and Meghalaya (Fig. 76).

Fig. 76: wild relatives of pointed gourd

Fig. 77: Variation in fruit characteristic in pointed gourd

Evaluation of pointed gourd female clones for yield and its contributing traits: A total of 142 clones of pointed gourd were evaluated during summer and rainy season 2018-2019. There was considerable variation observed for all the traits under consideration (Fig. 77). Fruit yield/per vine ranged from 3.50 to 13.00 kg. With respect to yield/plant and suitability for confectionary purpose VRPG-217 was found to be promising with 13kg fruit yield/vine.

Varieties notified and released by CVRC

Kashi Suphal (IC 599391): Kashi Suphal (Fig. 78) was developed through clonal selection at ICAR-IIVR. It is suitable for commercial cultivation in garden land as well as river bed. It is identified through State Variety Release Committee, Uttar Pradesh and release and notified by CVRC in the year 2018. It has attractive light green fruit colour with mild stripe and slightly tapper at the stem end and blossom end. Fruits are fleshier and contain soft seeds. This variety is capable of fruiting even when temperature goes beyond 40^{0}C. Fruit length and diameter is ranged from 6-7 cm and 2.5-3.0 cm respectively. Yield potential is 190-200 quintal/ha and is suitable for both culinary and confectionary purpose.

Fig. 78: Kashi Suphal

Kashi Amulya (IC 620681): Kashi Amulya is a less seeded unique yield potential improved variety of pointed gourd. It is identified through State Variety Release Committee, Uttar Pradesh and released and notified by CVRC in the year 2018. It has light green fruit with sparsely distributed white stripe. The fruits are

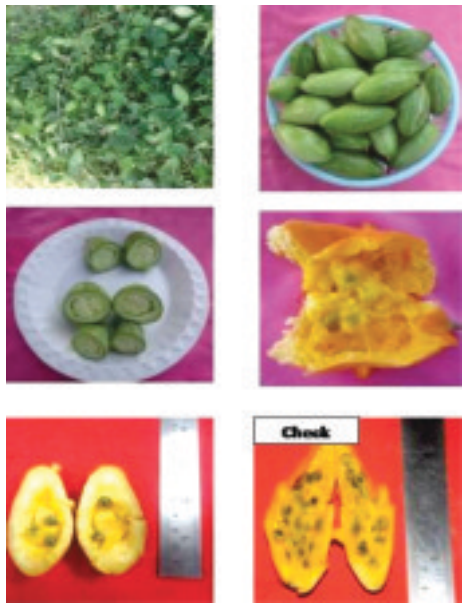


Fig. 79 : Kashi Amulya

tapper towards blossom- end than the stem-end.Fruits of this variety have mild longitudinal groves on the fruit surface. It is less seeded contain only 5-8 seeds/fruit as compare to 20-28 seeds in seeded variety (Fig. 79), which is 76.58% less than checks and more fleshy. Fruits remain at harvestable maturity for longer duration because of less number of seeds/fruit. It is suitable for culinary, stuffing and confectionary purpose. Fruit length and diameter is 7-7.5 cm and 3.0 cm, respectively. Yield potential of this variety is 210 quintal/ha.

Production of planting material and clonal multiplication of selected clones in pointed gourd; About 6000 planting materials of Kashi Alankar, Kashi Suphal and Kashi Amulya were produced and 4000 planting materials distributed to the farmers of Mirzapur, Varanasi, Jaunpur, Sonbhadra, Ghazipur and Barabanki district (Fig. 80). All the selected clones of pointed gourd were clonally multiplied to enhance the plant population. Beside this, approximately 150 planting materials were produced for all the improved clones viz., VRPG-141, VRPG-103, VRPG-05, VRPG-17,

Fig. 80: Production and distribution of planting materials

VRPG-73, VRPG-215, VRPG-216, VRPG-217 and VRPG-85.

Teasle gourd: A total 52 lines of Teasle gourd were characterized for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2018. Significant variability has been observed in germplasm for the traits like node number to first pistillate flower appearance, days to first pistillate flower anthesis, days to first fruit harvest, peduncle length, polar circumference of fruit, length of blossom end, number of fruits per plant, average fruit weight and fruit yield per plant. Based on the initial screening, some of the potential genotypes (Fig. 81) have been identified for various horticultural traits. Maximum fruit yield per plant found in VRSTG-38 (2.44 kg) followed by VRSTG-20 (1.95 kg) and VRSTG- 6 (1.94 kg).

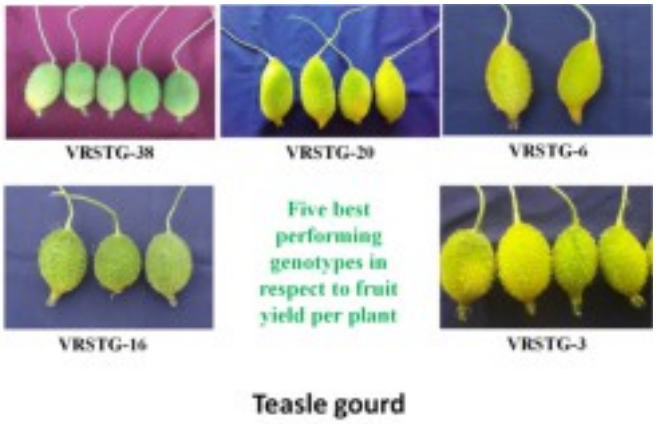


Fig. 81: Five best performing genotypes in respect to fruit yield per plant of Teasle gourd

Spine gourd: Sixteen lines of spine gourd (Fig. 82) were evaluated for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2018. High variability has been observed in germplasm for the characters like node number to first pistillate flower appearance, days to first pistillate flower anthesis, peduncle length, number of fruits per plant, average fruit weight and fruit yield per plant. Based on the primary screening, some of the potential genotypes have been identified for various horticultural traits that are given in Table 31. The genotype VRSEG-14 (2.18kg) gave maximum fruit yield per plant followed by VRSEG-10 (1.81kg) and VRISEG-9 (1.75kg).

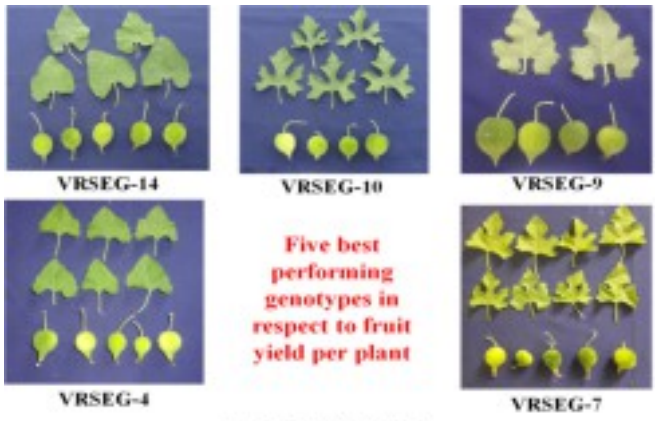


Fig. 82: Five best performing genotypes in respect to fruit yield per plant of spine gourd

Ivy gourd : Fourteen lines of Ivy gourd were collected and evaluated for various horticultural traits at ICAR-IIVR-RRS, Sargatia, Kushinagar, Uttar Pradesh during summer and rainy season, 2018. Significant variability has been observed in germplasm (Fig. 83) for the traits like days to first pistillate flower anthesis, days to first fruit harvest, peduncle length, polar circumference of fruit, equatorial circumference of fruit, number of fruits per plant, average fruit weight and fruit yield per plant. Based on the primary screening, some of the potential genotypes have been identified for various horticultural traits. Highest fruit yield per plant was observed in line VRIG-16 (15.19kg) followed by VRIG-14 (14.78kg) and VRIG-4 (7.95kg).

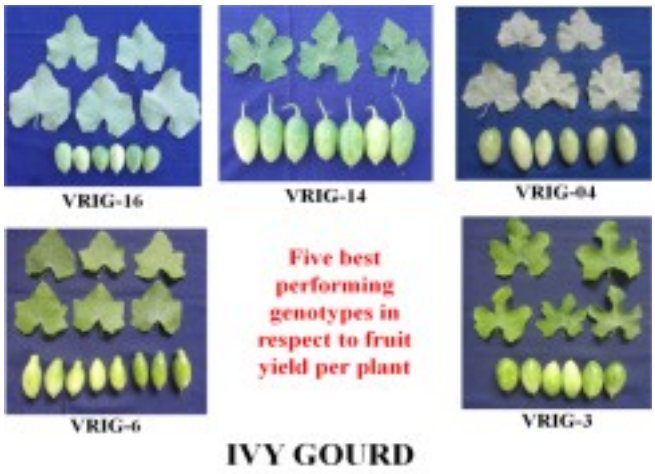


Fig. 83: Five best performing genotypes in respect to fruit yield per plant of Ivy gourd

Characterization of basella genotypes: Basella or Indian spinach or Poi is seed as well as vegetatively propagated crop. During the year 2018-19, 65 basella genotypes were evaluated. Data for fifteen descriptor traits were recorded including yield and yield contributing traits. The genotypes are classified into two groups based on stem pigmentation i.e. red (15) and green (50). Based on growth habit, these genotypes can be classified into bushy (5) and trailing type (60). The

days to flowering among all the germplasm varied from 56-179 days. The promising late flowering genotypes are VRB-4, VRB-17, VRB-10, VRB-21, VRB-28 and VRB-65. Leaf length also significantly varied among the germplasm accessions *i.e.* from 4.58 to 11.88 cm, the long leaf is preferred for high green biomass and promising genotypes are VRB-10, VRB-17, VRB-20, VRB-32, VRB-65, VRB-66, VRB-67, VRB-68, VRB-45 and VRB23-1. Similarly, leaf length was also significantly varying among the germplasm *i.e.* 2.88 to 8.38 cm and the promising genotype with broad leaves are VRB-9, VRB-10, VRB-17, VRB-20, VRB-65, VRB-66, VRB-67, VRB-1, VRB-5, VRB-33 and VRB-32. Spike length, which is the major determinant for the stem biomass was found to be showing huge diversity and ranged from 0.15 – 5.25 m length. The promising genotypes for spike length was VRB-3, VRB-4, VRB-12, VRB-22, VRB-42, VRB-46, VRB-65, VRB-66, VRB-67 and VRB-30. Number of spike per plant also showed huge variation and ranged from 1-118. The promising genotypes with high number of spikes per plant were VRB-3, VRB-4, VRB-12, VRB-16, VRB-21, VRB-22, VRB-39, VRB-43, VRB-50, VRB-61, VRB-61-1, VRB-23-1 and DB-2. Leaf to stem ratio was also showed significant variation among the genotypes *i.e.* 0.47 to 0.97 and promising genotypes with high stem and leaf ratio were VRB-2, VRB-10, VRB-13, VRB-14, VRB-17, VRB-28, VRB-34, VRB-41, VRB-46, VRB-48, VRB-50, VRB-54 and VRB-61. Yield per plot in a plot size of 3 x 2.5 m was found to be 0.55 to 14.5 kg the promising genotypes with higher yield were VRB-2, VRB-3, VRB-4, VRB-10, VRB-13, VRB-17 and VRB-19.

To decipher the genetics of betalain pigmentation in basella fruits, a cross was made between VRB-48-1 and VRB-23. The VRB-48-1 is low betalain pigment carrying line and VRB-23 is high betalain carrying line. The F_1 produced was planted during 2018-19 and selfed to produce the F_2 seeds. The F_1s were showing phenotype similar to the high betalain pigment type parent i.e. VRB-23. These result indicate towards presence of dominant gene in governing the genetics of betalain pigmentation.

Development of rapid screening protocol for screening against collar rot pathogen:

Seven methods were evaluated for their efficiency in transfer and development of suitable screening protocol against collar rot pathogen (Fig. 84) in basella. The methods include, a. mycelial solution drenching without injury, b. mycelial solution drenching with injury, c. attachment of mycelial disc to stem without injury, d. attachment of mycelial disc to stem with injury, e. infested toothpick Insertion at base, f. root dipping in mycelial suspension and g. soil infestation with grains. None of the above motioned method except the infested toothpick insertion method provided more than 10% disease incidence while latter provided more than 90% disease incidence.

Product developed: Three varieties, Kashi Poi-1, Kashi Poi-2 and Kashi Poi-3 were released for cultivation in Uttar Pradesh (S.O. 692 (E) dated 05.02.2019)

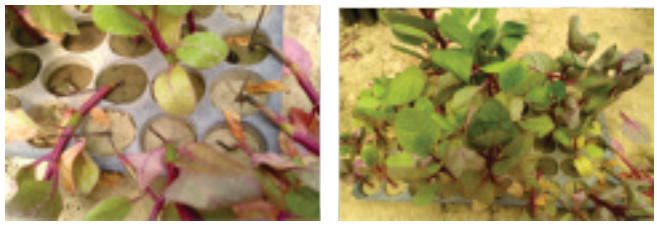


Fig. 84: Charcoal rot infected plants of basella with infected toothpick insertion method.

Selection of annual moringa:

The moringa plants were selected on the basis of the flowering throughout the year except few months of winters. Total 22 plants were selected on the basis of days to flowering. The genotypes were characterized for fruit and yield traits. The promising genotypes were VRMO-17 (Fig. 85), VRMO-16 (Fig. 86), VRMO-21, VRMO-9, VRMO-10, VRMO-12 and VRMO-14 with more than 200 fruits/plant/year. Fruit length among these selections varies from 45.25 to 104.25 cm (Fig. 87). More than 850 fruits were recorded on VRMO-17 selection. These genotypes were further multiplied through vegetative and air layering propagation.

Fig. 85: VRMO-17 plant with fruits (>850 pods/year)

Fig. 86: VRMO-16 plant with fruits

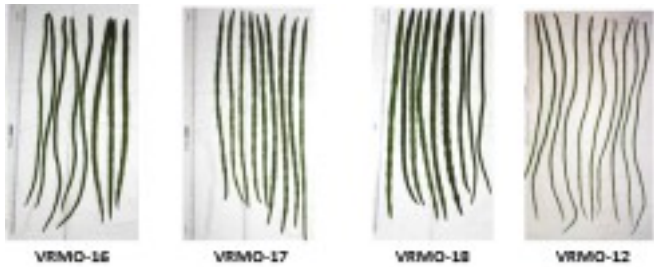


Fig. 87: Variation for fruit morphology among moringa selections

Germplasm supply/distribution from institute to other organizations:

1063 germplasm, promising accessions, released varieties and hybrids and related wild species in 24 vegetable crops were distributed for research and demonstration purpose to various organizations through material transfer agreement (MTA). The crop-wise detail of the number of germplasm supplied to various organizations (Table 15).

Table 15: Germplasm distribution to different organizations

Crop	Recipient Organizations
Tomato (134)	BHU, Varanasi (20), SKNAU, Jobner (20), NABI -Mohali, Punj ab (2), Bihar Agriculture University, Bihar (26), NBRI, Lucknow (1), IGKV, Raipur (3), University of Agricultural & Horticultural Sciences, Shivamogga, Karnataka (13), CCSHAU, Hissar (11), SKAUST, J&K (1), BAU, Bhagalpur (20), Real Agri Creation (2), TNAU, Central University of Gujarat (3), GBPUAT, Pantnagar (2), College of Horticulture & Forestry, Pasighat, Arunachal Pradesh (10)
Okra (178)	BUAT, Banda (40), BCKV, Kalyani, Nadia (2), RARI, Durgapur, Jaipur (3), MGCGVV, Chitrakoot (38), Ruchi Hi-Rich Seed s Pvt. Ltd (4), University of Horticulture, Karnataka (8), M/s Dinkar Seeds Pvt. Ltd. Gujarat (1), CSSRI, Karnal (24), BHU, Varanasi (28), P.G. College, Gazipur (20), AKS University, Satna, M.P. (10)
Brinjal (150)	Agricultural College and Research Institute, Madurai (1), MGCGKVV, Chitrakoot (65), AICRP on Nematodes in Cropping system (30), BBAU, Lucknow (20), University of Allahabad, Allahabad (1) BHU, Varanasi (1), Sumerpur Agriculture university, Jodhpur (30), IISER-Pune (1), SHUATS, Allahabad (1),
Chilli (161)	MGCGKVV, Chitrakoot (30), Ruchi Hi -Rich Seeds Pvt. Ltd (2), AICRP on Nematodes in Cropping system (30), College of Horticulture, Mandsaur (25), SKUAST-Kashmir (46), Real Agri Creation (2), Kalash seeds Pvt. Ltd (1), VCSG, UUHE, Uttarakhand (25)
Carrot (108)	ICAR-NBPGR, Thrissur (61), BBAU, Lucknow (14), BHU, Varanasi (1), SKUAST, Kashmir (32)
Cowpea (20)	SHUATS, Allahabad (20)
Garden Pea (62)	College of Horticulture & Forestry CAU, Pasighat, A.P (16), World Vegetable Center, Hyderabad (15), SVP, University of Agriculture & Technology, Meerut (15), ICAR- NBPGR, New Delhi (1), BHU, Varanasi (15)
Bottle Gourd (40)	MGCGKVV, Chitrakoot (30), BHU, Varanasi (10)
Bitter Gourd (35)	MGCGKVV, Chitrakoot (30), AICRP- Vasanthrao Naik, Marathwada, Krishi, Vidyapeth, Maharastra (5)
Pumpkin (60)	MGCGKVV, Chitrakoot (30), NDUAT, Kumarganj, Faizabad (30)
Cucumber (4)	Tamil Nadu Agricultural University (4)
Ridge Gourd (5)	College of Horticulture, UHS campus, Bengaluru, Karnataka (5)
Summer Squash(1)	SHUATS, Allahabad (1)
Amaranth (10)	Agriculture University, Pusa, Bihar (10)
Muskmelon (1)	Punjab Agricultural University, Ludhiana (1)
Cluster Bean (50)	Dr. Y. S. R. Horticultural University, Venkataramannagudem (50)
Carrot (20)	BBAU, Lucknow (20)
Radish (3)	BBAU, Lucknow (3)
Sponge Gourd (5)	BHU, Varanasi (5)
Snap melon (5)	Tamil Nadu Agricultural University (5)
French bean (10)	AKS University, Satna, M.P. (10)
Dolichos bean (1)	VNR Seeds Pvt. Ltd., Raipur, C.G. (1)

MEGA PROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES

Programme Leader : Dr. P. M. Singh

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

Alleviation of lead (Pb) toxicity through ZnO and Fe_2O_3 nano-particles seed priming in Indian spinach (*Basella* spp.): Soil contamination with various metals has become a global environmental concern. Among them lead (Pb) is a major environmental pollutant and when present in excess in the soil, cause inhibition of plant growth and alteration in its metabolism leading to decline in crop productivity. Anthropogenic activities, mining and smelting of ores, metalworking industries, waste incinerators, cement factories, industrial effluents, automobile exhausts, metal plating and finishing operations, fertilizers, pesticides *etc.* are main sources of these heavy metals to the soil. A study was conducted to observe the effect of lead (Pb) stress on seeds and seedlings of basella and to alleviate its effect through nano particles (NPs; Zn and Fe) seed priming (16 hrs at 25°C). Total of 40 treatment combinations (8 Pb concentration and 5 treatment including NPs priming) were studied. Ten treatment combinations showing contrasting results (P0T3, P2T3, P4T3, P6T3, P7T3, P0T5, P2T5, P4T5, P6T5 and P7T5) are presented in Tables 34, 35 and 36. Results revealed that increasing concentration of Pb (0 to 20 mM) is negatively affecting the germination, root growth and vigour by enhancing H_2O_2 and MDA and by reducing chlorophyll, SOD and Catalase activity. While seed priming with 100ppm ZnO + 100ppm Fe_2O_3 NPs for 16 hrs at 25°C is alleviating the Pb stress by increasing germination, root growth (more secondary roots), RLD (root length density) and seed vigour. This may be due to increased chlorophyll and antioxidant activity (SOD, CAT) and reduced MDA and H_2O_2 content. Therefore, above biochemical changes in NPs primed seeds under Pb stress condition indicated that priming of basella seeds with Zn and Fe NPs could effectively alleviates the Pb toxicity.

Morpho-biochemical changes during seed development, maturation and desiccation tolerance in *Moringa oleifera*: During seed development and maturation, attainment of desiccation tolerance is pre-requisite for seed quality and seed longevity. A study was conducted to examine the changes during seed development, maturation and desiccation tolerance in Moringa. Flowers were tagged and fruits were harvested at weekly interval starting from 14 DAA to 70 DAA. Pod morphology, external and internal structure of seed coat, embryo and embryonic axis (Fig. 88 and 89)

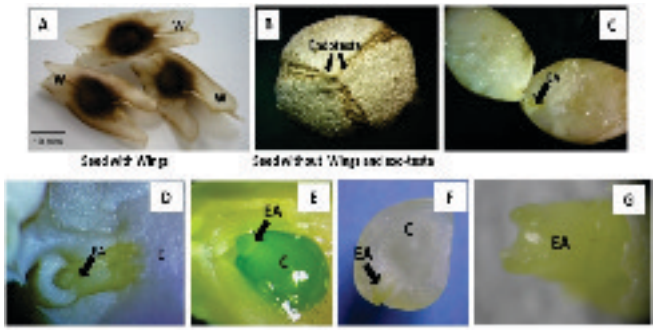


Fig. 88: Seed morphology of Moringa (C- cotyledon, EA- embryonic axis)

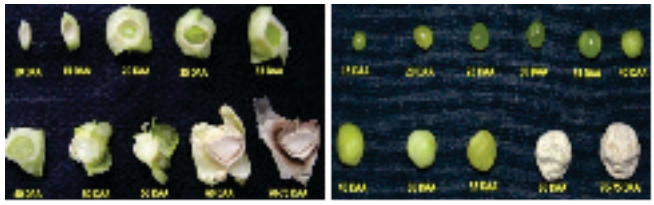


Fig. 89 (A&B): Development of embryo in Moringa

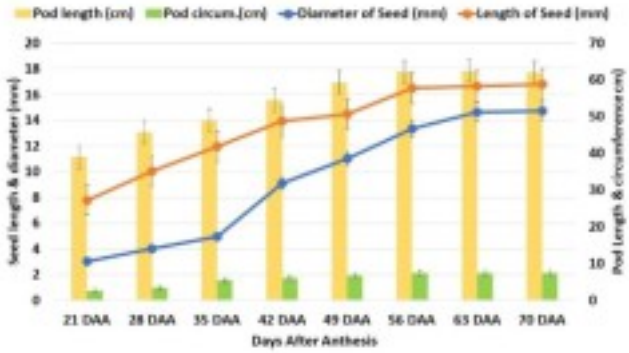


Fig. 90: Morphological changes during pod and seed development in Moringa

and seed quality were studied during seed development and maturation. Results revealed that pod length & diameter, seed length and diameter (Fig. 90), germination (%), dry weight of seedling, seedling length, seed vigour (Fig. 91) seed quality parameter after harvest at different stage, seed quality parameters after subjecting desiccation tolerance study, protein, sugar and oil accumulation followed almost a sigmoidal pattern.

Electrical conductivity, chl-a, chl-b, chl-total, moisture content and seed weight changed in a bell-shaped pattern (Fig. 104). Seed germinability increased with the advancement of seed towards maturity. Seed attained germinability form 49 DAA and desiccation tolerance form 56 DAA. Delay in harvesting (80 DAA) of seed leads to rupturing of pod and shattering of seeds.

Breeder and TL seed production of important vegetable crops: A total of 27075.53 kg vegetable seeds of ICAR-IIVR varieties of tomato, brinjal, chilli, okra,

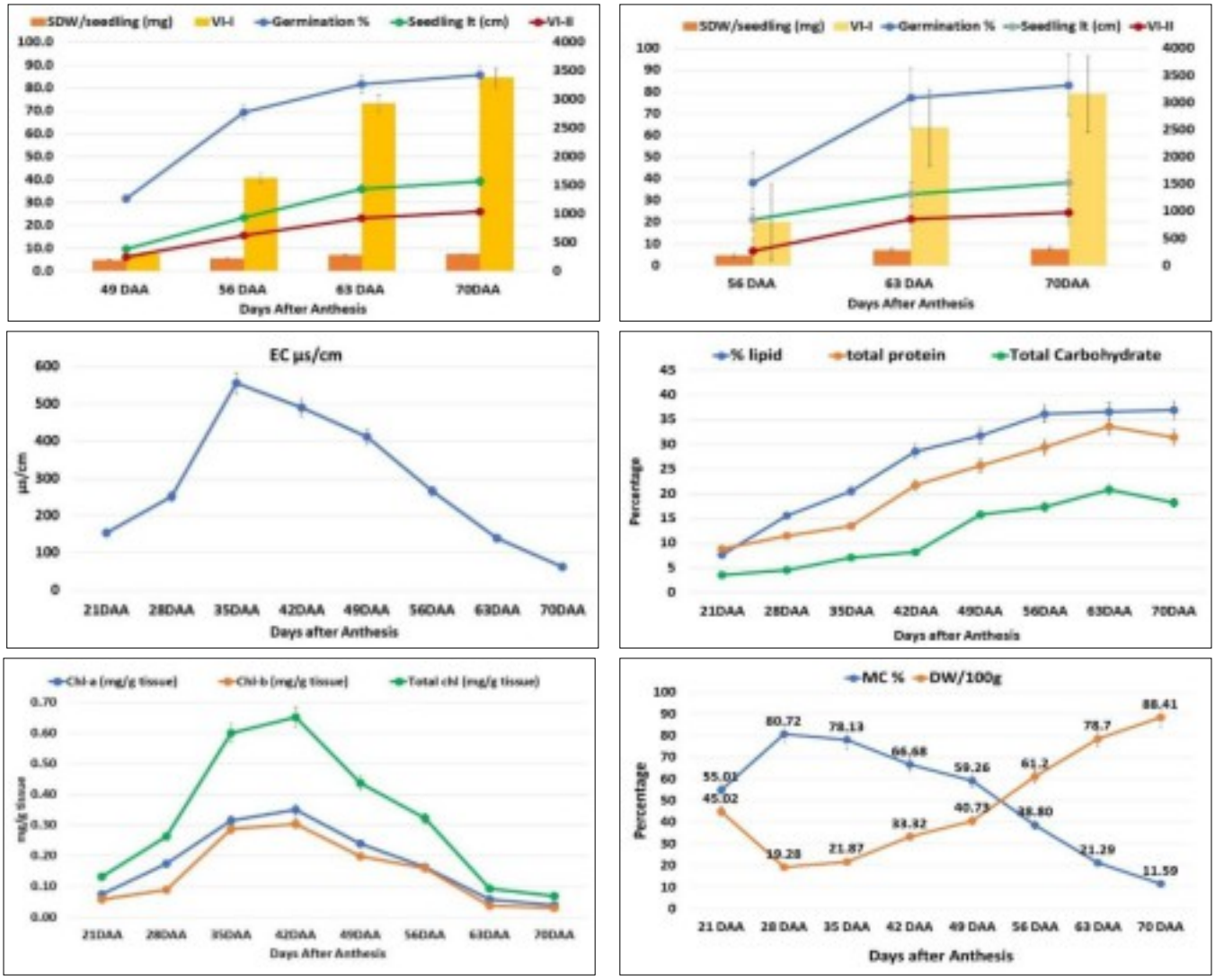


Fig. 91: Changes in physiological and biochemical parameters of moringa seed during seed development, maturation and desiccation tolerance.

Fig. 92: Seed production of vegetable varieties at ICAR-IIVR

cowpea, pea, bottle gourd, bitter gourd, pumpkin, cucumber, sponge gourd, ridge gourd, ash gourd, radish, French bean, Indian bean, carrot, cauliflower and Palak etc., were produced for distribution amongst the seed indenter and farmers (Fig.92). Among the total seeds, 23811.03 kg was truthfully labelled seeds of the open pollinated varieties of IIVR (Table 16), 181.50 kg was of the F_1 hybrid seeds of tomato, brinjal, chilli an sponge gourd (Table 17) and 3083.00 kg of breeder seeds (Table 18) were produced against 1524.40 kg of national indent. Total production of breeder seed was 49% higher than the national indent. Monitoring of breeder seed production plots was carried out for indented crops by the monitoring team consisting of representatives of State department of Agriculture, NSC, seed production scientists and respective breeders (Fig. 93). Apart from OP varieties, 151.4 kg of hybrid seeds of brinjal, tomato, chilli and sponge gourd were also produced and distributed among farmers. Single plant selection was carried out as a part of maintenance breeding in all the varieties. Seed quality (germination %) of 297 samples of institute and it's units were tested at seed testing laboratory for the purpose of quality maintenance and seed selling. Kitchen garden packets of ICAR-IIVR varieties were prepared for 17 vegetable crops and

Table 16: TL Seed produced during 2018-19 at ICAR-IIVR, Varanasi

Crop	Variety	Qty TL Seed (Kg)
Cow pea	Kashi Gauri	49.00
	Kashi Nidhi	1221.00
	Kashi Kanchan	1850.00
Okra	Kashi Pragati	50.00
	Kashi Kranti	200.00
Pumpkin	Kashi Harit	98.00
Bottle gourd	Kashi Ganga	611.00
Ridge gourd	Kashi Shivani	28.00
Ash gourd	Kashi Dhawal	80.00
	Kashi Surabhi	15.00
Bitter gourd	VRBTG-10	12.30
	Kal. Baramasi	0.15
Cucumber	VRCU Sel 12-2	0.25
Musk melon	Kashi Madhu	0.03
Garden pea	Kashi Nandini	7905.00
	Kashi Udai	8090.00
	Kashi Mukti	1500.00
	Kashi Ageti	355.00
	Kashi Samridhi	150.00
	Kashi Shakti	70.00
French bean	Kashi Rajhans	170.00
	Kashi Sampann	240.00
Indian bean	Kashi Haritima	360.00
Radish	Kashi Hans	29.00
	Kashi Shweta	52.00
Carrot	Kashi Arun	200.00
Palak	All Green	225.00
Chilli	Kashi Anmol	77.00
Brinjal	Kashi Uttam	15.00
	Kashi Taru	0.30
Tomato	Kashi Amrit	2.50
	Kashi Anupam	0.50
	Kashi Vishesh	9.00
	Kashi Aman	89.00
	Kashi Adarsh	44.00
Cauliflower	Kashi Gobhi -25	13.00
	Total	**23811.03**

Table 17: Hybrid seed produced at ICAR-IIVR, Varanasi (2018-19)

Crop	Hybrid	Quantity (Kg)
Brinjal	Kashi Sandesh	24
Tomato	Kashi Abhay	1.4
Chilli	Kashi Tej	23
	Kashi Ratna	3.1
Sponge gourd	Kashi Saumya	40
	Kashi Rakshita	90
	Total	**181.5**

Fig. 93: Monitoring of breeder seed production

distributed among the farmers (Fig. 94). At the Regional Research Station, Sargatia, a total of 29482 kg seed and planting materials were produced including turmeric and elephant foot yam (Table 19). To fulfil the need of the KVKs and local farmers, 141 quintals of turmeric seeds and 128 quintals of elephant foot yam are also produced at ICAR-IIVR-RRS, Sargatia.

Fig. 94: Kitchen garden packets of ICAR-IIVR varieties.

Table 18: Breeder seed produced at ICAR-IIVR, Varanasi (2018-19)

Crops	Varieties	Quantity (Kg)
Cow pea	Kashi Gauri	10
	Kashi Nidhi	250
	Kashi Kanchan	350
Okra	Kashi Pragati	350
	Kashi Kranti	330
Pumpkin	Kashi Harit	8
Bottle gourd	Kashi Ganga	24
Ridge gourd	Kashi Shivani	5
Ash gourd	Kashi Dhawal	5
	Kashi Surabhi	5
Garden pea	Kashi Nandini	495
	Kashi Udai	510
	Kashi Mukti	500
	Kashi Ageti	85
	Kashi Samridhi	70
Indian bean	Kashi Haritima	50
Radish	Kashi Hans	9
	Kashi Shweta	13
Chilli	Kashi Anmol	3
Brinjal	Kashi Taru	1
Tomato	Kashi Amrit	0.5
	Kashi Anupam	0.5
	Kashi Vishesh	3
	Kashi Aman	5
	Kashi Adarsh	1
	Total	**3083.00**

Table 19: TL seed production at RRS, Sargatia (2018-19)

Crop	Variety	Seed Yield (kg)
Brinjal	Kashi Uttam	213.00
Tomato	Kashi Aman	35.00
Chilli	Kashi Anmol	28.00
Cowpea	Kashi Kanchan	694.00
	Kashi Nidhi	410.00
Ash gourd	Kashi Dhawal	110.00
Sponge gourd	Kashi Divya	135.00
Pumpkin	Kashi Harit	113.00
Bottle gourd	Kashi Ganga	220.00
Palak	All Green	505.00 (unprocessed)
Radish	Kashi Hans	119.00 (unprocessed)
Turmeric	Megha Turmeric -1	14100.00
Elephant Foot Yam	Gajendra	12800.00
Total		**29482.00**

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

A total of eight treatments (10% sugar + multivitamin+100 ppm nano-ZnO as T1, 10% jaggery+multivitamin+ 100 ppm nano-ZnO as T2, 5% sugar+5% jaggery + multivitamin + 100 ppm nano-ZnO as T3, 10% sugar+multivitamin + 200ppm nano-ZnO as T4, 10% jaggery+multivitamin+200ppm nano-ZnO as T5 and 5% sugar+5% jaggery+multivitamin+200ppm nano-ZnO as T6, hand pollinated as T7 and control (without spray) as T8) were evaluated in bottle gourd and sponge gourd in a randomized block design with three replications. The pollinator activity was studied in both the crops during different time period of the day. From the table 20, it is evident that Treatment-6 comprising 5% sugar+5% jaggery+multivitamin+200 ppm nano-ZnO attracted maximum number of pollinators across the time followed by the treatment 3 (5% sugar+5% jaggery+multivitamin+100 ppm nano-

Table 20: Average number of pollinators visiting sponge gourd on different treatments

Time	Number of pollinators						
	T1	T2	T3	T4	T5	T6	T8 (control)
10 am	30	27	40	32	28	41	24
12 pm	25	21	28	24	23	27	14
2 pm	26	20	32	27	21	31	13
4 pm	22	18	28	23	19	29	7
6 pm	16	14	18	17	15	20	11

Table 21: Average number of pollinators visiting bottle gourd on different treatments

Time	Number of pollinators						
	T1	T2	T3	T4	T5	T6	T8 (control)
2 pm	8	7	12	9	8	13	0
4 pm	14	12	18	15	13	19	5
6 pm	16	12	23	17	14	24	8
8 pm	14	11	22	16	13	22	10

ZnO). A large number of honeybees (*Apis mellifera* and *A. dorsata*) were visited on sponge gourds during this period. Similarly, in case of bottle gourd, being nocturnal blooming, highest pollinators activity (24 numbers) was recorded from the Treatment-6 during 6 pm followed by Treatment-3. Sphingids were the dominant pollinators in the bottle gourd (Table. 21).

Project 2.3: Drying and Storage Studies on Vegetable Seeds including Modified Atmosphere Storage

Drying and storage studies including modified atmosphere storage: using desiccants like zeolite beads and silica gel under room temperature was standardized. Desiccants were recharged by drying at 200°C for 2h and cooled at room temperature in desiccator before using them for seed drying study (Fig.95). Freshly harvested and dried seeds were mixed with zeolite beads and silica gel, separately, in the ratio of 1:0.5, 1:1, 1:2 and 1:3 (seed: desiccant, by weight) in an air tight container and kept at room temperature (Fig. 96). Initial moisture content of seeds (9.02%) was estimated by hot air oven method. Seeds were separated from desiccant and weighed after 24h, 48h, 72h, 96h and 120h of drying. Significantly higher moisture content was removed from seeds (5.193%) within 24h by zeolite beads in 1:3 ratio. Final moisture content of seeds dried with zeolite beads reached 2.8% in 1:3 ratio and 6.48% in 1:0.5 ratio of drying condition after 120h of drying. In all

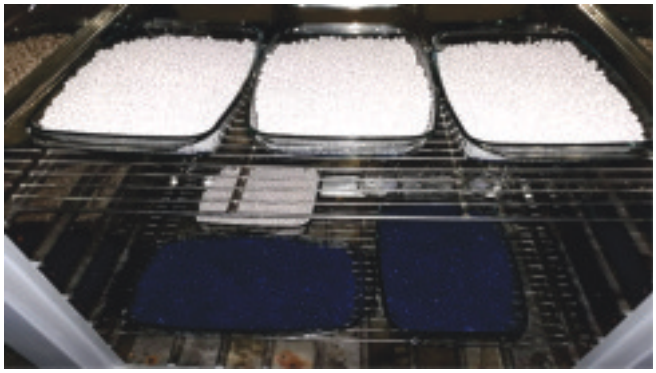


Fig. 95 : Recharging zeolite beads and silica gel at 200°C for 2h

Fig. 96: Seed drying with (a) zeolite beads and (b) silica gel

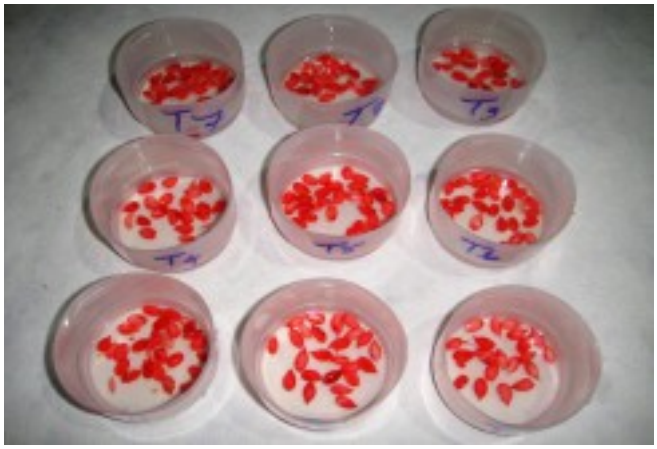


Fig.97: Confirmation of seed viability after drying with zeolite beads and silica gel by Tetrazolium test

Table 22: Effect of desiccants on moisture loss and viability seeds of ash gourd cv. Kashi Dhawal

Treatment	Moisture loss (%) between					Viability (%)	Final Moisture (%)
	0-24h	25-48h	49-72h	73-96h	97-120h		
T1	No loss in moisture content of seeds					84(66.4)	9.02
T2	2.825	0.213	0.171	0.094	0.020	83(65.6)	6.48
T3	4.137	0.430	0.228	0.184	0.115	84(66.4)	4.92
T4	4.765	0.579	0.325	0.252	0.188	82(64.9)	3.85
T5	5.193	0.698	0.474	0.263	0.208	83(65.6)	2.80
T6	2.582	0.178	0.136	0.062	0.020	81(65.1)	6.91
T7	2.939	0.248	0.148	0.120	0.056	82(64.9)	6.18
T8	4.137	0.290	0.232	0.190	0.178	81(64.1)	4.87
T9	4.194	0.365	0.278	0.218	0.193	83(65.6)	4.42
CD (0.05)	0.429**	0.037**	0.025**	0.022**	0.015**	NS	0.49**
CV (%)	6.44	5.64	5.70	7.18	6.87	-	5.17

the treatments, maximum moisture content from seeds was removed within first 24h of drying (Table 22). Gradual increase in weight of desiccants indicated continuous removal of moisture from the seeds during drying period. Since, dormancy is a problem in freshly harvested ash gourd seeds, Tetrazolium test was conducted to know the viability of seeds. Quick viability test reveals on par seed viability (more than 80%) in all drying conditions and non-dried control (Fig. 97).

Standardization of seed storage methods with zeolite beads and silica gel: Seeds of pumpkin cv. Kashi Harit, radish cv. Kashi Hans and vegetable cowpea cv. Kashi Nidhi were stored in air tight container with zeolite beads and silica gel @1:10 (desiccant: seeds) at room temperature and cold storage (10°C). Seeds were also stored in cloth bag, polythene bag and air tight container without desiccants for the purpose of comparison (Fig.98). Physiological seed quality parameters observed once in four months (M1- zero month, M2-four months, M3- eight months and M4-twelve months) in pumpkin seed storage revealed reduction in seed quality with increase of storage period. Among the storage condition, seed stored in cold storage (T2) recorded highest seed quality than seeds stored in room temperature (T1). Among the

Fig.98. Storage of seeds in different type of containers

Fig. 99: Speed of germination of pumpkin cv. Kashi

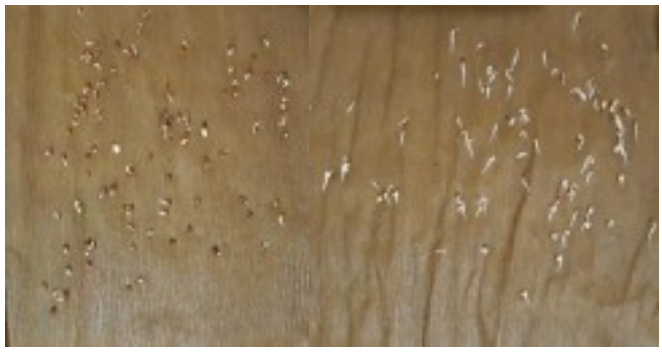


Fig.100. Speed of germination of radish cv. Kashi Hans

Fig.101: Speed of germination of cowpea cv. Kashi Nidhi

Fig.102: Vigour variation in pumpkin seedlings stored under different condition

storage containers (S1- Seeds with zeolite beads in air tight container, S2-Seed without zeolite beads in air tight container, S3-seeds in cloth bag, S4- seeds in polythene bag and S5-seeds with silica gel in airtight container), seed stored with zeolite beads (S1) recorded significantly highest seed quality after 12 months of storage period). Similar trends were observed in storage study of cowpea and radish.

In conclusion, after one year of storage, seeds stored with zeolite beads recorded highest speed of germination in pumpkin (Fig. 99), radish (Fig. 100) and cowpea (Fig. 101). Other parameters such as germination (%) and vigour (Fig.102) also recorded highest value when seeds were stored with zeolite beads.

Division of Vegetable Production

MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT

Programme Leader : Dr. Jagdish Singh

Project 3.1: Technologies for protected vegetable production

Under naturally ventilated polyhouse, response of 13 cultivars of parthenocarpic cucumber was studied. The maximum number of fruits (32.2) and fruit yield (4.57 kg/plant or 14.48 kg/m^2) was observed in Y-225 cultivar followed by Infinity (12.92 kg/m^2), Dinamik (11.55 kg/m^2) and Gurka (11.25 kg/m^2). The lowest fruit yield of 5.95 kg/m^2 was recorded in Rica cultivar followed by 162-92 F1 (7.20 kg/m^2) and 102-172 F1 (7.55 kg/m^2) (Fig. 1).

Fig. 1: Cvs. Y-225 and Dinamik being grown under polyhouse (Inset: harvested fruits)

Performance of muskmelon under polyhouse condition: Muskmelon cv. Kashi Madhu, which is characterized by round and yellow fruits with prominent green stripes and orange flesh color, was selected for off-season production. The seedlings were raised in polybags and planted on raised beds in last week of June in a naturally ventilated polyhouse. The distance between row to row and plant to plant was maintained at 1.0 m and 50 cm, respectively. Side branches were trained on four horizontal wires running parallel along the rows, while main stem was allowed to grow vertically. Flowering was noted 35 days after planting and first picking was done in second week of September, which continued till the first week of November. The average yield per plant was recorded to be 3.1 kg, while the average fruit weight was noted to be 1.1 kg (Fig. 2). However, the maximum fruit weight was found to be 2.2. kg. The weight was exceptionally higher under polyhouse conditions as Kashi Madhu is reported to produce fruit weighing around 800 g under open field conditions. Likewise, the fruit soluble solid content was also comparatively higher (13.5 ^{0}Brix) under polyhouse than reported under open condition (13.2 ^{0}Brix). The results indicated that cultivation of muskmelon under polyhouse conditions may not only enable growers to raise crop off-season but also facilitate them to harvest higher yield.

Fig. 2: Evaluation of Kashi Madhu under polyhouse (Inset: harvested fruits)

Performance of tomato on different training systems under polyhouse conditions: 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 unpruned plants were treated as control. Among different training systems, plants trained to two-stem performed better (Fig. 3). The highest numbers of clusters (12.10), average number of fruits per cluster (7.60), fruit length (4.44 cm), fruit diameter (5.25 cm) and yield per plant (9.76 kg) were noted in two-stem training system in variety NS-4266. However, the maximum soluble solid content (8.13 ^{0}Brix) was noted in plants trained onto one-stem.

Unpruned control registered lower value for most of the attributes except No. of fruits/ cluster.

Fig. 3: A picturesque view of bearing in tomato plants trained on two-stem system

Likewise, higher yield was noted in Heem Sohna as well when trained onto two-stem. Among the different canopy management practices, the highest yield (8.08 kg/plant), No. of fruits/cluster (7.71) and No. of clusters/ plant (14.66) were observed in two-stem plants. However, the highest soluble solid content (9.41 ^{0}Brix) was recorded in plants trained onto one-stem system. Higher yield in trained plants indicate channelization of assimilates towards fruit development, which would have otherwise been exhausted in supporting undesirable vegetative growth

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 V 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. And upto size grade 4 (47-56 mm) till cluster VII and grade 3 (40-46 mm) fruits onwards cluster VIII (Table 1). A similar trend was recorded in cv. Heem Sohna as well.

Table 1: Sizing of tomato (as per AGMARK standard) as influenced by canopy architecture management

Cluster No.	Size Code					
	NS-4266			Heem Sohna		
	Single stem	Double stem	Control	Single stem	Double stem	Control
I	5	5	4	5	5	4
II	5	5	4	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	3	3	3	3	3	3

Effect of PGRs on yield and associated characters of tomato: For yield enhancement in tomato, four different combinations of plant growth regulators (PGRs) *viz.*, T1=GA_3@15ppm+ salicylic acid (SA @70ppm), T2=NAA@15ppm + SA, T3=SA + promalin (GA_{4+7} + BA) @15 ppm and T4=SA were tried, while water spray served as control. Irrespective of training systems in cv. NS-4266, treatment T2 was found to be the best in terms of yield (10.63 kg/plant), fruit length (4.78 cm), fruit diameter (5.63 cm) followed by treatment comprising GA_3+ salicylic acid. The maximum content of soluble solid (7.73^0 Brix) and No. of clusters/ plant were noted in T5 and T3, respectively.

On the other hand, treatment comprising spray of salicylic acid alone was proven to be the best in terms of higher yield (8.08 kg/plant), No. of fruits/ cluster (7.57), fruit length (4.54 cm) and diameter (5.29 cm) in cv. Heem Sohna. The maximum content of soluble solids (8.85 ^{0}Brix) was noted in unpruned control .

Effect of canopy management in capsicum: Three varieties *viz.*, Indra, Orobelle and Indus-1201 were subjected to different canopy management practices such as two-stem, three-stem and unpruned plants. Generally fruits with 3-4 lobes weighing 150 gram and more are grouped as 'A' grade fruits, while fruits with 2-3 lobes weighing < 150 gram are graded as 'B' grade fruits in capsicum. In the present study, Indra was able to produce most of 'A' grade fruits when trained on two-stem (Table 2). The highest fruit weight was noted to be 369 g (Fig. 4).

Table 2: Fruit size as affected by canopy architecture management practices in capsicum

Variety / Training	Double	Triple	Control
Indra	200 g	110 g	70 g
Orobelle	110 g	90 g	60 g
Indus-1201	90 g	80 g	60 g

Fig. 4: Capsicum cv. Indra on two-stem system and harvested 'A' grade fruits (Inset: Heaviest fruit observed)

It is suggested that choice of training system may depend upon market aimed as two-stem gives fewer but larger fruits, which are suitable for export/ sell in Malls .

Likewise, three-stem produces some but fairly good size fruits; suitable for local market. On the other hand, control or unpruned plants give more fruits but of small size and misshapen (Fig. 5).

Fig. 5: Cultivar Orobelle trained as two-stem, three-stem and unpruned plants

Evaluation of antinemic activity of *Bacillus subtilis* (CRB7) against root knot nematode (*Meloidogyne incognita*) infecting tomato under protected cultivation.

Antinemic activity of plant growth promoting rhizobacterial agent *Bacillus subtilis* (CRB7) with different delivery mechanisms was evaluated for the management of root knot nematode (*Meloidogyne incognita*) infecting tomato under protected cultivation during 2017-18 and the same experiment was repeated to confirm the results during 2018-19. The two-year experiment's results revealed that among the imposed treatments, the treatment (T4) *i.e.* nursery drenching with *Bacillus subtilis* (CRB7) @ 15g/m^2+ soil drenching @ 0.5% at 30 days interval + soil application of *Bacillus subtilis* (CRB7) (5 kg/ha/2 tonnes of vermicompost) was found effective for the management of root knot nematode infecting tomato under protected cultivation with maximum reduction of final nematode population in soil (63.1%), egg mass per root system (53.1%) with gall index of 2.1 (Gall index 0-5 scale, Hussey and Janssen, 2002) and enhanced tomato yield to the tune of 23.2% (Fig. 6). This treatment (T4) was statistically at par with the treatment (T6), which comprised of chemical carbofuran 3G (1 kg a.i./ha) with respect to reduction of final nematode population in soil, egg mass per root system and gall index.

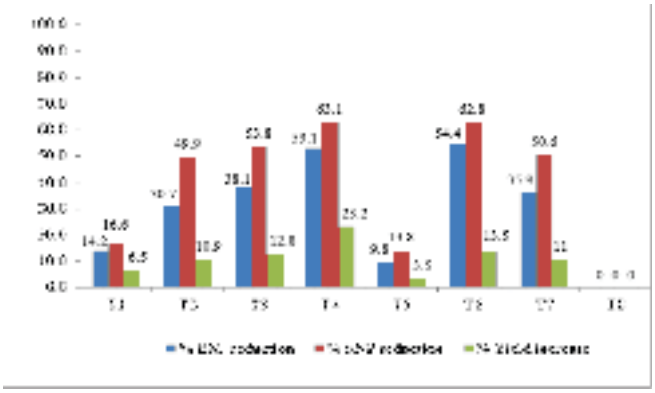


Fig. 6. Antinemic activity of *Bacillus subtilis* (CRB7) against root knot nematode (*Meloidogyne incognita*) infecting tomato under protected cultivation. EM: egg mass per root system; FNP: final nematode population in soil; Per cent. Treatment details: T1: Nursery drenching with *Bacillus subtilis* (CRB7) @ 15g/m^2; T2: Soil drenching @ 0.5% at 30 days interval; T3: Soil application of *Bacillus subtilis* (CRB7) (5 kg/ha/2 tonnes of Vermicompost); T4: Nursery drenching with *Bacillus subtilis* (CRB7) @ 15g/m^2+ Soil drenching @0.5% at 30 days interval + Soil application of *Bacillus subtilis* (CRB7) (5 kg/ha/2 tonnes of Vermicompost); T5: Vermicompost 2 tonnes/ha; T6: Carbofuran @ 1 kg a. i/ha; T7: Neem cake 2 tonnes/ha; T8: Control.

Project 3.2: Vegetable based cropping systems

The evaluation of ten different cropping systems was continued during 2018-19. After completion of one cycle, the system productivity in terms of rice equivalent yield was worked out. The data presented in table 3 revealed that highest total productivity (278.97 q/ha) was obtained with cowpea-tomato-okra cropping sequence followed by okra-tomato-cowpea (271.98 q/ha) with vegetables during all the three seasons. However with maize-pea-pumpkin, the maximum productivity was 238.76 q/ha.

Crop yield during *kharif* season of 2018-19: During *kharif* season, the yield of *kharif* crops was calculated and compared in terms of equivalent yield. The highest productivity during *kharif* season was obtained with brinjal crop having 177.57 q/ha of Rice Equivalent Yield (REY) followed by bottle gourd *i.e.* 106.56 q/ha.

Crop yield during *rabi* season: During winter season, the yield of different crops in the cropping system was also compared on the basis of Rice Equivalent Yield. The highest REY was obtained with tomato (112.48 q/ha) crop followed by cauliflower crop (106.50 q/ha). The grain yield of wheat was in the range of 39.87 to 40.23 q/ha. Since the spring crop is still in the field, the system productivity has not been worked out. The same will be done when all the crops are harvested.

Soil fertility status: Soil fertility status under different cropping systems after completion of one cycle revealed that there is no considerable change in the pH, EC, organic carbon and available nutrients in the soil under different cropping systems.

Table 3: Productivity (q/ha) of crops in different cropping sequence during 2017-18

Cropping Sequence	Yield (q/ha)			Rice Equivalent Yield (g/ha)			
	Kharif	*Rabi*	*Zaid*	*Kharif*	*Rabi*	*Zaid*	**Total**
Paddy –wheat	48.62	40.2	-	48.62	49.90	0.00	98.52
Paddy -wheat- coriander	47.50	39.87	10.23	47.5	49.49	17.64	114.63
Paddy–tomato-Mung bean	49.20	327.6	10.40	49.2	90.37	82.48	189.70
Paddy -broccoli-cowpea	49.00	145.63	128.58	49.0	60.26	88.68	197.94
Bottle gourd-wheat -amaranth	270.46	41.51	125.41	111.9	51.53	86.48	205.31
Maize- pea – pumpkin	140.65	95.5	291.64	38.8	98.79	100.57	238.16
Brinjal- cowpea-amaranth	-	315.48	60.82	0.0	195.82	41.94	236.76
Okra-tomato-cowpea	132.41	458.65	131.47	54.8	126.52	90.67	271.98
Paddy -Pea-Okra	48.52	89.5	128.68	48.5	92.59	53.25	194.35
Cowpea-Tomato-Okra	131.20	487.38	130.58	90.5	134.45	54.03	278.97

Price of different crops (Rs./kg): Rice - 17.50, Wheat-18.40, Bottle Gourd-6.00, Maize-10.00, Brinjal- 9.00, Okra-6.00, Cowpea-10.00, Tomato-4.00, Cauliflower-6.00, Pea-15.00, Radish-3.00, Coriander-20.00, Moong Bean-70.00, Amaranth-10.00, Pumpkin-4.00

Table 4: Benefit: cost ratio of different cropping sequences

S. N.	Vegetable based cropping systems	Total Cost of Cultivation	REY of VBCS	Price of paddy	Gross returns	Net returns	B:C Ratio	Rank
1	Paddy-wheat	100400	98.52	1750	172410.0	72010.0	1.72	
2	Paddy-wheat-Coriander	165400	114.63	1750	200602.5	35202.5	1.21	
3	Paddy-tomato-mungbean	224450	189.70	1750	331975.0	107525.0	1.48	
4	Paddy-cauliflower-cowpea	200050	197.94	1750	346395.0	146345.0	1.73	
5	Bottle gourd-wheat-amaranth	147700	205.31	1750	359292.5	211592.5	2.43	1
6	Maize-pea-pumpkin	178650	238.16	1750	416780.0	238130.0	2.33	2
7	Brinjal-cowpea-amaranth	211050	236.76	1750	414330.0	203280.0	1.96	4
8	Okra-tomato-cowepa	243100	271.98	1750	475965.0	232865.0	1.96	5
9	Paddy-pea-okra	192150	194.35	1750	340112.5	147962.5	1.77	
10	Cowpea-tomato-okra	243100	278.97	1750	488197.5	245097.5	2.01	3

Benefit: cost ratio: Bottle gourd-wheat-amarath cropping system was found profitable with the highest B:C ratio of 2.43. This system was followed by 2.33 B:C ratio of maize-pea-pumpkin cropping system. Cowpea-tomato-okra cropping system ranked third with the highest net returns of Rs. 245097.5 per ha, which included all the three vegetable crops in the year. It was followed by brinjal-cowpea-amaranth and okra-tomato-cowpea cropping systems with year round vegetable production as a profitable cropping sequence (Table 4).

Project 3.9: Physiological and biochemical mechanisms of heat stress tolerance in chilli

A field evaluation of twenty four chilli genotypes was conducted in two different seasons including *kharif* (main season; M) and late *kharif* (L) in 'Randomized Complete Block Design' with three replications to identify genotypes tolerant to high temperature and study the genotypic variation for heat tolerance and other yield related traits. During both the seasons, transplanting of chilli genotypes was done at 45x60 cm spacing. All the management practices were carried out uniformly for all the treatments in both the seasons. During the *kharif* sowing, chilli genotype Kashi Anmol showed the maximum number of fruits per plant (98.00) followed by Taiwan-2 (83.40), however, the maximum 10 fruit weight was recorded in chilli genotypes Kashi Gaurav (101.00 g), followed by CM-334 and PT-12-03 x BJ, PT-12-3 F9 (78.00 g). Yield per plant was recorded maximum in Kashi Gaurav (696.90 g) followed by PT-

12-03 x BJ, PT-16-7-2 F9 (645.00g). High temperature (40/24 °C, day/night) decreased the number of fruits/plant (24.07%) as well as fruit yield/plant in all the test genotypes with overall mean of 35.55 % against optimum temperature (29/16 °C, day/night). During summer season, maximum number of fruits per plant was recorded in Kashi Anmol (78.0 g), maximum 10 fruit weight was recorded in PT-12-03 x BJ,PT-16-7-2 F9 (68.88 g), the yield per plant was also maximum in PT-12-03 x BJ,PT-16-7-2 F9 (406.39g). The minimum yield reduction was recorded in PBC-904 (13.73%), followed by Kalyanpur Chanchal (15.56%), however, maximum yield reduction was recorded in genotype Phule Jyoti (65.80%). On the basis of heat susceptibility index (HSI) for fruit yield, three genotypes PBC-904, Kalyanpur Chanchal and Pant C-1 were classified as highly heat tolerant (HSI<0.5). Six genotypes namely BS-20 Red, Japanese Longi, PBC-453, Taiwan-2, Pb Lal and VR-338 x VR-339, PT-1 F9 were classified as heat tolerant (HSI= 0.51-0.75) and six genotypes Kashi Anmol, Perennial, PT-12-03 x BJ, PT-13-3-2, Pusa Jwala, PDG-49-A, and PT-12-03 x BJ,PT-16-7-2 F9 which showed moderate heat tolerance (HSI= 0.76-1.0).

Project 3.10: Agronomic bio-fortification studies in vegetable crops

Preparation and evaluation of crop-group specific micronutrient formulations: Crop-group specific micronutrient formulations for Solanaceous (4 Nos.) and Cole crops (4 Nos.) were prepared in the laboratory and were evaluated for their efficacy under field conditions during *rabi*-2018-19 on tomato, cabbage and cauliflower crops, respectively. A commercial formulation available in the market as well as the 'Vegetable Special' formulation 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. In control plot, only water was sprayed. 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 where no micronutrients were applied. Although all the tested micronutrient formulations proved statistically equally effective in improving the growth and yield, however, among the four prepared formulations, Micromix B proved better recording numerically higher values for all the parameters in both the crops.

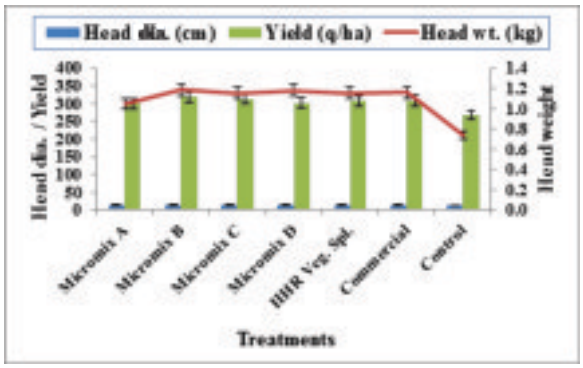


Fig. 7: Response of cabbage to foliar application of micronutrient formulations

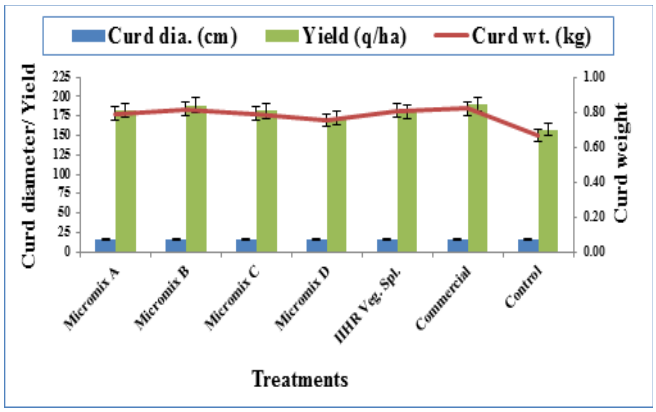


Fig. 8: Response of cauliflower to foliar application of micronutrient formulations

Effect of micronutrient formulations on tomato: An experiment was conducted to evaluate the performance of four different micronutrient formulations prepared for solanaceous crops during *Rabi*-2018-19. Tomato var. Kashi Aman was taken as the test crop. For comparision, the micronutrient formulation 'Vegetable Special' from ICAR-IIHR, Bengaluru as well a commercial formulation were also used. All the formulations, except Vegetable Special, were applied @ 1 g/l three times at 15 days intervals after 30 days of planting, whereas the Vegetable Special was sprayed @ 5 g/l as per its recommendation. The data recorded on growth and yield has been presented in Fig. 9. It is evident from the results that all the micronutrient formulations under test significantly improved the growth and yield of tomato as compared to the control.

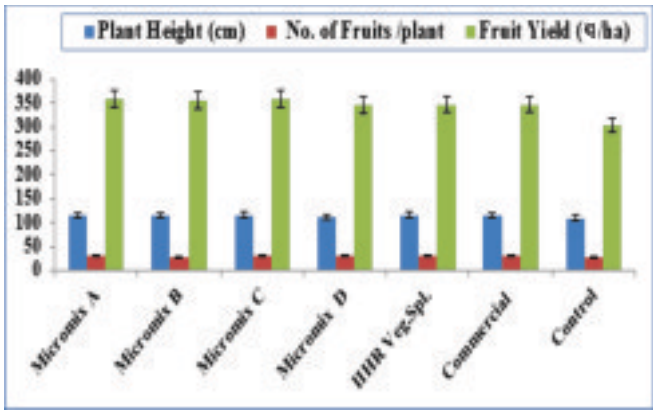


Fig. 9: Response of tomato to foliar application of micronutrient formulations

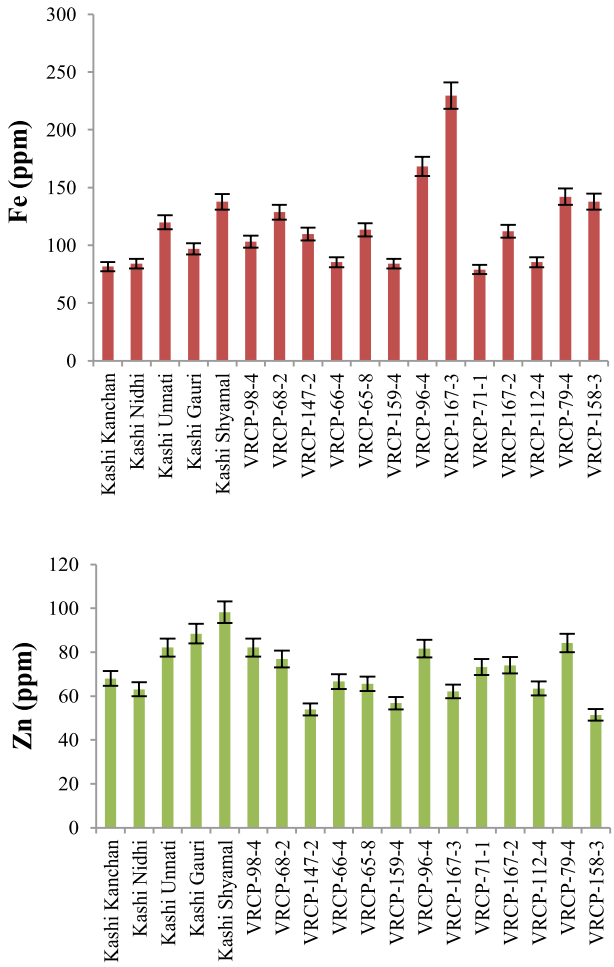


Fig. 10: Micronutrients contents in cowpea genotypes

It is also evident from the data that there was no significant difference among the micronutrient formulations. However, Micromix A proved slightly better registering numerically maximum fruit yield (357.8 q/ha).

Studies on micronutrients profiling in vegetable crops: With a view to identifying micronutrient acquisition efficient varieties/ lines in cowpea and okra, pods at edible stage from 18 lines of cowpea and 41 lines of okra were analyzed for different micronutrients.

Micronutrients content in cowpea: The data on variability of Fe and Zn in cowpea varieties/lines have been presented in Fig. 10. It is evident from the data that there was a large variation in micronutrients content in the pod of cowpea genotypes. The copper content ranged from 3.2 ppm in VRCP-112-4 to 14.45 ppm in VRCP-96-4 with a mean value of 9.3 ppm. The iron content varied from the lowest value (79 ppm) in VRCP 71-1 to the highest value (229.6 ppm) in VRCP 167-3 with a mean content of 116.6 ppm. The zinc content in cowpea pods ranged from 51.45 ppm in VRCP 158-3 to 98.25 ppm in Kashi Shyamal. The mean Zn content in the tested cowpea lines was found to be 71.8 ppm. Similarly, Mn content varied from 40.1 ppm in VRCP 112-4 to 67.3 ppm in Kashi Unnati with a mean concentration of 54.5 ppm.

Micronutrients profile in okra: The minerals (Fe and Zn) content in pod of okra genotypes has been presented in Fig 11. It is evident from the data that there is large variation in the minerals content in pods of different okra genotypes. The level of copper ranged from 1.5 ppm in *A. moschatus* IC-14985 to 37.0 ppm in VROB-178 with a mean value of 14.0 ppm. The iron content varied from a minimum of 30.0 ppm in *A. moschatus* IC-14985 and EC-360345 to a maximum of 87.6 ppm in VROR -158. Its mean content across the evaluated genotypes was 56.6 ppm. Zinc content ranged between 9.7 ppm in *A. moschatus* IC-94985 to 59.7 ppm in IC-93892 x VRO-156 with a mean value of 31.5 ppm. The Mn content in okra pods also showed a very large variation among the evaluated genotypes. It varied from 11.9 ppm in EC-360345 to 53.8 ppm in IC-93802-VRO-156 with a mean concentration of 31.3 ppm.

Project 3.11 : Development of organic production technologies for vegetables based cropping systems

The experiment was started during the *kharif* season 2018 on a fixed site with fourteen treatments. The treatments were replicated thrice in Randomized Block Design.

The soil of the experimental site was sandy loam in texture with low organic carbon (0.37 to 0.41%) and pH in the range of 7.4-7.8. During *kharif* season green manuring with *dhaincha* was done. The green biomass added and the major nutrient supplied thereof to the soil is given in Fig. 12.

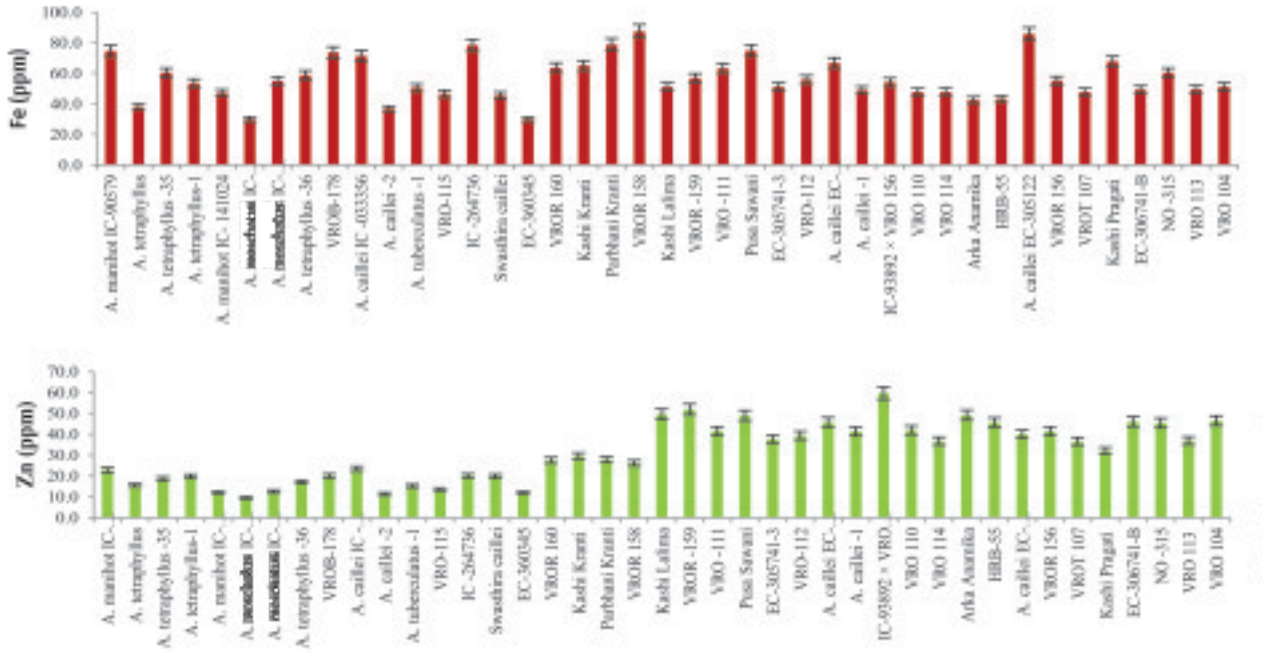


Fig. 11: Micronutrients content in different okra genotypes

The result presented in Fig. 13, revealed that highest yield of tomato (456.83 q/ha) was noted with application of recommended dose of inorganic fertilizer. However, the yield obtained under organic farming with application of FYM @ 25 t/ha (452 q/ha), or vermicompost @10 t/ha (442 q/ha) or NADEP @ 20 or 25 t/ha was at par with inorganic fertilizer application. The minimum yield was noted under absolute control (128.23 q/ha). The average fruit weight of tomato was maximum in plot fertilized with FYM @ 25 t/ha (67.24g), which was comparable to the fruit weight obtained with application of inorganic fertilizer or NADEP compost @ 20 or 25 t/ha but was significantly superior to rest of the treatments. The cost of cultivation was the lowest in control but varied between Rs. 119648/ha (in inorganic cultivation with application of RDF) to Rs 143140/ha (in organic farming with application of vermicompost @ 10t/ha). The highest total return (Rs. 228415/ha), net return (Rs.108767/ha) and B: C ratio (1.91) was obtained in inorganic farming with recommended dose of chemical fertilizers. Among organic farming treatments, application of FYM @ 25 t/ha or NADEP compost @ 20 or 25 t/ha was found the best and was comparable to inorganic farming in terms of the total return (Rs. 202790 to Rs 209990/ha), net return (Rs. 80740 to Rs.74,790/ha) and the B:C ratio (1.58 to 1.62).

In carrot, all the three sources produced significantly higher yield over control. The highest yield was obtained with application of FYM @25t/ha which was significantly higher than inorganic source. Among different organic sources, FYM was found superior than the other two sources. There was significant difference

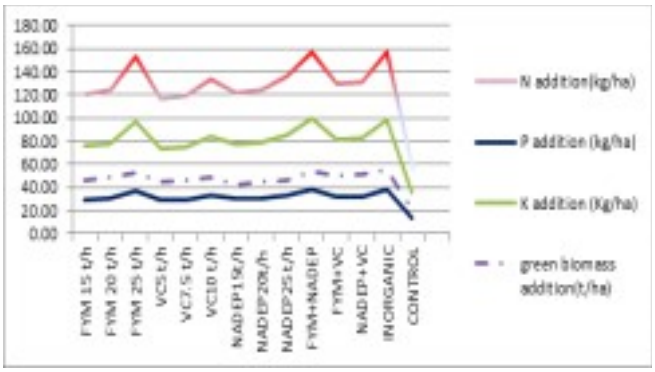


Fig. 12: Green biomass added and the major nutrient supplied through *dhaincha* green manuring

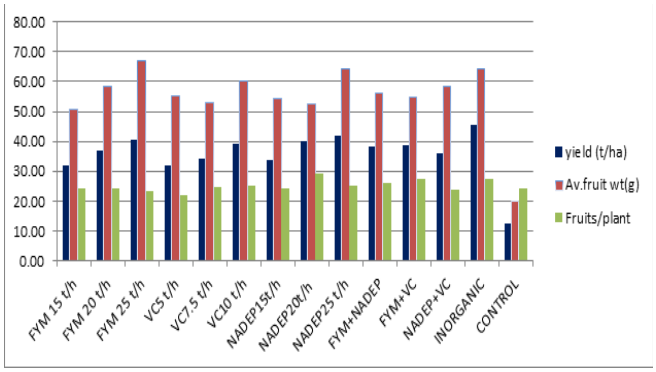


Fig 13. Yield and yield attributes of tomato as influenced by different treatments

with regards to root length and average root weight. It was also observed that increasing dose of all the three sources increased the carrot root yield. The combined application of sources improved the carrot root yield (Fig. 14).

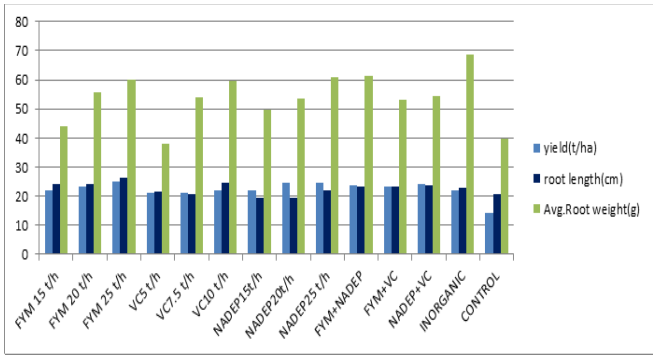


Fig. 14: Yield and yield attributes of carrot as influenced by different treatments

The organic cultivation of pea was superior to inorganic cultivation, with the highest yield of 135.4 q/ha recorded under combined application of FYM@10t.+ NADEP compost @ 10t/ha. Organic sources FYM @ 25t/ha, NADEP compost @15/20/25 t/ha, FYM @10t/ha+ VC@3.5t/ha produced significantly higher green pod yield over inorganic cultivation with recommended dose of fertilizers, while the rest of the organic treatments were at par to inorganic treatment. The increase in yield was associated with increase in No. of pods/plant as well as No of grains per pod and 1000grain weight. Among three organic sources, NADEP compost was best suited to vegetable pea while FYM was the second best (Fig. 15).

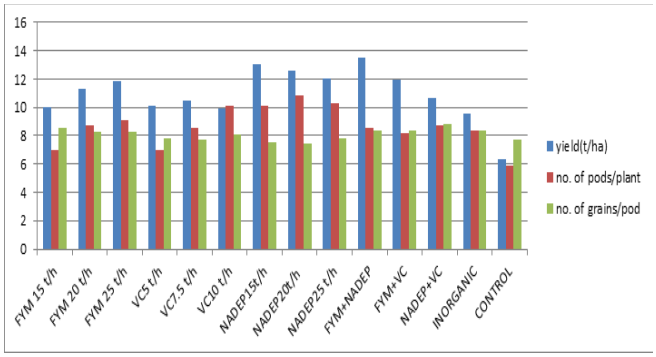


Fig. 15: Yield and yield attributes of pea as influenced by different treatments

The organic cultivation of *Kasuri methi* was superior to inorganic cultivation, with the highest yield of green leaves (122.26 q/ha) recorded under combined application of FYM@10t + VC @ 3.5t/ha. Organic sources FYM @15/20/25 t/ha, NADEP compost @10t/ha+ VC @ 3.5t/a and FYM @ 10t/ha+ NADEP compost @10t/ha produced significantly higher green leaf yield over inorganic cultivation with recommended dose of fertilizers, while the rest of the organic treatments were at par to inorganic treatment. Among the three organic sources, FYM was the best suited to *Kasuri methi* for production of green leaves, while the second best organic source was vermicompost. The highest seed yield of *Kasuri methi* was recorded with application of FYM @ 25t/ha, which was at par to inorganic cultivation (Fig. 16).

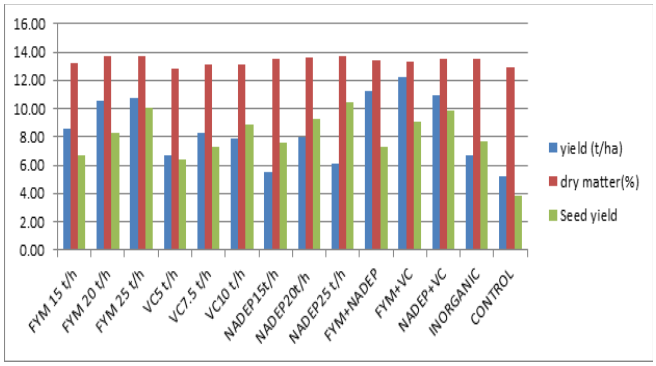


Fig. 16: Yield and yield attributes of *Kasuri methi* as influenced by different treatments

Economics: The benefit: cost ratio as presented in Fig. 17 revealed that the organic production of vegetable crops is remunerative over inorganic production method. However among the five vegetable crops tested, *Kasuri methi* emerged as the most profitable crop followed by pea and carrot.

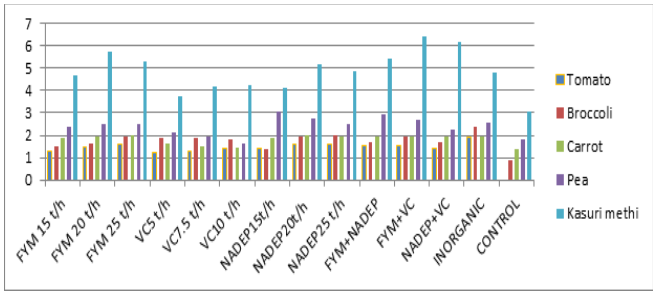


Fig. 17: Benefit: cost ratio of five vegetable crops as influenced by treatments

Quality parameters: The quality of vegetables in terms of vitamin C content was better under organic system as compared to inorganic system in broccoli and *Kasuri methi*. Ascorbic acid, total phenol and anti-oxidant contents increased by 40.1, 43.4 and 16.8%, respectively in broccoli and 31.8, 48.8 and 14.96%, respectively in *Kasuri methi* over inorganic system. There was no consistent trend in colour and texture of broccoli and *Kasuri methi*.

Project 3.12: Improving water productivity of vegetable crop sequences through drip irrigation system

Experiments were conducted to study water productivity of 03 vegetable crop sequences *viz.*, i) Cowpea- tomato- pumpkin, ii) Okra- cabbage- radish, and iii) Bitter gourd-cauliflower-cowpea under drip irrigation. The irrigation treatments for all crops were drip irrigation with 100% ET and 75% ET, and Furrow irrigation.

Crop yield and water use efficiency under vegetable crop sequences: The results in table 5 revealed that under vegetable crop sequence cowpea-tomato- pumpkin, the yield of cowpea (Kashi Nidhi) (10.90 t/ha) and water use efficiency (WUE) (0.496 t/ha-cm) with drip irrigation at 100% ET were 12% and 83% higher than furrow irrigation, respectively. However, maximum WUE 0.617 t/ha-cm was realized with drip irrigation at 75% ET. Tomato (Kashi Aman) under drip irrigation with 100% ET realized maximum yield of 38.93 t/ha with WUE of 1.062 t/ha-cm, which were respectively, 14.9% and 88.9% higher than furrow irrigation.

Table 5: Yield and water use efficiency of different crops

Irrigation level	Yield (t/ha)	WUE (t/ha-cm)	Yield (t/ha)	WUE (t/ha-cm)
	Cowpea		Tomato	
100 % ET	10.90	0.496	38.93	1.062
75 % ET	10.18	0.617	35.18	1.279
Furrow irrigation	9.74	0.271	33.86	0.564
C.D.	0.789		3.147	
	Okra		Cabbage	
100 % ET	7.51	0.28	53.19	1.88
75 % ET	7.27	0.35	38.69	1.82
Furrow irrigation	7.16	0.16	27.37	0.59
C.D.	0.247		1.199	
	Bitter gourd		Cauliflower	
100 % ET	10.05	0.34	48.47	1.98
75 % ET	9.26	0.42	30.19	1.65
Furrow irrigation	7.75	0.16	25.68	0.64
C.D.	1.165		3.799	

The yield of okra (Kashi Kranti) under vegetable sequence okra- cabbage- radish realized the highest yield of 7.51 t/ha and WUE 0.28 t/ha-cm with drip irrigation to the tune of 100% ET. The yield and WUE were 5% and 75% higher as compared to furrow irrigation, respectively. Cabbage yield with irrigation at 100% ET was 95% higher than furrow irrigation while WUE enhanced by 218%. Bitter gourd realized maximum WUE with drip irrigation at 75% ET, which enhanced over furrow irrigation by 1.62 times in crop

Table 6: Effect of inter-specific rootstocks on yield attributes of tomato cultivars

Graft combination (Rootstock x Scion)	Plant height (cm)	Fruits/ plant	Fruit weight (g)	Fruit dia. (cm)	Fruit length (cm)	Fruit yield/ plant (kg)
IC 111056 x Kashi Aman	43.97	35.67	59.00	4.73	4.48	1.84
IC 354557 x Kashi Aman	47.33	41.50	62.33	4.75	4.53	1.95
S. aethiopicum x Kashi Aman	47.10	30.67	53.33	4.59	4.27	1.46
*S. macrocarpon** x Kashi Aman	57.00	31.67	47.00	4.34	4.01	1.35
Kashi Aman ungrafted	44.33	32.50	62.50	4.70	4.38	1.43
IC 111056 x NS 4266	140.33	68.00	49.67	4.45	4.10	4.10
Surya x NS 4266	132.67	59.33	43.67	3.92	3.97	2.69
S. aethiopicum x NS 4266	137.67	48.67	51.00	4.52	4.19	2.21
*S. macrocarpon** x NS 4266	95.33	43.33	57.67	4.56	4.71	1.34
S. laciniatum x NS 4266	125.00	49.67	53.67	4.48	4.64	2.27
NS 4266 ungrafted	136.50	38.33	58.00	4.66	4.25	2.28
IC 111056 x Kashi Adarsh	41.67	36.67	62.67	4.63	4.44	1.49
IC 354557 x Kashi Adarsh	47.33	49.67	42.00	4.61	4.66	1.91
Surya x Kashi Adarsh	50.33	48.67	56.00	4.57	4.54	2.25
*S. macrocarpon*** x Kashi Adarsh	-	-	-	-	-	-
Kashi Adarsh ungrafted	43.67	35.00	48.67	4.55	4.44	1.36
SEm±	8.49	7.58	1.73	0.11	0.08	0.11
$CD_{0.05}$	25.23	22.53	5.14	0.33	0.25	0.34

*About 90% plants died due to infestation of *Rhizoctinia* root rot. ** All 38 plants died during flowering.

sequence bitter gourd-cauliflower-cowpea. Yield with drip irrigation at 100% ET was at par with that 75% ET. Maximum yield and WUE of cauliflower was realized with drip irrigation at 100% ET, which was, respectively, 88% and two times higher than furrow irrigation. Crop equivalent yield of cowpea- tomato- pumpkin sequence was found superior over other two sequences.

Project 3.13: Enhancing productivity, quality and tolerance to biotic and abiotic stresses in vegetables by grafting technology

Yield attributes of tomato cultivars grafted on to various brinjal rootstocks: Under grafting study, three wild spp. of brinjal *i.e. Solanum aethiopicum*, *S. macrocarpon* and *S. laciniatum* and three cultivated varieties of brinjal *v.i.z.*, IC 111056, IC 354557 and Surya were used as rootstocks for three tomato scion cultivars i.e. Kashi Aman (OP, determinate), Kashi Adarsh (Hyb., determinate) and NS 4266 (Hyb., indeterminate) to study the stionic effect on fruit yield and quality of tomato fruits (Fig. 18). It was found that grafting with some specific rootstocks significantly enhanced the yield of tomato. Kashi Aman variety registered 28.67% and 36.36% higher fruit yield, respectively with IC 111056 and IC 354557 rootstocks. As compared to ungrafted, the NS 4266 grafted on IC 111056 registered 79.8% higher fruit yield (Table 6).

Fig. 18: Kashi Aman tomato grafted on brinjal IC 354557 (L) and un-grafted Kashi Aman (R)

Quality traits of tomato cultivars as affected by various brinjal rootstocks: Grafting had no significant effect on TSS content of fruits, except S. *torvum* x Kashi Aman and Surya x Kashi Chayan graft combination, where significant reduction in TSS were observed in comparison to non-grafted control. Singnificantly higher lycopene content in fruits was recorded in graft combination of IC-354557 x Kashi Chayan and *S. laciniatum* x Kashi Adarsh. β- Carotene content in fruit varied marginally with different graft combinations, and its contents were higher in *S. cheesmani* x Kashi Adarsh and *S. torvum* x Kashi Aman combinations. Ascorbic acid content in fruit was maximum in IC-354557 x Kashi Chayan (31.25 mg/ 100 g) followed by *S. aethiopicum* x Kashi Adarsh (27.50 mg/ 100 g). The titrable acidity was maximum in IC-354557 x Kashi Chayan (0.74%) followed by *S. aethiopicum* x Kashi Adarsh (0.73%).

Project 3.14: Weed management in vegetable crops

Weed management in french bean with mulches and herbicide application: The perusal of the data (Table 7) revealed that black polythene mulch effectively controlled the weed with maximum weed control index (WCI; 98.9). Among herbicides, the maximum WCI (97.2) was attained with pendimethalin followed by (fb) sodium acifluorfen + clodinafop-propargyl 100 g/ha. Highest pod yield was attained with black polythene mulch (16.9 t/ha), which was significantly superior over other treatments. Application of combination of pre and post herbicides of pendimethalin (pre-emergence) followed by sodium acifluorfen 16.5 % + clodinafop- propargyl 8 % EC (post emergence) at 25 DAS (13.4 t/ha), pendimethalin @ 750g/ha (pre-emergence) *fb* imazethapyr @ 100 g/ha (post emergence) at 25 DAS (12.9 t/ha). The post emergence herbicides were selective and the harmful effects on crop were not observed. The results showed that efficient weed management in French bean can be achieved with single application of post emergence herbicide.

Weed management in vegetable cowpea: The present experiment was conducted to find out suitable and cost effective weed management practice during the critical period of crop-weed competition in cowpea.

Weed management practices significantly reduced the weed population (Fig. 19; Table 8). Black polythene mulch effectively controlled the weed with maximum weed index of 89.3% followed by the treatment pendimethalin 750 g/ha (pre-emergence) + imazethapyr 100 g/ha (post emergence) 86.6%. Maximum yield (15.6 t/ha) was recorded with black polythene mulch followed by organic mulch (14.8 t/ha). Among herbicide treatments, maximum yield was recorded with pendimethalin + imazethapyr (12.3 t/ha)

Project 3.15: Conservation agriculture under vegetable based cropping system

The experiment on conservation agriculture under vegetable based cropping system started during *kharif* 2018 to study the effect of conservation tillage on the

Table 7: Effect of herbicides and mulch on french bean

Sl No	Treatments	Weed dry Weight (g/m²)	WCE	WI	Green pod yield (t/ha)	Pods/plant
1	Sodium acifluorfen + clodinafop	5.29	95.1	37.9	10.5	24
2	Pendimethalin fb imazethapyr	4.61	95.7	29.6	12.9	27.3
3	Black Polythene mulch	1.18	98.9	0.0	16.9	39.5
4	Imazethapyr	7.80	92.8	39.6	10.2	23
5	Pendimethalin fb quizalofop-p-ethyl	30.75	71.5	58.9	6.94	13
6	Organic Mulch	2.44	97.7	16.0	14.2	36.3
7	Weed mat	1.61	98.5	18.9	13.7	32.1
8	Pendimethalin fb Sodium acifluorfen + clodinafop- propargyl	3.06	97.2	26.6	13.4	29.2
9	Weed free	0.00	100.0	20.1	14.6	31.4
10	Weedy Check	107.8	0.0	75.4	4.16	10.2
	LSD at 5 %	4.08			1.97	1.7

Table 8: Effect of different weed management treatments on weed density, weed dry weight, WCI and WI yield and benefit: cost ratio in vegetable cowpea

Treatment	Weed population (No./m²)			Dry wt. of	WCE	Yield	B:C
	Grasses	Broad leaf	Sedge	weed (g/m²)	(%)	(t/ha)	ratio
Pendi *fb* imazethapyr + imazemox	2.12 (4.0)	4.80 (19.9)	2.54 (6.5)	15.6	85.7	12.2	3.6
Pendimethalin *fb* quizalofop	2.20 (4.3)	5.05 (22.6)	4.22 (17.9)	16.8	84.6	11.3	2.9
Halosulfuron	4.89 (19.8)	6.43 (41.5)	1.76 (3.1)	24.0	78.0	10.8	2.3
Black polythene mulch	1.64 (2.7)	3.75 (14.1)	1.64 (11.7)	11.7	89.3	15.6	3.1
Pendimethalin	2.93 (5.6)	5.15 (26.1))	5.32 (28.04)	37.6	35.5	9.2	2.7
Organic mulch	2.88 (7.8)	4.06 (16.5)	4.63 (21.0)	23.4	78.5	14.8	2.9
Pendi *fb* imazethapyr	2.08 (3.8)	4.69 (21.5)	2.39 (5.8)	14.6	86.6	12.3	3.8
Weedy check	3.94 (15.0)	7.06 (49.4)	6.16 (38.2)	108.9	0.0	7.9	1.9
2 HW	2.02 (3.6)	4.08 (16.2)	3.49 (15.2)	13.4	87.7	12.4	2.8
weed free	0.71 (0)	0.71 (0)	0.71 (0)	0		13.5	2.7
LSD at 5%	0.57	0.434	1.26	6.16		2.2	

Cowpea treated with pendimethalin 750 g/ha fb imazethapyr 100 g/ha

Cowpea weedy check

Cowpea under plastic mulch

Fig. 19: Comparative performance of different weed management practices in cowpea

Table 9: Effect of tillage treatments and weed management practices on maize yield and weed population

Treatments	Yield (t/ha)	Plant Height (cm)	Weed count (no)	Weed dry wt (g)
Main Plot Treatments				
Zero tillage with residue of previous crop	13.0	183	61	84.1
Zero tillage without residue	11.6	176	74	102.1
Conventional tillage with residue	12.6	162	80	110.4
Conventional tillage without residue	11.1	164	91	125.5
Maximum tillage with residue	12.1	169	101	139.3
Maximum tillage without residue	11.1	171	134	184.9
LSD at 5%	1.27	23.9	16.6	22.90
Sub Plot Treatment				
Weedy check	5.0	158	227	298.2
Topramezone	13.6	181	20	27.6
Tembotrione	13.2	177	35	48.3
Halosulfuron	10.4	165	56	77.2
2 Hand weeding	13.8	179	31	42.7
LSD at 5 %	0.62	8.5	7.3	10.07

production potential and soil heath in vegetable maize-pea-okra cropping system. The minimum tillage consisted of one cross ploughing with harrow/cultivator while rotational tillage consisted of two cross ploughing with cultivator and one harrowing followed by ploughing with rotavator. The recommended dose of fertilizer for the crop was applied at the time of field preparation in conventional (CT) and reduced tillage (RT) treatments, while in zero tillage (ZT), fertilizer was dibbled in soil at the time of sowing. In ZT, the residues were retained on surface by cutting the residues of crops and spreading it on soil surface. While in reduced tillage and conventional tillage, the residues of the crop of respective plot were incorporated in the soil by ploughing immediately after the completion of the crop. Pre-emergence herbicides were applied at the time of sowing and post- emergence herbicides were applied 25 days after sowing.

Zero tillage with residue retention produced maximum green cob yield (13.0 t/ha) which was significantly superior to other tillage treatments. Among weed management practices, maximum yield was obtained with 2 hand weeding (13.8 t/ha) which was at par with the application of topramezone 25 g/ha and tembotrione 105 g/ha (Table 9).

The increase in organic carbon (%) of soil due to residue incorporation/retention was 6.06% over residue removal (Table 10). The organic carbon content of soil increased in plots where residues of crops were incorporated /retained over its removal. The organic carbon content of soil was in general more in residue retention/incorporation over residue removal in all the three tillage treatments.

Table 10: Effect of tillage treatments and weed management practices on soil organic carbon

Treatments			
	With residue	Without residue	Average
ZT	0.56	0.51	0.54
RT	0.49	0.46	0.48
CT	0.48	0.46	0.47
Average	0.51	0.48	

MEGA PROGRAMME-4: POST HARVEST MANAGEMENT AND VALUE ADDITION

Programme Leader: Dr. Sudhir Singh

Project 4.3: Modified atmosphere storage for retaining the quality assurance of vegetables for longer time

Shelf life extension of cucumber: The present study has been undertaken to package the cucumber in 30µ Flexfresh bags of 1kg size ±10% (325 mm width and 615 mm height, oxygen transmission rate (OTR) 2500 cc/kg/24 hrs) and 2 kg size ±10% (300 mm width and 400 nm height, OTR 6000 cc/2kg/24 hrs). Both packaged cucumber in Flexfresh bags were stored at 10 and 15°C with RH of 85-90%. The atmospheric gaseous composition consisted of 20% oxygen and 0.02% carbon-di-oxide. Around 20% (oxygen and carbon dioxide) was built up after 8-10 days of storage at 10 and 15°C. The gaseous composition in cucumber varied (16.9-19.9% oxygen/3.2-3.7% carbon dioxide) after 18 days of storage at 10 and 15°C in Flexfresh bags. The increased level of carbon dioxide is helpful in increasing the shelf life of cucumber during storage at 10 and 15°C. Peroxidase activity increased in all the treatments. However, minimum peroxidase activity was obtained in cucumber during storage at 10°C in Flexzfresh bags while control cucumber had maximum peroxidase activity. There had been no definite pattern of polyphenol oxidase (PPO) activity in all the treatments. Initially PPO activity increased in all the treatments, thereafter, it decreased for all the treatments. However,

minimum PPO activity was recorded in cucumber packaged in Flexfresh bags during storage at 10 and 15°C, respectively. Sensory score for flavour, body and texture, colour and appearance and overall acceptability score decreased during storage of cucumber at 10 and 15°C. However, maximum sensory score was obtained in cucumber packaged in Flexfresh bags at 15°C while control cucumber had minimum sensory score after 28 days of storage at 15°C. PLW in cucumber increased in all the treatments during storage at 10 and 15°C.

The post-harvest quality dynamics of chitosan coated eggplant cultivars (IVBL-22, PR-5, BR-14. Kashi Taru and Kashi Himani) in cold storage condition (10°C) were assessed (Fig. 20). The results showed that chitosan (1%) coating can be used for maintaining quality and prolonging shelf life of eggplant, thus reducing postharvest loss. The functional quality of purple long cultivars was higher than purple round cultivars. Postharvest keeping quality of purple round cultivars was higher over long cultivars. The hierarchy in decreasing order for phenolics content was Kashi Taru > Kashi Himani > IVBL-22 > PR-5 > BR-14. Total flavonoids content in eggplant genotypes ranged from 2.01 (PR-5) to 3.86 (Kashi Taru) mg RE/100 g fresh weight (FW), depicting 1.9 fold variation. Total anthocyanin content ranged from 53 to 156 mg/100 g fw on zero day of storage, indicating initial variation of about 3 folds. Anthocyanin content was lower in purple round cultivars than in purple long cultivars. Purple round cultivars exhibited lower antioxidant activity than purple long cultivars. About 50% reduction in weight loss was observed in chitosan-coated eggplant over non-coated fruits on 8th day of storage. Purple round cultivars (PR-5 and BR-14) exhibited lower weight loss over purple long cultivars at each storage interval. Malondialdehyde content was higher in control group, over treated fruit. Malondialdehyde accumulation increased with progression of storage. IVBL-22 cultivar showed higher malondialdehyde accumulation at all intervals of storage in both treated and untreated in comparison to other cultivars. PPO activity in white coloured Kashi Himani and purple round cultivars (PR-5 and BR-14) was lower (<50

Fig. 20: Shelf life extension of fresh brinjal fruit using chitosan

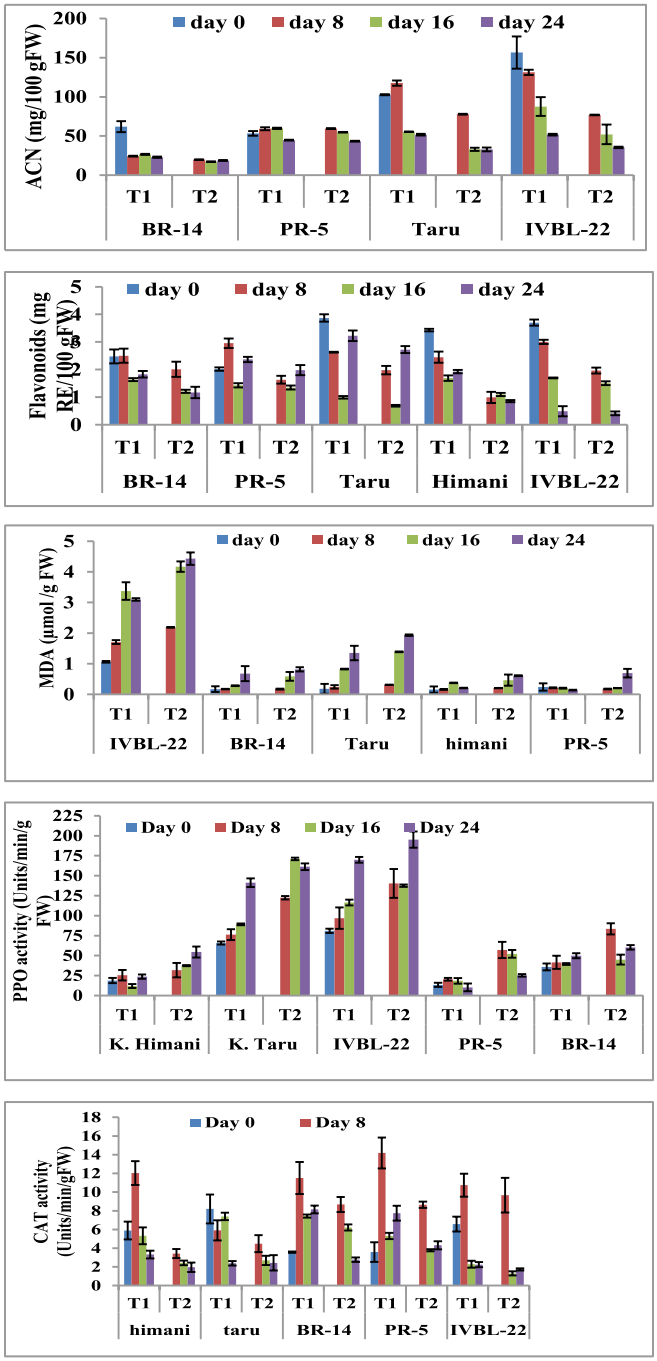


Fig. 21: Effect of chitosan coating (T1) on quality and enzymatic activities of different eggplant cultivars.

Units/min/g FW) at all intervals during storage, than Kashi Taru and IVBL-22 cvs. Maximum PPO activity (195 Units/min/g FW) was recorded in untreated IVBL-22 cv. on final day of storage. Control fruits showed higher enzyme activity. CAT activity was recorded highest on the 8th day of storage in almost all cultivars in both the treatments. CAT activity decreased with the advancement in storage period. Chitosan treated fruit showed higher catalase activity over untreated (Fig. 21).

Estimation of solasodine in brinjal (*Solanum melongena*): The maximum content of solosodine was found in *Solanum incanum* D, EC790360 and *Solanum torvum*, while the lowest content in Jharkhand Orissa cultivated small, YSR 2015 and ADM-214. The varieties like K. Himani, K. Taru, BR-14, PR-5 and IVBL-22 showed <2 mg/100g dw content. method of Chandler and Dodds (1983). The maximum content was found in *Solanum incanum* D, EC790360 and *Solanum torvum*, while the lowest content in Jharkhand Orissa cultivated small, YSR 2015 and ADM-214. The varieties like K. Himani, K. Taru, BR-14, PR-5 and IVBL-22 showed <2 mg/100g dw content.

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

Programme Leader: Dr. Neeraj Singh

Project 5.4: Empowering rural youth for vegetable based entrepreneurship

Empowering rural youth for vegetable based entrepreneurship: In the year 2018-19 contact has been made with 124 members of self help groups (SHGs) formed under National Rural Livelihood Mission (NRLM) to study entrepreneurial behaviour and introduction of economic activities as per their interest and need. Socio-economic status of the respondents was studied. Most of the respondents were marginal (52.5%) to small (31.3%) farmers. Only 15.1% were medium and 1.3% were big farmers. Forty percent of the respondents got their earnings from farming alone, 35.1% from farming and agriculture related activities and 25% from farming and service. Economic level of the respondents showed that 20.9% belonged to APL category and 79% belonged to BPL category.

Project 5.5: Economic impact assessment of IIVR developed technologies

Twelve promising technologies were selected under major vegetable crops, which are popular in farmer's field for their economic impact assessment. Kashi Kanchan a vegetable cowpea variety released in 2007 from ICAR-IIVR, Varanasi has been studied for its economic impact during 2018-19.

The approximate spread of area under Kashi Kanchan variety was estimated at 90314.8 ha from 2007-08 to 2019-20 covering 443 districts of 29 states and 2 union territories (calculated from the sale of both TL and breeder seeds). Around 65% of the estimated total area covered was in Uttar Pradesh and Bihar. Apart from this, the variety has earned around Rs. 24.6 lakh from 2013-14 to 2018-19 under commercialization to 7 different private seed companies.

Details of farmer's field primary data collection: Farmers growing Kashi Kanchan were purposely selected for data collection. Hence all the farmers had grown this variety along with Kashi Nidhi and other local varieties; the data was collected from all the three varieties for comparison. The average area under vegetable cowpea was 1.91 acres. It was grown in both rainy (July - October) and summer seasons (February – May). Farmers were growing the variety from average 1.7 years for both the seasons.

The total cost of cultivation of Kashi Kanchan variety was Rs. 37518 per ac during summer and Rs. 34067 during rainy season compared to Rs. 76985 per ac of local variety during rainy season. The difference in the cost of cultivation of Kashi Kanchan variety over the local variety was mainly due to its short duration and bushy nature which does not require staking of the crop. The net profit earned was Rs. 36406 higher than that of local variety by growing Kashi Kanchan during rainy season and Rs. 84942 per ac earned during summer season. The BC ratio was 3.26 and 3.04 for Kashi Kanchan and 1.43 for the local variety grown in the farmer's field.

The economic impact at farmer's level was analyzed using the partial budgeting technique. The results showed that the total added cost due to adoption of Kashi Kanchan variety was Rs. 1709 per ha for the farmer. Similarly, the reduced returns for the farmers from the adoption of the technology was zero, reduced cost of cultivation due to savings on stacking and pesticide use as the variety was resistant to cowpea golden mosaic virus was Rs. 53400 per ha. Added returns due to 32 per cent higher yield of the variety was Rs. 35000 per ha. Hence, the total debit side (A+B) = 1709 + 0 = Rs. 1709 and total credit side (C+D) = 53400 + 35000 = 88400. The economic worthiness of growing Kashi Kanchan variety is given by, Credit – Debit = 88400 – 1709 = Rs. 86691/ha (Table 11).

Table 11: Economic impact of Kashi Kanchan (vegetable cowpea variety) using partial budgeting framework (Rs. per ha)

Debit side (-)		Credit side (+)	
A. Added cost		C. Reduced cost	
1. Added seed cost of K. Kanchan from the local	600	1. Reduced cost on pesticides	4400
2. Added labour due to extra yield (5 mandays @ Rs.150)	750	2. Reduced cost on trellis system	49000
3. Interest on additional WC @ 5% p.a. for 4 months	23	Total C	53400
4. Risk Premium @ 10% of additional WC	45		
5. Management Cost @ 10% of additional WC	45		
6. Research cost	194		
7. Extension cost	52		
Total A	1709		
B. Reduced returns		**D. Added returns**	
Total B	**0**	1. Higher yield (32%) over local	35000
		Total D	**35000**

Division of Vegetable Protection

MEGA PROGRAMME 6: INTEGRATED PLANT HEALTH MANAGEMENT

Programme Leader : Dr. A. B. Rai/Dr. K. K. Pandey

Project 6.1: Bio-intensive management of major insect pests of vegetables

Evaluation of different pest management modules in bottle gourd: Four pest management modules were evaluated against insect-pests of bottle gourd (cv. Kashi Ganga). Among the tested modules, module-2 (M2) *i.e.*, integrated pest management module comprising spraying of dichlorvos @ 0.75 ml/L during 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var. *Kurstaki* @2 g/L at 40 DAS, imidacloprid @0.4 ml/L at 50 DAS, *Lecanicillium lecanii* @ 5 g/L at 60 DAS and Azadirachtin 0.03% @ 10 ml/L at 70 DAS was found superior in terms of reducing red pumpkin beetle (82.43 and 62.11 per cent over control during summer and *kharif* season, respectively), whitefly (86.70 and 80.57 PROC), white plume moth (79.23 and 93.10%) and mirid bugs (71.01 and 56.07 PROC) on fruits followed by chemical module.

Evaluation of different pest management modules in pumpkin: Among the three pest management modules the integrated module (M2) comprising sprayings of DDVP 76% EC @ 0.75 mL L^{-1}at 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var *Kurstaki* @ 2 g L^{-1}at 40 DAS, Imidacloprid 17.8 SL @1 ml $3L^{-1}$ at 50 DAS, *Lecanicillium lecanii* @ 5 g L^{-1}at 60 DAS and Azadirachtin 300 ppm @ 10 ml L^{-1}at 70 DAS was most effective in reducing the red pumpkin beetle (75 and 68.65 per cent during summer and *kharif* season, respectively), white fly (44.12 and 86.90) and mirid bug population on leaves (74.24 and 87.25) with significant increase in the yield (320 q ha^{-1}) over chemical (307 q ha^{-1}), biointensive modules (289 q ha^{-1}) and untreated control (195 q ha^{-1}).

Project 6.2: Toxicological investigations on the novel and botanical insecticides against major insect-pests of vegetables

Field bio-efficacy of new insecticide molecules against major insect-pests of cauliflower: Total ten treatments comprising new insecticides were evaluated with two sprays taken at 15 days interval during *rabi* season 2018. Among these treatments, thiamethoxam 25 WG @ 0.25g/L, imidacloprid 17.8 SL @ 0.3ml/L and dimethoate 30 EC @ 2ml/L were found to be most effective with 68.05, 65.12 and 64.87 per cent protection against aphid population respectively, as compared to untreated control. DBM population was significantly reduced by cyantraniliprole 10 OD @ 1.2 ml/L with 76.02 per cent protection over untreated control. In all the treatments, minimum number of biocontrol agents ranging from 0.07 to 0.30 per plant were recorded as compared to 0.37 per plant in control.

Evaluation of different newer insecto-acaricide molecules against chilli thrips and mites: A field experiment was conducted to evaluate different newer insecticide cum acaricides against thrips and mites in chilli. Among different insecto-acaricides, chlorfenapyr 10% SC @ 1.5ml/L and fipronil 5% SC were found to be most effective against mites and thrips with 63.16 and 75.69% reduction in population, respectively, as compared to untreated control. Fenazaquin 10% EC and fenpyroximate 5% EC and spiromesifen 22.9% SC, chlorfenapyr 10% SC, emamectin benzoate 5% SG were the next best treatments against mites and thrips, respectively (Table 1).

Field evaluation of newer insecticide molecules against Pod borer, *Maruca vitrata* in vegetable cowpea: Seven newer insecticide molecules *viz.*, chlorantraniprole 18.5 SC, emamectin benzoate 5 SG, indoxacarb 14.5 SC, lambda cyhalothrin 5 EC, novaluron 10 EC, quinalphos 25 EC and spinosad 45 SC were evaluated against cowpea pod borer *Maruca vitrata* (cv. Kashi Kanchan) during *kharif* 2018. Spinosad 45 SC @ 0.3ml/L was found most effective giving 87.37% protection against cowpea pod borer population and highest yield of 142.47 q/ha as compared to untreated control (96.03q/ha).

Field evaluation of newer insecticide molecules against leaf webber, *Spoladea recurvalis* in amaranth: Novel insecticide molecules having different mode of action *viz.*, fenvalerate 20 EC, indoxacarb 14.5 SC,

Table 1: Evaluation of different newer insecto-acaricide molecules against chilli thrips and mites

Treatments	Dose (per lit)	Mites / leaf			Thrips / leaf			Spiders / plant
		Before spray	After spray	PROC	Before spray	After spray	PROC	
Spiromesifen 22.9% SC	0.8 ml	5.33	2.37^{ab}	53.80	2.41	0.72^{a}	66.97	1.45^{a}
Chlorfenapyr 10% SC	1.5 ml	5.49	1.89^{a}	63.16	2.75	0.69^{a}	68.35	1.69^{a}
Fenazaquin 10 % EC	2 ml	6.04	2.19^{a}	57.31	2.65	0.89^{ab}	59.17	1.87^{a}
Fenpyroximate 5% EC	1 ml	5.61	2.08^{a}	59.45	2.08	1.11^{b}	49.08	2.08^{a}
Emamectin Benzoate 5% SG	0.5 g	5.39	2.52^{b}	50.88	2.27	0.61^{a}	72.02	1.96^{a}
Fipronil 5% SC	2 ml	6.14	2.97^{c}	42.11	2.36	0.53^{a}	75.69	1.37^{a}
Propargite 57% EC	2.5 ml	5.98	2.59^{b}	49.51	2.49	1.46^{c}	33.03	1.11^{a}
Untreated control	--	5.64	5.13^{d}	--	2.40	2.18^{d}	--	4.23^{b}
SEm(±)	--	--	0.15	--	--	0.11	--	0.35
LSD (5%)	--	--	0.37	--	--	0.26	--	0.97

* Average of 15 observations over three sprays of different treatments at 15 days interval; PROC=Per cent Reduction over Control

chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG, novaluron 10 EC, spinosad 45 SC and cypermethrin 10 EC were evaluated against amaranth leaf webber *Spoladea recurvalis* (VR AM-44) during *kharif* 2018. Indoxacarb 14.5 SC and Chlorantraniliprole 18.5 SC were found most effective giving 85.92 and 84.73% protection over control, respectively in amaranth leaf webber population (Table 2).

Table 2: Field evaluation of novel insecticides against *S. recurvalis* in amaranth

Treatments	PTC	Average *S. recurvalis* population*	PPOC
Chlorantraniliprole 18.5 SC @0.3ml/L	8.80±0.53	1.73±0.18	84.73±1.43
Emamectin Benzoate 5 SG @ 0.2 g/L	5.73±0.29	3.20±0.23	71.80±1.75
Indoxacarb 14.5 SC @ 0.5 ml/L	8.67±0.18	1.60±0.23	85.92±1.89
Cypermethrin 10 EC @ 1ml/L	10.13±0.18	3.07±0.18	72.91±1.80
Novaluron 10 EC @ 1 ml/L	9.73±0.35	3.20±0.23	71.76±2.09
Fenvalerate 20 EC @ 1 ml/L	6.73±0.44	3.67±0.24	67.67±1.88
Spinosad 45 SC@ 0.3 ml/L	7.21±0.24	2.27±0.24	80.03±1.97
Control	10.67±0.07	11.33±0.13	-
CD	0.97	0.59	-
SEm±	0.32	0.19	-

PTC= Pre Treatment Count, PPOC = Per cent Protection over Control, *Pooled data of three spray

Determination of median lethal concentration of some new insecticide molecules against *Spilosoma obliqua*: A laboratory experiment was conducted against third instar larvae of *S. oblique* to determine median lethal concentration. Five insecticides comprising of novel and conventional molecules were evaluated by leaf dip method. *S. obliqua* larvae were found highly susceptible to lambda cyhalothrin and quinalphos with lowest LC_{50} values at 24 and 48HAT, respectively. Lambda cyhalothrin (148.23 ppm) as recorded lowest LC_{50} and was found to be more effective against *S. obliqua* followed by indoxacarb (186.51 ppm) and quinalphos (239.96 ppm) at 24 hours after treatment (HAT) while at 48 and 72 HAT, quinalphos (12.07 and 2.876 ppm) was found to be most effective.

Comparison of efficacy of new insecticide molecules against *Spodoptera litura* through different bioassay methods: Six newer insecticides having novel mode of action belonging to different chemical groups were tested under *in vitro* condition by three different bioassay methods *viz.,* leaf dip, topical application and direct spray method against third instar larvae of *Spodoptera litura.* In all the three bioassay methods large variation was observed in the larval mortality. *S. litura* larvae was proved to be highly susceptible to indoxacarb in leaf dip (31.28ppm) and topical application method (11.16ppm) and to emamectin benzoate in direct spray method (186.34ppm) with lowest LC_{50} values recorded at 24 HAT. Among three bioassay methods, leaf dip method as recorded maximum larval mortality and found to be the suitable method to determine toxicity of new insecticide molecules .

Project 6.3: Biological control of major insect-pests of vegetable crops

Collection and identification of important natural enemies from brinjal ecosystem: Two prominent encyrtid Aligarh endoparasitoid *viz*., *Leptomastix nigrocincta* Risbec and *Aenasius* spp. feeding on brinjal mealybug, *Centrococcus insolitus* were identified with the help of AMU, Aligarh during *kharif* season of 2018-19. A hyperparasitoid *Prochiloneurus pulchellus* Silvestri was also recorded from the endoparasitoid (Fig.1). Similarly, three Coccinellid polyphagous predators *viz*., *Coccinella septempunctata*, *Menochilus sexmaculatus* and *Micraspis discolor* were also recorded form the brinjal ecosystem during the study (Fig.2).

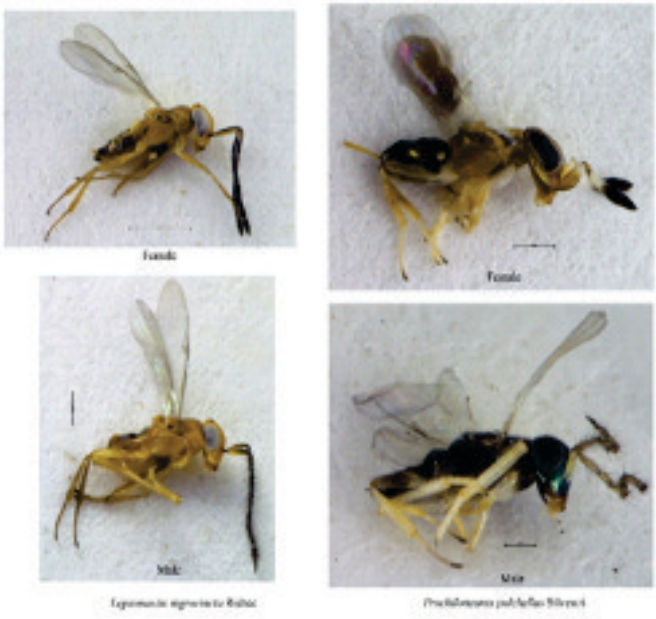


Fig. 1: Female and male of primary parasitoid, *Leptomastix nigrocincta* (Left) and the hyperparasitoid, *Prochiloneurus pulchellus* (Right)

Micraspis* sp.** ***Eocanthecona furcellata

Fig. 2: Adults of Coccinellid predators, *Coccinella septempunctata* L., *Menochilus sexmaculatus* (Left), *Micraspis* sp. (Middle) and the nymphs and adult of preadatory pentatomid bug, *Eocanthecona furcellata* (Right)

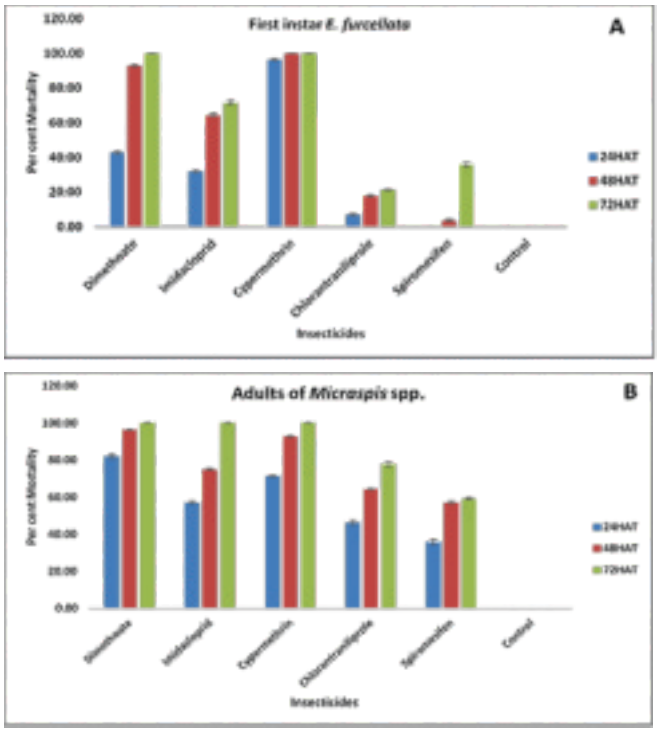


Figure 3: Effect of insecticides against a predatory pentatomid bug (a) *E. furcellata* and (b) coccinellid beetle *Micraspis* sp.

Biosafety evaluation of certain insecticides against a predatory pentatomid bug, *Eocanthecona furcellata* and coccinellid beetle *Micraspis* sp. under laboratory conditions: Five different insecticides were tested against a preadory bug and the coccinellid beetle at field recommended doses under laboratory condition. Among these insecticides tested against *E. furcellata*, chlorantraniliprole and spiromesifen were found to be harmless (< 30% mortality); dimethoate and imidacloprid were slightly toxic (30-79% mortality); and cypermethrin was moderately toxic (80-99% mortality) in leaf residue bioassay method (Fig. 3 a). Against *Micraspis* sp., imidacloprid, chlorantraniliprole and spiromesifen were found to be slightly toxic (30–79% mortality); whereas dimethoate and cypermethrin were moderately toxic (80-99% mortality) in leaf residue bioassay method (Fig. 3 b).

Distribution, host range, taxonomy and bionomics of *Rhopalosiphum nymphaeae* (Linnaeus, 1761), a polyphagous aphid in aquatic vegetables: Occurrence of water lily aphid, *Rhopalosiphum nymphaeae* (Linn., 1971) (Aphididae: Homoptera) on different aquatic plants from Varanasi was observed. Both nymphs and adults prefer to feed on petiole, leaf lamina and buds towards terminal portion of different

aquatic plants. They suck the cell sap resulting in curling of leaves, stunted plant growth with lower number of fruits in water chestnut. The aphid population initiated on water chestnut from last week of October (1.35 aphids leaf^{-1}) coinciding with the initiation of winter in the region. Its population gradually increased from November till January months with a highest peak (21.95 aphids leaf^{-1}) during fourth week of January. An untimely rain lashed out during last week of January (Fig. 4) and the maximum population of *R. nymphaeae* washed away leading to the drastic reduction of aphid population during last week of January (9.55 aphids leaf^{-1}). From March onwards population of aphids gradually declined and was nil from second week of April onwards.

Among the 6 different host plants analysed for host preference with the help of a six-armed olfactometer, significantly the highest number of *R. nymphaeae* (28%) were attracted towards the young leaves of lotus followed by leaves of water chestnut (21.3%) and water lily (20%). So, their descending order of attraction/preference towards different hosts was lotus> water chestnut > water lily > water spinach > Azolla > water hyacinth.

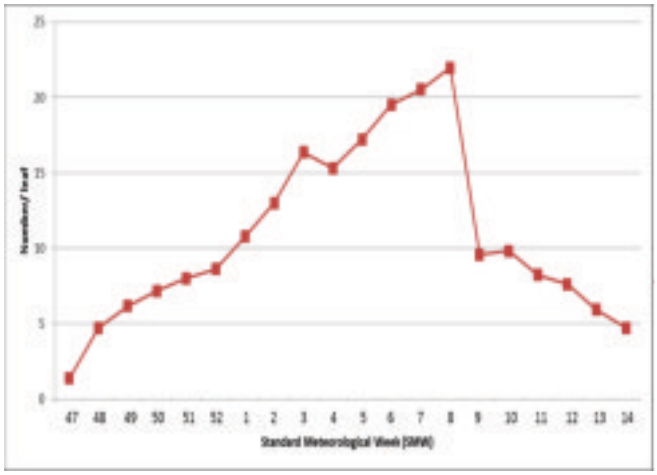


Fig. 4: Seasonal incidence of *R. nymphaeae* on water chestnut in Varanasi

Amongst the different biopesticides tested, *L. lecanii* was found most promising and registered lowest median lethal time (31.09 h) followed by *neem* oil (41.59 h) and *M. anisopliae* (43.95 h). When, these three EPF were mixed with *neem* oil at 1:1 ratio and sprayed at half of their recommended doses, *L. lecanii* and *neem* oil showed their highest compatibility and synergistic activity against the adults of *R. nymphaeae* as evidenced by their lowest median lethal time of 23.60 h amongst all the treatments (Table 3).

Bionomics and biorational management of *singhara* beetle, *Galerucella birmanica*, a potential threat to water chestnut: The plant was severely infested by *singhara* beetle, *Galerucella birmanica* during July to November in Varanasi region. Almost 100% plants and 70–80% leaves were infested by the grubs and adults of this beetle. Under laboratory conditions, the biology of the pest revealed that the incubation, larval and pupal periods were 4.15±0.56, 12.75±0.80 and 2.80±0.40 days, respectively. Adult females lived longer (21.10±1.57 days) than the males (16.38±0.77). Gravid females laid on an average 90.4±14.67 eggs, whereas egg viability was 58.9±3.75 per cent (Table 4). Amongst the different biopesticides tested, *neem* oil was found most promising having lowest median lethal time of 17.32 h followed by *Metarhizium anisopliae* IIVR strain (52.67 h). Combinations of these entomopathogenic fungi (EPF) and *neem* oil (1:1) had lower LT_{50} values than each of their individual indicating the compatibility among them.

Table 3: Bio-efficacy of different EPF alone and in combination with *neem* oil (1:1) against adults of *R. nymphaeae*

Biopesticides	Heterogenity		Regression Equation (Y=)	LT_{50} (hr)	Fiducial Limit
	df	χ^2			
Metarhizium anisopliae	6	0.524	2.570X - 0.777	43.95	53.69 – 35.98
Beauveria bassiana	7	0.512	2.792X – 0.212	51.90	64.81 – 41.56
Lecanicillium lecanii	5	2.408	2.210X – 1.701	31.09	39.27 – 24.62
Neem oil (1%)	6	2.499	2.519X – 0.922	41.59	50.71 – 34.10
Metarhizium anisopliae + *Neem* oil	5	0.402	2.438X – 1.509	27.03	34.45 – 21.22
Beauveria bassiana + *Neem* oil	5	0.676	1.990X – 0.932	36.04	45.81 – 28.36
Lecanicillium lecanii + *Neem* oil	5	0.903	3.189X – 0.622	23.60	29.40 – 18.94

Table 4: Biological events in life-cycle of *G. birmanica* on water chestnut under laboratory conditions

Biological parameters	Minimum	Maximum	Mean* ± SD
Fecundity (Nos.)	73	111	90.4 ± 14.67
Egg viability (%)	53	64	58.9 ± 3.75
Incubation period (days)	3.50	5.50	4.15 ± 0.56
Larval duration (days)			
First instar	3.25	4.25	3.68 ± 0.39
Second instar	4.50	5.25	4.85 ± 0.36
Third instar	4.00	4.75	4.28 ± 0.38
Total larval period	11.75	14.00	12.75 ± 0.80
Pre-pupal period (days)	2.50	3.25	2.80 ± 0.40
Pupal period (days)	3.50	4.75	3.98 ± 0.52
Adult longevity (days)			
Male	15.50	17.25	16.38 ± 0.77
Female	19.00	23.75	21.10 ± 1.57

SD= Standard Deviation; *Means are based on thirty replications

Compatibility and synergism of major neonicotinoids with different entomopathogenic fungi (EPF) against *Myzus persicae* Sulz: To control the polyphagous *Myzus persicae* feeding cole crops commonly using neonictinoids (Imidacloprid, thiamethoxam and acetamiprid) and biopesticides *viz*., *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii* were tested at half of their recommended doses and found compatible. Combination of acetamiprid and *L. lecanii* took the lowest median lethal time (22.68 hour) with co-toxicity coefficient (CTC) value with respect to entomopathogenic fungi (2.18). A similar observation was also noted in case of thiamethoxam where *L. lecanii* when mixed with thiamethoxam at half of their recommended doses took the lowest median lethal time (27.81 hour) and with CTC value with respect to EPF was 1.78. Similar observation was also noted with combination of imidacloprid and three EPF. Co-application of these EPF with sub-lethal concentration of neonicotinoids could not only be a green eco-friendly option against this sucking pest but also able to minimize the chemical insecticides load in the environment.

Morphological characterization and morphometrics of entomopathogenic nematode *Steinernema siamkayai*: Molecularly characterized entomopathogenic nematode *Steinernema siamkayai* strains such as IIVR EPN03 (MG976754), IIVR JNC01 (MH208855) and IIVR JNC02 (MH208856) were studied for their morphology and morphometrics. In this study, wax moth (*Galleria mellonella*) larvae infected with these EPN strains were dissected in ringer solution on third and fifth day and processed samples and examined first, second generation adults and third stage infective juveniles under upright trinocular research microscope at ICAR-NBAIR, Bengaluru (Fig. 5 (a) & (b)). The study confirmed that, morphological characters of these strains were similar with originally published description of *S. siamkayai* (Table 5).

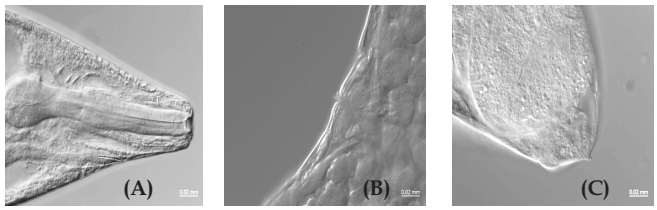


Fig. 5 (a) : First generation female: A. Anterior part with excretory pore, B. Vulva with epiptygma, C. Tail with mucro. (400x)

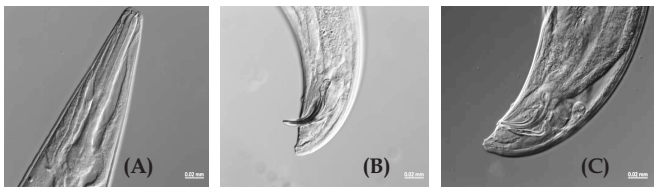


Fig. 5 (b) : First generation male: A. Anterior part with excretory pore, B. Spicule lateral view with mucro, C. Gubernaculum lateral view (400x)

Table 5: Morphometrics of *Steinernema siamkayai* (Measurements are in µm)

Characters	First generation		Second generation		Infective juvenile
	Male	Female	Male	Female	
Body length	1098-1124	3897-3921	785-906	1812-1919	452-472
Anterior end to excretory pore	59-62	61-68	59-63	65.5-69.2	32-36
Mucro length	3.0-3.3	8.0-8.8	2.8-3.0	4.7-5.2	-
Spicule length	76-79	-	59-63.2	-	-
Gubernaculum length	52-57	-	42.5-46.0	-	-

Heat tolerance of *Steinernema siamkayai*: To determine effect of temperature on survivability of two EPN strains of *S. siamkayai* a laboratory study was conducted. In this study, multi-well plates were filled with 2.5 ml of distilled water containing approximately 1000 freshly emerged third stage infective juveniles (IJs) and exposed to different temperature levels 5, 10, 15, 20, 25, 30, 35, 37 and 40°C at 24 h and 48 h exposure period . The results revealed that, upon completing the maximum exposure time at 5 to 37°C, the percentage survival of IIVR JNC01 strain was ranging from 1000 to 95.4%. In IIVR EPN03 though 100% survival was

observed after exposure to 20 to 30°C, but decreased survival per cent was observed at lower temperature levels *i.e.* 15 to 5°C and higher temperature levels *i.e.* 35 and 37°C. However, both the strains did not survive at 40°C.

Virulence assay of *Steinernema siamkayai* IIVR JNC01 on water chestnut beetle *Galerucella birmanica*: A laboratory experiment was conducted to determine the pathogenicity of indigenous entomopathogenic nematode strain, *Steinernema siamkayai* IIVR JNC01 on second instar larvae of water chestnut beetle, *Galerucella birmanica*. Each petri-dish was filled with 6 g sand. Soil moisture was maintained up to the field capacity and provided fresh leaf as food source. Further each petri dish was inoculated with the treatments at five levels: 0, 25, 50, 100, 200 infective juveniles per instar. After 1 h, ten second instar larvae were released to each petri-dish. After 48 h mortality of dead cadavers were examined and confirmed nematode infection through white trap method. The results revealed that *S. siamkayai* IIVR JNC01 was capable to infect and cause mortality between 55-100% at 25 to 200 IJ's concentration (Fig. 6).

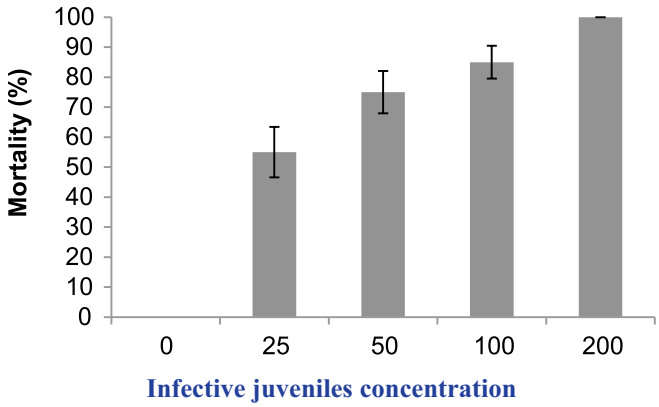


Fig. 6: Per cent mortality of second instar larvae of *Galerucella birmanica* at different infective juvenile concentrations of entomopathogenic nematode *Steinernema siamkayai* IIVR JNC01 at 48h after treatment.

Project 6.4: Development of effective integrated management package for important fungal diseases of vegetable crops

Experiment was conducted on tomato variety Kashi Aman and its seed showing was carried out on 14th August in solarized nursery beds. The transplanting of theses nursery was completed in green manured field on 19th September. Six different Integrated Diseases Management (IDM) modules were imposed with its following details:

T1-Chemical module: Seed treatment by carbendazim @ 0.2% and nursery drenching of pencycuron @ 5 liter/m^2 of 0.1%, seedling drenching by fosetyl-Al @ 0.1% after 15 days of sowing, One spray of streptocycline @ 150 ppm on seedling after 20 days of sowing, seedling root dip in imidacloprid @ 0.04% for 30 minutes just before transplanting, one spray of copper oxychloride @ 0.3% after 25 days of transplanting (DAT).

T2-Biological module: Seed treatment by *Trichoderma* sp. (BATF-43-1) @ 1%, Nursery application of talc based *Trichoderma* sp. (BATF-43-1) @ 25 gram/m^2, seedling root dip in slurry BATF-43-1 10 gram + 100 gram FYM/vermicompost + 250 ml water, drenching by BATF-43-1 @ 1% thrice at 25 days interval started 25 DAT.

T3-Good agricultural practices (GAP) module: Soil application with neem cake @ 100 gram/m^2 10 days before sowing, seed soaking in cow urine for 60 minutes, nursery bed covering by 40 mesh nylon net, seedling root dipping in cow dung slurry, spot use of vermicompost @ 50g/plant thrice at 25 days interval, foliar spray of micronutrient @ 0.2% twice at 25 days interval, *neem* oil sprays @ 0.3% twice at 20 days interval Azatarachtin 0.03% (300ppm).

T4-Integrated module: Seed treatment by *Trichoderma* sp. BATF-43-1, seedling drenching of talc based BATF-43-1@ 1%after 15 days after sowing, spray of streptocycline @ 150 ppm on seedling 20 days after sowing, seedling root dip in imidacloprid @ 0.04% for 30 minutes followed by BATF-43-1 @ 1% for 10 minutes, spot application of (BATF-43-1) 10 g + vermicompost 50g/plant thrice at 25 days interval started 25 DAT, one spray of copper oxychloride @ 0.3% after 30 days of transplanting.

T5-Research gap module: Seed treatment by *T. asperllum* @ 0.5%+ *Bacillus subtilis* @ 0.5%, imidacloprid @ 0.03% + *T. asperllum* @ 1%, drenching of CRB7 (*Bacillus subtilis* as antagonistic to *S. rolfsii*, *M. phaseolina* and RKN as well as IAA producer) @ 1% +TRB17 (*Stenotrophomonas maltophila*) as antagonistic to *F. oxysporum*) @ 1% thrice at 25 days interval started 25 DAT, foliar spray of BS2 @ 1% thrice at 25 days interval after 25 DAT.

Observation on different diseases component revealed that good agricultural practices (GAP-T3) module was best for maximum seedling stand, biological module (T2) for minimum early blight, research gap module (T5) for minimum late blight and integrated module (T4) was the best for minimum root

knot nematode (RKN) incidence in comparison to control. Maximum marketable yield was obtained in biological module (T2). Unmarketable yield comprising maximum 60% diseased fruits, 20% bird damage, 10% borer & *Tuta*, rest 10% abiotic stress. Out of total diseased fruits, 50% early blight infected fruits, 25% late blight, 20% *Rhizoctonia* infected fruits, 5% soft rots and other secondary pathogens infected fruits (Fig. 7).

Fig. 7: Evaluation of different IDM modules on tomato nursery variety Kashi Aman

Effect of talcum based powder on seedling stand of chilli in net house conditions: Damping off was very severe in chilli during August, 2018 hence an experiment was conducted in net house using different fungal and bacterial bioagents of institute claimed as potential for the management of damping off diseases of nursery.

These bioagents were applied uniformly @10 grams per pot having two kg of field soil. Two types of pots *i.e.* earthen and plastic pots were used for the experimentation. Bioagents performance was compared by standard fungicide captan and control. Earthen pots were better than plastic pots for increasing seedling stand (Fig. 8). Soil application of talc based formulations of *Stenotrophomonas maltophila (TRB-17)* was best followed by captan in comparison to control and other bioagents. Interestingly two bioagents *i.e.* CRB-7and BATF-43-1 was inferior than control (Table 6).

Table 6: Chilli seedling stand in relation to different bioagents

Treatments	Dose	Plastic pot	Earthen pot
		Seedling stand % 32 DAS	Seedling stand % 33 DAS
T1- Captan	5g/pot	69.9	83.3
T2- BS2 (*Bacillus subtilis*)	10g/pot	48.9	65.8
T3- BATF-43-1 (*Trichoderma* sp. IIVR-2)	10g/pot	43.3	51.7
T4- *T. asperllum*	10g/pot	59.4	78.0
T5- TRB-17 (*Stenotrophomonas maltophila*)	10g/pot	76.9	84.2
T6- CRB-7 (*Bacillus subtilis*)	10g/pot	41.9	54.2
T7- Control	-	45.4	55.8

Fig. 8: Evaluation of bioagents on chilli seedlings grown in earthen pots

Monitoring quality control of bioagent formulations: Quality of different fungal and bacterial bioagents must be determined before use in research purpose and distribution to stakeholders for seed and soil application. *Trichoderma asperllum* was produced in bulk quantity for management of soil borne diseases under R&D while others exclusively for research purpose. All the bioagents were produced on talcum powder. The total fungal colony of the bioagents were determined on Peptone Dextrose Rose Bengal Agar medium at serial dilution 1:1000 while total bacteria on Soil Extract Agar medium at 10^6 serial dilution (Table 7). *Trichoderma asperllum* was distributed about 15 kg to

Table 7: Viable spore count of different bioagent talcum based formulations

Bioagents	Production time	cfu/gram of formulation	Production (kg)
Trichoderma asperllum	18.7.2018	1.7×10^7	68
Trichoderma sp. (BATF-43-1)	30.6.2018	0.6×10^7	4.0
Stenotrophomonas maltophilia TRB-17	30.6.2018	3.0×10^9	4.0
Bacillus subtilis (CRB-7)	30.6.2018	2.6×10^9	4.0
Bacillus subtilis (BS-2)	30.6.2018	5.4×10^9	3.0

IIVR scientists, 18 kg in organic block, 15 kg to KVK Deoria and one kg each for seed treatment to trainees of Jaunpur, Dumaka and Meerut districts.

Effect of soil solarization on biological and chemical properties of the soil: Soil samples were from solarized and unsolarized nursery beds and plated on Peptone Dextrose Rose Bengal Agar medium at serial dilution 1:1000 and incubated for 10 days (Table 8).

Table 8: Effect of solarization of nursery beds on total fungal population

Soil fungi	Solarized cfu/g of soil	Unsolarized cfu/g of soil
Aspergillus niger	1.3 x 10^3	3.3 x 10^3
A. luchuensis	-	1.3 x 10^3
A. flavus	2.2 x 10^3	3.2 x 10^4
A. fumigatus	2.0 x 10^3	3.8 x 10^3
A. parasiticus	-	1.3 x 10^3
Eurotium sp.	-	1.7 x 10^3
Glomus mosae	-	1.0 x 10^3
Rhizopus stolonifer	-	1.0 x 10^3
Fusarium sp.	-	1.8 x 10^3
Pytium sp.	-	3.3 x 10^3
Unidentified	-	2.0 x 10^3
Trichoderma sp.	2 x 10^3	-
Total	**7.3 x 10^3**	**2.37 x 10^4**

Fig. 9: Fungal colony isolated from solarized and unsolarized nursery bed on PDA plates

Microscopic observation of each colony was recorded. Colony of the fungi was counted. Further all the colonies were purified by hyphal tip method on potato dextrose agar plate (Fig. 9) and microscopic observation were made to identify the pathogen. Total soil fungi were 7.3 x 10^3 in solarized soil and significantly very high 2.37 x 10^4 in unsolarized nursery beds (Table 8). Pathogenic fungi like *Pythium* and *Fusarium* were suppressed during solarization process. Total actinomycetes count was 3.9 x 10^5 in solarized soil and 6.6 x 10^5 in unsolarized soil. Weeds particularly nut grass (*Cyprus rotundas*) population drastically reduced (95.1%) in solarized nursery bed over unsolarized beds and its count was 590/m^2 in unsolarized in comparison to 29/m^2 in solariozed beds.

Similarly soil samples were analyzed for its various chemical properties and the quantity of available phosphorus, sulpher, boron, zinc and copper slightly increased after solarization (Table 9).

Table 9: Effect of solarization of nursery beds on chemical properties of soil

Soil factors	Solarized	Unsolarized
pH	7.39	7.47
Electrical conductivity (ds/m)	0.15	0.15
Organic carbon (%)	0.49	0.51
N (kg/ha)	279.5	273.6
P (kg/ha)	42.4	37.6
K (kg/ha)	256	272
S (ppm)	38.6	33.5
B (ppm)	1.79	1.43
Mn (ppm)	15.25	16.21
Zn (ppm)	8.6	5.5
Cu (ppm)	1.9	1.1
Fe (ppm)	16.0	19.3

Associated microorganisms in NADEP and vermicompost of IIVR: Two organic supplements *i.e.* NADEP and vermicopmost were analyzed for presence of fungal populations. The fresh samples were collected in the first week of September and plated on Peptone Dextrose Rose Bengal Agar medium at serial dilution 1:1000 and incubated for 10 days. Microscopic observation of each colony was recorded. Colony of the fungi was counted. Further all the colonies were purified by hyphal tip method on potato dextrose agar plate and microscopic observation were made to identify the pathogen. Total fungi were maximum 1.18 x 10^4 cfu/g of vermicopmost sample observed as compared to NADEP (5.3 x 10^3) (Table 10). Pathogenic fungus *Fusarium* and *Pythium* were recorded more in vermicompost as compared to NADEP.

Table 10: Total fungal population in two different organic sources in August-September

Soil fungi	Varmicopmost cfu/g of sample	NADEP cfu/g of sample
Aspergillus flavus	2.1 x 10^3	0.6 x 10^3
A. ochraceous	0.8 x 10^3	1.0 x 10^3
A. parasiticus	1.3 x 10^3	0.3 x 10^3
A. niger	1.4 x 10^3	-
A. fumigatus	0.9 x 10^3	-
Agaricus sp.	0.4 x 10^3	1.0 x 10^3
Pythium sp.	0.9 x 10^3	0.7 x 10^3
Fusarium sp.	0.6 x 10^3	0.3 x 10^3
Colletotrichum sp.	0.1 x 10^3	-
Curvularia sp.	0.1 x 10^3	-
Rhizoctonia sp.	1.8 x 10^3	0.8 x 10^3
Rhizopus stolonifer	0.4 x 10^3	0.6 x 10^3
Unidentified	1.0 x 10^3	-
Total	**1.18 x 10^4**	**5.3 x 10^3**

Status of *Trichoderma asperllum* after amalgamation in vermicopmost and NADEP: Generally *Trichoderma* spp. has been mixed in different organic matters like FYM, vermicompost, NADEP and oil cake assuming it will multiply enormously on this organic substrate. However, it has never been considered that the inherent fungal, bacterial and actinomycetes of this organic matter are antagonistic or synergistic or inactive against the *Trichoderma*. In view of above 500 gram vermicmpost and NADEP were mixed with talcaum based *Trichodrma asperllum* having viable spore of 1x10^7cfu/ gram at different dose @5-50 gram/kg compost. This mixture was kept in small plastic pots @ 250/ pot (Fig. 10) for fifteen days and colony status of *Trichoderma* was determined on Potato Dextrose Rose Bengal Agar medium. The population of *Trichoderma asperllum* decreased after amalgamation in all dose in vermicompost as well as NADEP (Table 11). Other fungi were recorded at lower doses in both the organic supplement but its number was higher in vermicompost than NADEP. Gradually colony of *Trichdoerma* increased at higher dose in both the organic matter.

Fig. 10: Viability study of *Trichoderma asperllum* in vermicompost and NADEP

Antagonism of entomopathogenic fungi by *Trichoderma* spp.: Three different entomopathogenic fungi *viz., Beauveria bassiana*, *Lecanicillium lecani* and *Metarhizium anisopliae* are being used since last several years for biocontrol of sucking pests. These are soil inhabitant fungi just like *Trichoderma*. Sometime all these biocontrol are used along with *Trichoderma* for

Table 11: Fungal status at different dose of *T. asperllum* amalgamation in two organics source

Treatment (g/kg)	Vermicompost (cfu/g of sample)	NADEP (cfu/g of sample)
T1- 5g	*T.asp.*3.7 x 10^3, *A. niger*-2.7 x 10^3, *Fusarium*-1.7 x 10^3, *Rhizoctonia*-1 x 10^3, *Pythium* -0.3 x 10^3, *Curvularia*-0.3 x 10^3, Unidentified-1.3 x 10^3	*T.asp.* 4x 10^3 , *A. niger*-1.7 x 10^3 , Unidentified 0.3x 10^3
T2 – 10g	*T.asp.* 4 x 10^3 , *A. niger*-4 x 10^3, *A. flavus* 2.3 x 10^3, *Fusarium*-1.3 x 10^3, *Pythium* -0.3 x 10^3.	*T.asp.* 9 x 10^3
T3 - 20g	*T.asp.* 9 x 10^3 , *Rhizoctonia*-1 x 10^3, *Pythium* -0.7 x 10^3,	*T.asp.* 9 x 10^3 , *A. niger*-0.3 x 10^3,
T4 – 30g	*T.asp.* 6 x 10^3 ,*A. niger*-1.5x 10^3, *Fusarium*-1x 10^3 ,*A. flavus* 2 x 10^3, Unidentified-2 x 10^3	*T.asp.* 1.1 x 10^4
T5 – 40g	*T.asp.* 1.3 x 10^4 ,*A. flavus* 5.7 x 10^3, *A. fumigatus* 0.3 x 10^3, Unidentified-0.3 x 10^3	*T.asp.* 1.2 x 10^4
T6 – 50g	*T.asp.* 1.4x 10^4	*T.asp.* 1.5 x 10^4
Control	*A. niger*-8 x 10^3 , *A. fumigatus* 1 x 10^3, *A. flavus* 1.5 x 10^3, *Fusarium*-0.5 x 10^3, *Pythium* -1.5 x 10^3,	*A. niger*-9.7 x 10^3 , *A. flavus* 2 x 10^3, *A. ochraceous* 0.3 x 10^3, Unidentified 2 x 10^3,

management of diseases and insect-pests in crop plants without considering its compatibility. Considering these facts an *in vitro* experiment was carried out using dual culture technique. Interestingly all these entomopathogenic bioagents were completely antagonized by the *Trichoderma* (Fig. 11). It indicates that these cannot be used as soil application and the inherent insect bioagents of soil may be depleted by the antagonistic behaviors of *Trichoderma.*

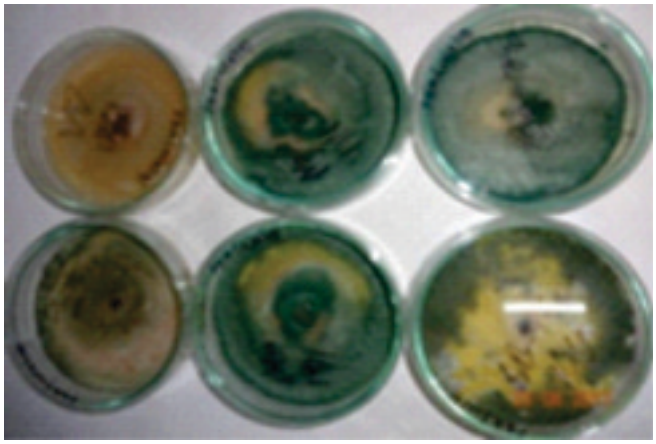


Fig. 11: Antagonism of entomopathogenic bioagents by *Trichodrma* spp.

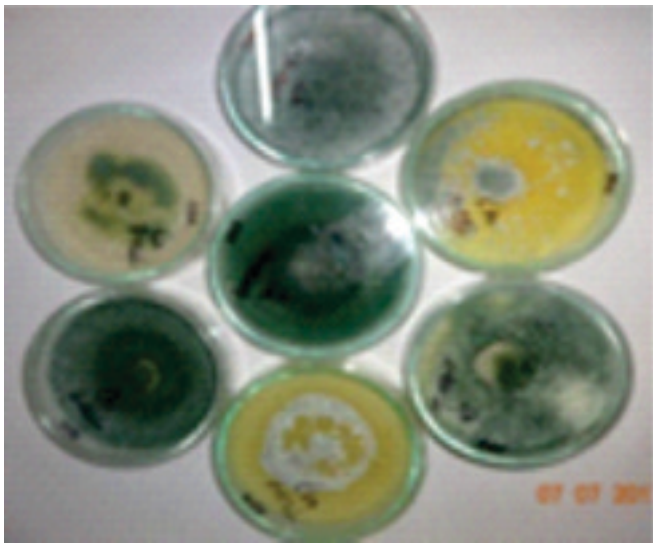


Fig. 12: *Trichoderma* spp. isolated from wilted and rotted roots of tomato, chilli and bottle gourd

Isolation and characterization of different *Trichoderma* isolates from vegetable crops: During examination of wilted and root rot plants of various vegetable crops particularly tomato, chilli and bottle gourd some of the roots were superficially colonized by fungal colonies. This colony was isolated, purified and identified as *Trichoderma*. Colony characters, growth pattern and sporulation behavior was recorded on culture media (Fig. 12). Total five different isolates of *Trichoderma* were purified and pure cultures are being maintained in the laboratory. The isolates of *Trichoderma* were named as TTV-1, TTV-2, TCV-1, TCV-2 and TBG-V and compared with *Trichoderma asperllum* as well as BATF-43-1 isolate of IIVR.

***In vitro* evaluation of Actinomycetes against soil pathogen:** Actinomycetes strains were isolated from Vermicompost (17 strains), NADEP (11 strains), and vermiwash samples (13 strains), and were evaluated *in vitro* for biocontrol potential against pathogenic fungi [*Sclerotonia* sp., *Sclerotium* sp., and *Macrophomina* sp.] by dual culture technique on PDA. Among all the isolates, actinomyces sp. strain N1.2 isolated from the NADEP showed promising broad spectrum biocontrol potential against all the three fungal pathogens inhibiting > 75% radial growth of the pathogen within 4 days of incubation at ambient temperature during January, 2019.

Screening of tomato for bacterial leaf blight resistance: A total of 94 advanced tomato lines including few varieties were screened against bacterial leaf spot under natural epiphytotic conditions. Tomato was transplanted in last week of July and screening was carried out in last week of September on 0-5 basis of rating scale on ten randomly selected plants from each replication. It was observed that out of 94 lines only six lines. RR-323-01, Kashi Chayan, Pusha Rohit Unique 1, VRTH-16-5, TolCV-28, VRTH-18-51, Mont-Favet (Table 12) were resistant in which PDI varied from 5-7% while 10 were moderately resistant (13-21%). These lines can be utilized for further research on bacterial blight resistant variety development.

Table 12: Bacterial leaf spot screening of tomato advanced lines

Rating grade and PDI	Disease reaction	Numbers	Name of tomato line
1 (<10)	Resistant (R)	6	PR-323-01, Kashi Chayan, Pusa Rohit, Unique-1, VRTH-16-5, ToLCV-28, Vrth-18-51, Mont-Favet
2 (11-25)	Moderately Resistant (MR)	10	ToLCV-32-1, VRTH-16-4, Vaibhav, DVRT-2, VRT-2, H-88-78-1, VRTH-18-1, VRTH-16-70, Ageta-30, VRTH-77

Project 6.5: Bio-prospecting of microbial agents with vegetables against plant pathogen

Isolation of strains of microbial bioagents: 56 different strains of microbial bioagents namely 12 endophytic bacteria (6 from pointed gourd and 5 from bottle gourd including one strain of *Pseudomonas fluorescens* from winged bean), 3 *Trichoderma harzianum* and 41 *actinomycetes* (17 from vermicompost, 11 from NADEP, and 13 from vermi-wash) were isolated using serial dilution and spread plate technique and pure cultures were established on specified agar medium for further experimentation.

***In vitro* antagonism of established *T. harzianum* strains against soil borne vegetable pathogens:** *In vitro* antagonism of *T. harzianum* strains were tested against soil borne vegetable pathogens *viz. Fusarium oxysporum* (winged bean), *Rhizoctonia solani* (cauliflower), *Macrophomina phaseolina* (musk melon), *Sclerotium rolfsii* (tomato and cluster bean), *F. verticilloide* (chilli) under dual culture confrontation test in which results revealed that highest mycelial growth inhibition efficacy, recorded with Th-2 (42.85-100%), followed by Th-3 (28.57-100%) and Th-1 (14.28-100%).

Evaluation of *B. subtilis* IIVR strain CRB-7 under field condition: Biocontrol modules of *B. subtilis* IIVR strain CRB-7 comprises T1 (root dipping @1% PGPR solution), T2 (Root dipping @1% PGPR solution, basal application of enriched NADEP compost (10g/kg)], T3 (Root dipping @1% PGPR solution, basal application of enriched FYM (10g/kg)], T4 (Root dipping @1% PGPR solution, basal application of enriched vermicompost (10g/kg)], T5- control evaluated under field condition in tomato. The highest yield recorded with treatment T2- root dipping @1%, soil application of enriched NADEP compost (10g/kg) with 3 soil drenching @ 1% at 15 days' intervals after transplanting (Table 13).

Table 13: Evaluation of PGPR bioagent IIVR strain CRB-7 in tomato

Treatment	No of branch	Height (cm)	Yield (t/ha)
T1-Root dipping @1% PGPR solution	4.46	77.70	31.76
T2-Root dipping @1% PGPR solution, basal application of enriched NADEP compost (10g/kg)	5.13	78.86	33.65
T3-Root dipping @1% PGPR solution, basal application of enriched FYM (10g/kg)	5.23	84.30	32.45
T4-Root dipping @1% PGPR solution, basal application of enriched Vermicompost (10g/kg)	6.16	79.16	31.86
T5- Control	3.70	59.43	27.32
C.D.	NS	11.59	NS
SE(m)	0.97	3.50	2.62
C.V.	34.28	7.99	8.05

No. of soil drenching 3 @ 1% at 15 days' interval after transplanting

Project 6.6: Management of important bacterial diseases of vegetables

Isolation and confirmation of bacteria from bacterial wilt infected solanaceous crops particularly chilli and brinjal: During 2018, samples of wilted plants of brinjal (*Solanum melongena* cv. Naveen) and Chilli (*Capsicum annuum* cv. VNR 305) were obtained from Kushi Dour and Khyotha district of Sonabhadra. Pure culture of pathogen isolate was established using nutrient agar and Kelman's Tetrazolium Chloride (TZC) medium from chilli and brinjal. Morphological and cultural variability and biochemical test of EPPO standard were performed for confirmation and identification of the isolated bacterial pathogen. *Pseudomonas* agar base were conducted. Physiological tests revealed that pathogen isolate reaction positive for utilization of tested substrates. The pathogen was gram negative rod shaped and also exhibits wide cultural and physiological variability. Biochemical tests were performed for oxidation of sugar (maltose, lactose, cellobiose) and sugar alcohol (mannitol, sorbitol, dulcitol) for categorization of isolate into biovar. On the basis of cultural and biochemical test (Fig. 13), isolated bacterial wilt pathogen was identified and confirmed as race-1/ biovar III of *Ralstonia solanacearum*.

Fig. 13: Growth of *R. solanacearum* on nutrient agar after two days of incubation at 24◦C

Isolation and confirmation of tomato bacterial blight pathogen: Bacterial blight pathogen, *Xanthomonas compestris* pv. *vesictoria* (X. *euvesictoria*) isolated from tomato (cv. Namdhari 585) and their morphological and cultural growth was recorded on different agar media followed by EPPO standard for their identification (Fig. 14).

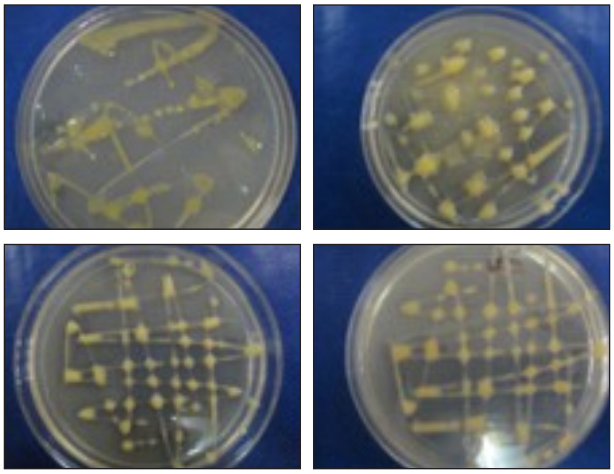


Fig. 14: Cultural growth of *X. campestris* pv. *vesictoria* (new *X. euvesictoria)* on nutrient and pikovaskayas agar

Chemo sensitivity of bacterial pathogen: Chemo sensitivity of bacterial pathogen (*X. compestris* pv. *vesictoria*, *R. solanacearum*, fluorescent and non-fluorescent *Pseudomonas*) were tested with copper oxychloride 50%WP and azoxystrobin 23% SC in various concentration @ 10, 20, 40 ppm; streptomycin sulphate + tetracycline hydrochloride, streptomycin and nimbicidine in concentration @ 5, 10, 50 ppm. All tested pathogens showed resistance/ non-chemo sensitivity towards tested concentration of chemicals and botanicals except non-fluorescent *Pseudomonads* which also exhibited sensitivity towards streptomycin and resistance to other chemical molecules.

Effectiveness of bacterial bioagents, fungicides and bactericides against bacterial diseases on tomato and yield: Talc based formulation of microbial bio agents *viz., Bacillus subtilis* strain CRB-7, *B. subtilis* strain BS2, *Trichoderma viride,T. asperellum* @ 10 g/L and fungicides namely copper oxychloride 50 WP @ 2.5 g/L, copper hydroxide 53.8 DF @ 2.0 g/L, azoxystrobin 23 SC @ 1 ml/L and bactericide streptomycin sulphate + tetracycline hydrochloride (9:1 SP), streptocycline @ 100 ppm were evaluated under field condition in tomato (Cv. Kashi Amrit) against bacterial diseases as three subsequent foliar spraying at 15 days interval after 20 days of transplanting (DAT). The highest tomato yield (24.76 t/ha) was recorded with *T. asperellum* IIVR strain KT 824429 however all treatments were found free from bacterial blight and bacterial speck (Table 14).

Table 14: Effectiveness of microbial bioagents, fungicides and bactericides against bacterial diseases and yield of tomato

Particulars	Yield (t/ha)
T1 – *B. subtilis* (CRB-7)	24.55
T2 - *B. subtilis* (BS-2)	19.82
T3- Copper oxychloride 50 WP	17.50
T4 - Copper hydroxide 53.8 DF	19.16
T5-Streptomycin sulphate + tetracycline hydrochloride (9:1 SP) (Streptocycline)	18.30
T6 - Azoxystrobin 23 SC	22.96
T7-*Trichoderma viride* (Biocure F)	20.40
T8- *T. asperellum* IIVR strain	24.76
T9- Control	16.76
C.D.	1.83
SE(m)	0.60
C.V.	5.143

Management of black rot of cabbage: Talcum based formulation of *P. fluorescens* @5 g/L, *B. subtilius* (IIVR strain BS 2) @10g/L, bactericides *viz.* Streptocycline @100 ppm, Copper oxychloride 50 WP Copper hydroxide 53.8 DF @2.5 g/L and plant defense activator namely salicylic Acid @1 g/L and Acibenzolar S- Methyl (ASM) @ 0.5 g/L were evaluated under field in cabbage (cv. Golden Acre) against bacterial black rot caused by *Xanthomonas compestris* pv *compestris* as first foliar spraying after 20 days of transplanting and second application after 15 days of first application. Among tested molecules highest yield (47.5 t/ha) was recorded in cabbage with foliar sprays of streptocyline however all treatments were found free from incidence of black rot (Table 15).

Table 15: Effectiveness of bioagents, fungicides and plant defense activators against bacterial rot on cabbage and yield

Particulars	Yield (t/ha)
T1 - *P. fluorescens*	36.66
T2 - *B. subtilius (IIVR-BS 2)*	35.25
T3 - T1+ Salicylic Acid	40.08
T4 - T2+ Salicylic Acid	33.66
T5 - Salicylic Acid	40.33
T6- Streptomycin sulphate + Tetracycline hydrochloride (9:1 SP) (Streptocycline)	47.50
T7- Copper oxychloride 50 WP	45.91
T8 - Copper hydroxide 53.8 DF	42.50
T9 - T1 + ASM	41.95
T10 - T2 + ASM	30.85
T11 - Control	30.00
C.D.	6.54
SE(m)	2.20
CV	9.87

Screening and scoring of sponge gourd germplasm against downy mildew: 106 Varieties/advanced breeding line/germplasm/ hybrids of sponge gourd against downy mildew were screened and scored in crossing block at Research Farm during September - October 2018. Observation were

recorded on 5-point rating score. The disease reaction was categorized based on mean PDI (%). Out of 106 germplasm only 16 *viz.*, VRSG-13 (50%), VRSG-18 (50%), VRSG-57 (48%), VRSG-136 (44%), VRSG-5A (50%), VRSG-6A (45%), Kashi Jyoti (44%), Vinay-Indus Seed (45%), Pusa Sneha x 195 (47.75%), 214 × 57 (45%), 6-17× 42 (46%), 180×14-1(44%), 57× 14-1 (46%), 214× 67 (48%), 14x14-1 (48.75), 182× 14-1 (42%) were found moderately resistant.

Screening and scoring of pea germplasm against powdery mildew: 172 pea germplasm against powdery mildew were scored under field condition at Research Farm during February - March, 2019. Observation were recorded on 9-point disease severity key. On the basis of disease severity germplasm viz. BHU-7, BHU-25, BHU-64, BHU-114BHU-11, BHU-33, BHU-56, BHU-57, BHU-76, BHU-113, HUDP-15, ARKA AJEET, HUDP-15, EC-11993, EC-6621, VRP-147, VRP-3904, VRP-310, VRP-311, VRP-316, VRP-378, VRP-305, VRP- 306, VRP-314, VRP-322, VRP-339, VRP-343, VRP-345, VRP-351, VRP-354, VRP-358, VRP-166, VRP186, VRP-701, VRP 703, CHP-2, VRPR-1, VRPMR-10, Snowpea, No-6, EC-97280, VRP-90, IC-395609, VRP-152, VRP-150, VRP-27, VRP32, VROPD-3, VL-3, Samrath, Swarna Mukti, VRPD-2, IC-208366,IC-208378,IC-296678, No-17, Samridhi, Sampoorna, Arka Karthik were found powdery mildew resistant.

Project 6.7: Characterization of viruses infecting vegetable crops and their management

Survey and characterization of viruses infecting cucurbits in UP: An intensive survey was conducted in cucurbits growing regions of all nine agro-climatic zones of Uttar Pradesh during May-September, 2018. Disease incidence ranging between 2-90% was recorded across the 14 different cucurbitaceous crops. Around 540 samples were collected and processed for testing of virus infection. Samples were tested for infection of begomovirus through Dot-IBA using squash leaf curl virus (SLCV) antiserum and *Cucumovirus, Potyvirus, Polerovirus, Tobamovirus, Orthotospovirus, Potexvirus* and *Crinivirus* through RT-PCR assay. Among the 96% positive samples, infection of *Cucumovirus* (6.11), *Potyvirus* (39.44), *Polerovirus* (10), *Tobamovirus* (38.33) and *Orthotospovirus* (2.22) were observed (Table 16 &17). Mixed infection of more than one virus was also detected among 64% of samples (Fig. 15).

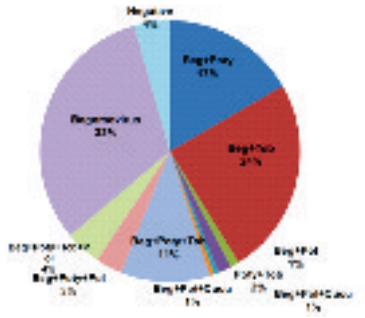


Fig. 15: Distribution of different combination of multiple virus infection among surveyed cucurbits sample

Table 16: Detection of viruses by DotIBA/RT-PCR in cucurbit crops

Crop	Poty	Cucumo	Tobamo	Polero	Tospo	Begomo
Bottle gourd	29	-	49	3	-	92
Cucumber	32	-	58	-	-	100
Bitter gourd	17	4	33	4	-	83
Sponge gourd	36	3	36	6	-	94
Snake gourd	100	-	100	-	-	100
Pumpkin	68	-	19	23	-	94
Ridge gourd	100	100	-	-	-	100
Water melon	-	-	29	-	14	86
Round melon	-	-	-	-	100	-
Ivy gourd	100	-	33	33	-	100
Long melon	40	-	20	-	-	100
Satputia	-	-	-	-	-	100
Squash	100	-	46	46	-	100
Musk melon	-	-	100	-	-	100
Total	**39.44**	**6.11**	**38.33**	**10**	**2.22**	**93.33**

Table 17: Distribution of viruses in different agro-climatic zones

S.N	Zones	Percent Positive Samples					
		Potyvirus	Tobamo	Polero	Tospo	Cucumo	Begomo
1	Vindhyachal	29	14	-	-	-	100
2	Eastern Plain	38	40	21	4	-	94
3	Central	56	53	9	-	-	100
4	North-Eastern Plain	46	11	18	-	11	86
5	South-Western	20	35	-	-	-	95
6	Bundelkhand	50	88	-	-	-	100
7	Tarai	58	67	-	-	-	92
8	Mid-Western	18	36	-	-	-	91
9	Western Plain	40	40	-	-	-	87
	Total	39.44	38.33	10	2.22	6.11	93.33

First report of watermelon bud necrosis virus infecting round melon in India: During summer (April to May) 2018, nearly 80% of plants with symptoms resembling virus infection, such as chlorotic and necrotic spots on leaves and necrosis on buds, were observed in experimental plots of the research farm at ICAR-IIVR, Varanasi. Infected plants died before attaining the fruiting stage. Dot immunobinding assay (DIBA) and reverse transcription polymerase chain reaction (RT-PCR) using universal orthothospovirus primer pair were performed to confirm identification. Further, the specific primer pair of WBNV (GK WBNV

F/R) encompassing the complete coat protein gene on S RNA amplified 947 bp from all five symptomatic samples, and the amplicon was sequenced directly. The consensus sequence (MH717083) had 95% identity with the coat protein gene of WBNV isolates reported earlier from India on various crops. These results indicated infection of WBNV in symptomatic round melon samples for the first time from India.

Detection of ToLCNDV in sponge gourd seeds collected from infected plant: Immature fruits were collected from mosaic infected sponge gourd plant and the DNA was isolated from different parts of the fruits such as pericarp, pith and immature seed. In PCR assay with begomovirus specific primer pair (PAL1c1960 / PAR1v722), detected virus in all the tested fruit parts. Further, seeds were extracted from mature fruit of infected plant was tested for the presence of begomovirus through Dot-IBA using SLCV antiserum resulted in 72% of seeds were detected with virus. Further grow out test is in progress to test the expression of symptoms with the same batch of seeds collected from the infected fruit.

Molecular characterization of begomovirus associated with leaf curl disease of basella: During the period of August-October 2017, basella plants were observed with virus-like symptoms such as stunted growth, rosetting and severe curling of leaves at Research Farm of ICAR- IIVR, Varanasi (Uttar Pradesh, India). Total DNA molecules extracted from symptomatic samples were subjected to rolling circle amplification (RCA) and were tested positive for the presence of begomovirus, using universal primer pair corresponding to DNA A and DNA B through PCR analysis. Further RCA product was subjected to RFLP analysis with restriction enzymes (BamHI, EcoRI, HindIII, KpnI and XbaI), fragment size of ~2.7 kb was produced upon restriction only with HindIII enzyme which was cloned into pBluescriptK^{+} vector linearized with HindIII enzyme. Two different patterns were observed among the 32 recombinant colonies, among them four clones (two of each restriction pattern) were sequenced through primer walking. Sequences were assembled using the NCBI ORF finder and sequence

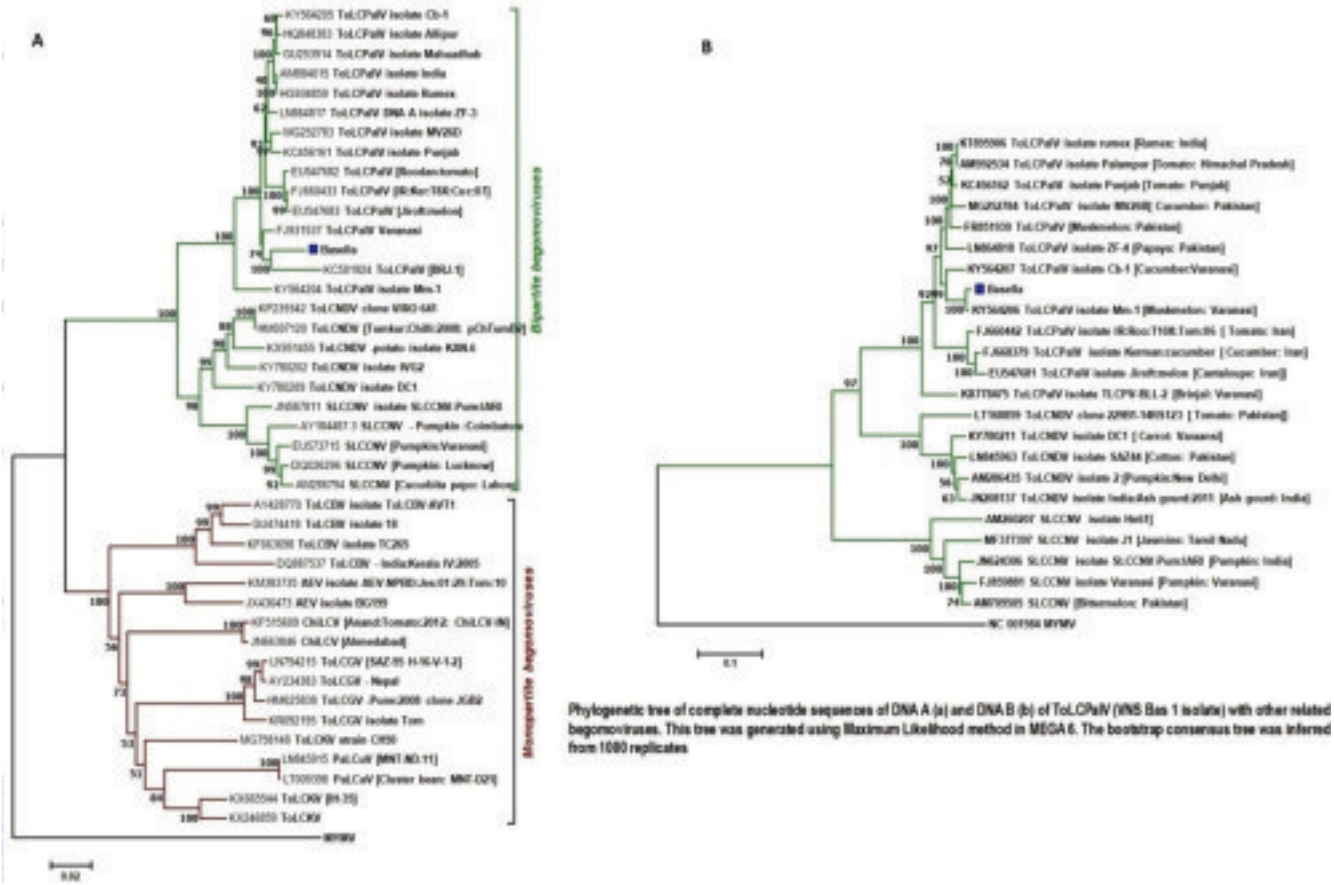


Fig. 16: Phylogenetic analysis of nucleotide sequences of tomato leaf curl Palampur virus causing leaf curl disease in basella with other begomoviruses associated with leaf curl disease

identity analysis were performed using BLASTn by comparing sequences available in the Gene Bank database. Sequence analysis revealed tomato leaf curl Palampur virus (ToLCPalV) were associated with leaf curl disease of basella with DNA A (MK618465) consisting of 2756 nucleotides (nt) and DNA B (MK618465) consisting of 2725 nt . The complete sequence of DNA-A showed maximum sequence identity of 95.65% with ToLCPalV isolate (FJ931537) reported on pumpkin from India. The DNA-B of ToLCPalV having maximum identity of 98.64% with ToLCPalV isolate reported from Varanasi on musk melon (KY564206) in BLAST analysis. Phylogeographical study based on DNA A and DNA B revealed ToLCPalV isolate infecting basella (VNS Bas1) is sharing common ancestry with other isolates of ToLCPalV reported from different parts of Asia infecting solanaceous and cucurbitaceous vegetable crops (Fig.16). In recombination analysis with the Recombination Detection Program 4 (RDP4), DNA A genome predicted to have recombination event between the position 1818 and 1949 nucleotide with unknown major parent and ToLCNDV isolate from Gujarat infecting tomato (KF551576) as minor parent. Predicted recombination events were detected through GC (1.698×10^{-14}), MC (1.1460×10^{-06}), Chi (1.552×10^{-06}), BootScan (3.554×10^{-14}), SiScan (1.286×10^{-06}) and 3Seq (1.274×10^{-12}) methods with p-value of less than 1×10^{-6}. No recombination event was detected in DNA B genome. There was no association of alpha- and betasatellites observed in PCR assay. This is the first report of association of begomovirus with leaf curl disease on basella from India.

Standardization of date of sowing for the management of little leaf of brinjal: Little leaf disease incidence and yield was assessed with different dates of planting of brinjal seedling in four different varieties. Disease incidence was reduced with delay in time of planting. But yield was also reduced with the delay in planting time. It is found optimum that, planting during September first week has recorded least disease incidence with optimum yield.

IDM module for management of brinjal little leaf disease: Five different modules were evaluated under field conditions for the little leaf disease management in brinjal in variety Kashi Taru. Modules were Module 1: IDM module without mulching; Module 2: IDM module with mulching: Module 3: Farmers practice; Module 4: Biocontrol; Module 5: Untreated control. Components used in the IDM modules are as follows: Seed treatment with imidacloprid@3 g/kg; Covering of nursery seedlings with insect proof net; seedling dip with tetracycline @ 100ppm; soil application of FYM enriched with bioformulation (BS2); mulching with black silver polythene; soil application of neem cake @ 5g/plant; raising of *bajra* as border crop; installation of yellow sticky traps @ 20/acre; periodical spraying with micronutrient mixture and salicylic acid (2mM); need based application of insecticides such as flonicamid, acetamiprid (0.5g/l) and antibiotic tetracycline @ 200ppm. Among the different module, integrated module with black silver mulching (Module 2) is performing better than other module in recording highest fruit yield (323.33q/ha) with least disease incidence of 2.2%.

Project 6.9: Management of plant parasitic nematodes infecting vegetable crops

Effect of nematicidal *Bacillus* strains, *Bacillus subtilis* (CRB7) and *Bacillus marisflavi* (CRB2) on germination and seedling growth of okra: Under *in vitro* condition, two nematicidal *Bacillus* strains, *Bacillus subtilis* CRB7 and *Bacillus marisflavi* CRB2 are evaluated for their effect on germination and seedling growth of okra cv. Kashi Pragati by following standard protocol. The study revealed that, *B. marisflavi* CRB2 was giving maximum percent germination (79%) and vigour index I and II (1951.3 & 1978.9 respectively) as compared to control (70% germination and1732.5 vigour index-II). (Table 18).

Table 18: Effect of nematicidal *Bacillus* strains, *Bacillus subtilis* (CRB7) and *Bacillus marisflavi* (CRB2) on germination and seedling growth of okra.

Treatments	Germination (%)	Vigour I	Vigour II
B. marisflavi CRB2	79	1951.3	1978.95
B. subtilis CRB7	73	1661.48	1835.95
Control (dw)	70	1582	1732.5
CD (P<0.05)	**NS**		
SE(M)	**0.9**		

Detection of antimicrobial genes from nematicidal *Bacillus* strains, *Bacillus subtilis* (CRB7) and *Bacillus marisflavi* (CRB2): Detection of antimicrobial genes from *Bacillus subtilis* (CRB7) and *Bacillus marisflavi* (CRB2) through polymerase chain reaction (PCR) revealed that, the strain *B. marisflavi* CRB2 have highest number of AMP genes (10) responsible for the biosynthesis of iturin, bacilysin, bacillomycin, surfactin, subtilin, mersacidin, ericin, subtilosin and mycosubtilin followed by *B. subtilis* strain CRB7 with eight AMP genes (Table 19).

Table 19: Detection of AMP genes in nematicidal *Bacillus* strains

Name of the organism	Iturin				Bacillomycin	Bacillin		Surfactin	Mersacidin
	ituA	*ituC*	*ituD*	*ipa14*	*bamC*	*bacAB*	*bacD*	*srfA*	*mrsA*
Bacillus marisflavi CRB2	-	+	+	+	+	+	+	+	+
Bacillus subtilis CRB7	+	+	+	+	-	+	+	+	+

Name of the organism	Ericin	Fengycin			Subtilin	Subtilosin		Mycosubtilin
	eriB	*fenA*	*fenB*	*fenD*	*spaC*	*albA*	*albF*	*mycC*
Bacillus marisflavi CRB2	+	+	+	+	+	+	+	+
Bacillus subtilis CRB7	+	+	+	+	+	+	+	-

Biocontrol efficacy of nematicidal *Bacillus* strains on *Meloidogyne incognita* infecting okra under field condition: Among imposed twelve treatments, the two treatments T7 and T8 having different delivery mechanisms such as seed treatment with *Bacillus subtilis* CRB7 @ 20 g/ kg seed + soil application of *Bacillus subtilis* CRB7 enriched vermicompost (2 tonnes/ha) + soil drenching *Bacillus subtilis* CRB7 @ 1% at 30 days interval and seed treatment with *Bacillus marisflavi* CRB2 @ 20 g/ kg seed + soil application of *Bacillus marisflavi* CRB2 enriched vermicompost (2 tonnes/ha) + soil drenching *Bacillus marisflavi* (CRB2) @ 1% at 30 days interval, respectively were found significantly effective in reducing maximum final nematode population in soil 62.5 and 58.9 %, egg mass per root system 56.1 and 54.0 % with lesser gall index 1.73 and 1.87 (0-5 gall index scale), respectively, compared to control. In addition, these treatments were statistically comparable with chemical check (T_{11}) Vermicompost 2 tonnes ha^{-1} + Carbofuran @ 1kg a. i ha^{-1}. Both treatments *i.e.* T7 and T8 were recorded maximum yield to the tune of 16.79 and 16.30 tonnes/ha, respectively compared to chemical check (T11) and untreated control 15.26 and 12.26 t/ha, respectively.

Screening of resistant rootstock for root knot nematode management: Brinjal rootstock (*Solanum melongena*-EG219) which is resistance to *Fusarium* wilt, bacterial wilt susceptible check Kashi Taru (Brinjal) were screened for root knot nematode (*Meloidogyne incognita*) resistant through nematode inoculation under pot condition. This rootstock was found moderately resistant with gall index 3.0 according to gall index scale 1-5 scale.

Project 6.10: Pest and disease dynamics of important vegetable crops in relation to changing weather scenario

Seasonal incidence of cucurbit fruit fly in and around Varanasi: The seasonal incidence of cucurbit fruit fly, *Bactrocera cucurbitae* infesting different cucurbitaceous vegetables was observed almost throughout its growth period of during April, 2018 to March, 2019 in and around Varanasi, Uttar Pradesh, India using cuelure trap. The fruit fly population was higher during April–June and November months. Highest number of fruit fly (94 per trap) was recorded during 16th SMW (3rd week of April, 2018) followed by 24thSMW (2nd week of June, 2017) *i.e.*, 93.67/trap (Fig. 17).

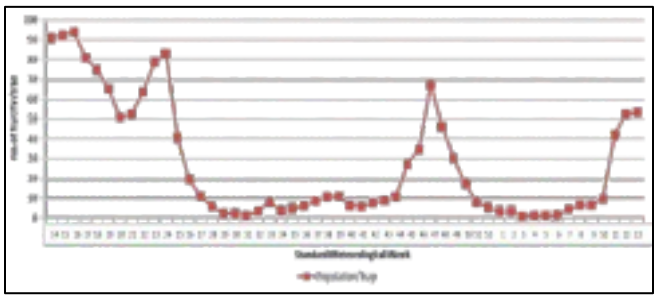


Fig. 17: Seasonal incidence of cucurbit fruit fly, *B. cucurbitae*

Incidence of *Spodoptera litura* during the cropping period of tomato and cabbage: Seasonal incidence of *S. litura* infesting tomato and cabbage was studied by installing the sex pheromone traps. The incidence of *S. litura* was recorded throughout the crop growth period from October 2018 on tomato and from November 2018 on cabbage to till April 2019 at IIVR farm, Varanasi, Uttar Pradesh, India. A considerable fluctuation in the incidence and trap catches was observed in both the vegetable crops during their cropping period. In tomato crop, the highest moth catches (124 moths/trap) in pheromone traps was recorded during 45th SMW (1st week of November 2018). While, in cabbage, the moth catches were highest (94.33 moths/trap) during 46th SMW (2ndweek of November 2018) (Fig. 18).

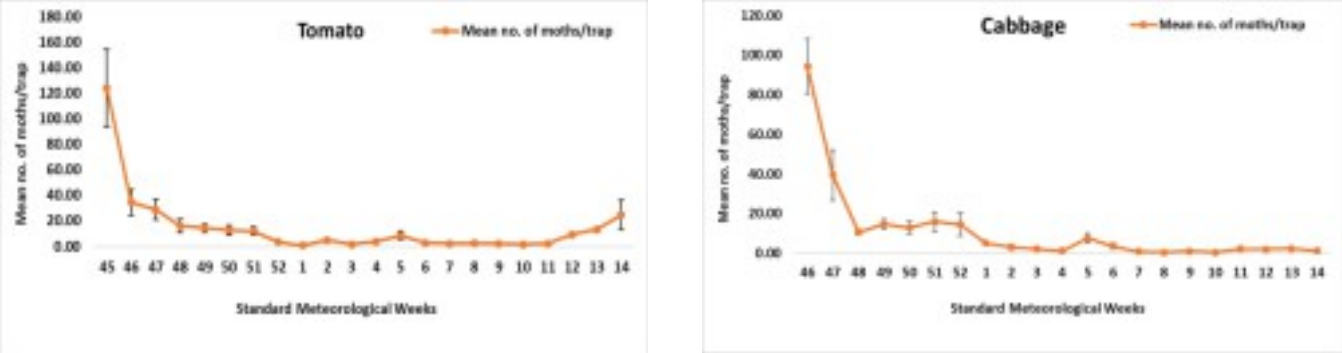


Fig. 18: Monitoring of incidence of *Spodoptera litura* during the cropping period of tomato and cabbage

During the main vegetable growing period (July 2018 to March 2019) periodical monitoring was carried out at institute research farm as well as farmers field. Tomato was severely infected by grey leaf spot disease during December–January and pathogen was identified as *Stemphillium solani*. Small, circular to irregular, dark brown, isolated, scattered over entire leaf. The incidence was 25-40% in different varieties in this region. This disease was showing sporadic behvaiour and appeared after long time in this area. Water spinach (*Ipomoea aquatic*) a leafy vegetable was found infected with leaf blight during July August. Neither pathogen was isolated nor was any sporangia observed under microscopic examinations. However, symptoms was typically similar to *Phytophthora* blight. Incidence was 2-3 percent only on broad leaved variety. Interestingly an ubiquitous and necrotropic pathogen *Sclerotinia sclerotiorum* was not observed in most of the vegetable crops during winter season of this year. Chilli was severely infected in most of the field by *Alternaria* fruit rot with 12-20% incidence but anthracnose was not observed in any of the field of this region. Early blight infected fruits rots was as high as 60%, late blight 25% and *Rhizoctonia* 20% in Kashi Aman variety.

Externally Funded Projects

Project 1: Introgression of begomovirus resistance genes in tomato (*Solanum lycopersicum* L.) using MAS and genomics approach

Pyramiding of resistance genes from diversified sources to develop stable ToLCV resistant tomato cultivars and hybrids was undertaken. Pyramiding involved two backcross programs for two different recurrent parents *viz.* Kashi Vishesh and Kashi Aman. In the first program with Kashi Vishesh as recurrent parent, tomato lines VRT 8-6-1 and VRT 2-2-3 were used as donors for *Ty-2* and *Ty-3* genes, respectively. Two BC_3F_1 populations of Kashi Vishesh were grown at ICAR-IIVR, Varanasi. Marker assays were performed to select the plants carrying target *Ty-2* and *Ty-3* genes using linked flanking markers. The plants that tested positive (heterozygous) and that resemble recurrent parent morphologically were selected for intercrossing to combine *Ty-2* and *Ty-3* (Fig. 1).

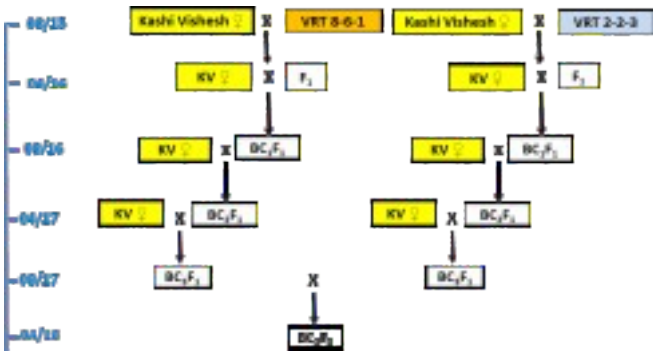


Fig. 1: Status of backcross program being followed for pyramiding *Ty-2* and *Ty-3* genes in the background of 'Kashi Vishesh'. The timeline is provided as the vertical bar on the left (Month/Year).

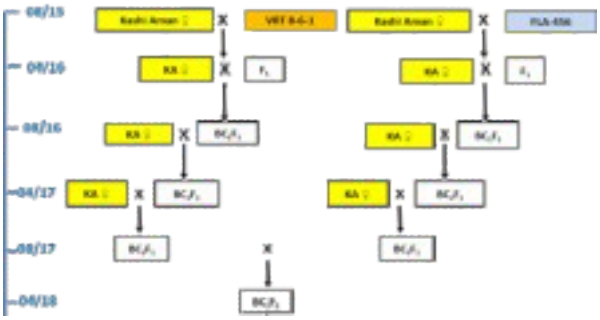


Fig. 2: Status of backcross program being followed for pyramiding *Ty-2* and *ty-5/ty-6* genes in the background of 'Kashi Aman'. The timeline is provided as the vertical bar on the left (Month/Year).

In the second backcross program, Kashi Aman is being used as recurrent parent, tomato lines VRT 8-6-1 and FLA 456 are being used as donors for *Ty-2* and *ty-5/ty-6* genes respectively. Two BC_3F_1 generations were developed for pyramiding *Ty-2* and *ty-5/ty-6* in the background of 'Kashi Aman'. Marker assays were performed to select the plants carrying target *Ty-3* + *Ty-2* in one population and to select the plants carrying *Ty-3* +*ty-5/ty-6* genes using linked flanking markers. The plants that tested positive and that resemble recurrent parent morphologically were intercrossed to combine *Ty-2*, *Ty-3*, *ty-5* and *ty-6* genes (Fig. 2).

Development of lines and hybrids: Because *Ty-3* carrying lines are holding up resistance, several *Ty-3* carrying lines were developed using MAS. Promising F_6 lines are being evaluated for horticultural traits. These advanced lines were developed in the diverse genetic background to generate diverse inbred lines for leaf curl resistant hybrid development. Based on the initial evaluation, three promising tomato hybrids have been selected for multiplication and evaluation. Both the seed and pollen parent of these three hybrids carry *Ty-3* gene (Table 1 & 2; Fig. 3).

Table 1: Number of lines in F_6 from different crosses

Cross	No. of lines in F_6	Breeding method
VRT-16-15 × VRT-16-13	5	Marker assisted pedigree method with *Ty3* markers
VRT-16-07 × VRT-16-13	4	
VRT-16-07 × VRT-16-05	20	

Table 2: Promising Hybrid combinations with both the parents carrying *Ty3* gene

Hybrid combinations	Remarks
VRT 16-01 × P18-3	Semi determinate plant, fruits are round in shape with light green shoulder.
VRT 16-12 × P18-3	Semi determinate plant, fruits are round in shape with green shoulder.
VRT 16-04 × P18-3	Determinate plant, fruits are round in shape with light green shoulder.

VRT 16-01 × P18-3 VRT 16-12 × P18-3 VRT 16-04 × P18-3

Fig. 3: Promising hybrid combinations with *Ty3* gene in both parents.

Development of mapping populations and identification of markers (SSR/SNP/CAPS) linked to putative resistance genes: RIL population consisting of 168 $F_{8:9}$ lines of cross Punjab Chhuhara × VRT-78-1 were grown in the field conditions (natural epiphytotic conditions) along with the parents and phenotyping of the same for ToLCV disease severity was completed. Seventy five $F_{3:4}$ families of Kashi Vishesh × VRT-78-4 were grown in the field conditions along with the parents (natural epiphytotic conditions) and phenotyping of the same for ToLCV disease severity was performed.

Project 2: National Innovations in Climate Resilient Agriculture (NICRA)

Development of F_1s for high temperature stress tolerance: 139 F_1s along with 12 private sector hybrids as checks were evaluated for high temperature tolerance during March-June, 2018. Out of 139 hybrids, 7 hybrids *viz.*, VRNTH-18114, VRNTH-18123, VRNTH-18125, VRNTH-18127, VRNTH-18128, VRNTH-18133 and VRNTH-18283 were found superior over all the checks for their yield and fruit quality traits.

Development of F_1s tolerant to moisture deficit condition: 109 F_1s along with 6 private sector hybrids as checks were evaluated for moisture deficit tolerance during October,2018–February,2019 in field trial. Observations on yield and fruit quality traits were recorded. Analysis of data revealed that 5 hybrids *viz.* VRNTH-18-1, VRNTH-18-2, VRNTH-18-3, VRNTH-18-4 and VRNTH-18-5 were superior over popular private sector hybrids in terms of yielding ability under moisture deficit conditions.

Validation and evaluation of brinjal rootstocks for waterlogging tolerance: Two scion cultivars of tomato *viz.* Kashi Aman & Kashi Adarsh were grafted on five eggplant rootstocks *viz*. IC-111056, IC-354557, Surya, *Solanum macrocarpon* and *Solanum laciniatum*. The graft combinations along with un-grafted scion cultivars were exposed to waterlogging at vegetative stage (*i.e.* 15 days after transplanting) and at reproductive stage (*i.e.* at 30 days after transplanting). Changes in several enzymatic activities (superoxide dismutase, catalase and ascorbate peroxidase) and other biochemical attributes (proline content, hydrogen peroxide content, lipid peroxidation, chlorophyll content and carotenoid content) as a response to waterlogging stress were analysed. Physiological attributes *viz.* relative water content and stomatal conductance were also recorded during stress. Less reduction in stomatal conductance and RWC and high level of enzymatic activity, proline levels, along with low lipid peroxidation and H_2O_2 levels were recorded in surviving graft combinations in comparison to non-grafted control and non-surviving combinations. IC-354557 and IC-1111056 emerged as best rootstocks in mitigating waterlogging stress.

Stionic effect on yield, quality and physio-biochemical traits in tomato: Stionic effects, in terms of yield and fruit quality changes, were studied in interspecific graft combinations surviving waterlogging stress during early formative and reproductive stages. For yield traits, observations were recorded on number of fruits per plant, average fruit weight and yield per plant. Fruit quality was determined by analyzing lycopene content, beta-carotene content, titratable acidity, TSS and ascorbic acid content. IC-354557/ Kashi Aman and IC-354557/Kashi Adarsh recorded highest yield.

SNP genotyping for identification of QTLs linked to heat stress tolerance : Nursery of F_1 seeds of H-88-78-1 x Punjab Chhuhara was sown during April, 2018 and seedlings were transplanted in glass-house (with temperature & humidity control) to collect F_2 seeds. F_2 population was grown in field during October, 2018 and seeds from 265 F_2 plants were collected, separately. Genomic DNA were isolated and quantified from 265 F_2 plants for genotyping. Nursery of 265 $F_{2:3}$ progenies was raised and transplanted in field in March 2019 for phenotyping during high temperature.

q-Real time PCR expression analysis of heat shock factors : A total of 69 heat responsive genes in tomato were studied for their expression under high temperature stress to characterize high temperature tolerant genotypes H-88-78-1 and CLN-1621. Compared to high temperature stress susceptible genotype Punjab Chhuhara, both H-88-78-1 and CLN-1621 showed better phenotype as well as better profile of heat stress responsive gene expression. Phenotypic and molecular characterization of these genotypes shows that these genotypes have potential to be used as a source of important genes conferring tolerance to high temperature. Among the genes studied here, HSF17

exhibited the highest expression after 16h, 32h and 48h of stress treatment in both of the tolerant genotypes making it probable candidate gene governing high temperature stress tolerance in tomato. Besides HSF17, several other genes like HSF59, HSF2, HSF18, showed significant up-regulation after stress treatment.

Dissemination of evolved grafting technology to the farmers' field: About 4000 grafted tomato plants were distributed among 22 farmers of 3 villages (Fig. 4), including Jayapur - the village adopted by Hon'ble Prime Minister.

Fig. 4: Distribution of grafted plants among farmers of different villages

Project 3: CRP on hybrid Technology (Tomato)

Hybrids tolerant to tomato leaf curl virus: 242 F_1s were made from 2016-2018 and evaluated in 2016-2017(110), 2017-2018(31) and 2018-2019(101). Out of which fifteen F_1s were high yielder with tolerant to ToLCV carrying *Ty3* gene. A summary of findings are given below

Hybrids for Multilocation testing: On the basis of two years evaluation at two locations (IIVR and IARI), six F_1,s were promising *viz.*, **CRPVRTH-16-4** (Yield=179.9 t/ha, extent of heterosis for yield over BP=73.33% and PDI=5.0), **CRPVRTH-16-80** (Yield: 156.6 t/ha extent of heterosis for yield over BP= 81.93% and PDI=2.5),**CRPVRTH-16-8** (Yield=143.3 t/ha, extent of heterosis for yield over BP=75.77% and PDI=2.5),**CRPVRTH-16-70** (Yield: 134.9 t/ha; extent of heterosis for yield over BP=66.66 and PDI=0.0),**CRPVRTH-16-5 (**Yield: 123.3 t/ha extent of heterosis for yield over BP =33.85%; PDI=12.5),**CRPVRTH-16-74** (Yield:111.6 t/ha extent of heterosis for yield over BP= 62.52% and PDI =6.6).These hybrids may be commercialized for cultivation (Fig. 5).

Fig. 5: Performance of CRPVRTH-16-4, CRPVRTH-16-5, CRPVRTH-16-80, CRPVRTH-16-70 and CRPVRTH-16-08

Hybrids for Further confirmation

- Thirty one F_1s were developed in 2017 and evaluated in September 2018 – February, 2019 at IIVR, Varanasi. On the basis of yield and disease incidence, five F_1s namely CRPVRTH-17-55 (Yield:163.3 t/ha;PDI=5%) CRPVRTH-17-49 (Yield: 146.6 t/ha; PDI=10%), CRPVRTH 17-33 (Yield:136.9 t/ha;PDI=7.5), CRPVRTH-17-20(Yield: 131.6 t/ha; PDI=7.5%) and CRPVRTH-17-183 (Yield:129.9 t/ha; PDI=5%) were found superior. These hybrids will be tested again in 2019 for confirmation.
- One hundred one (101) F_1s developed in February, 2018 and were evaluated during October 2018 to March, 2019 at IIVR, Varanasi. Four F_1s namely, CRPVRTH-18-38 (Yield:163.3 t/ha;PDI=5%), CRPVRTH-18-81(Yield:160.6 t/ha; PDI=5%), CRPVRTH-18-36 (Yield:153.8 t/ha; PDI=5%) and, CRPVRTH 18-28 (Yield:143.3 t/ha; PDI=2.5%) were found superior. These hybrids will be tested again in 2019 for confirmation.

Hybrids tolerant to abiotic (high temperature, drought and salinity) stresses

(a) Tolerant to moisture deficit condition: For this objective, a total 20 F_1s were developed in 2016-2017 and evaluated in two environmental conditions (2017-2018 and 2018-2019) at IIVR, Varanasi. During the year 2017-2018, out of 20 F_1s, only four F_1s performed very well in moisture stress condition (60-70 days without irrigation from first week of November to second week of January).

Fig. 6: CRPVRTH -16-3

Out of four F_1s, only one F_1 namely CRPVRTH-16-3 could perform under moisture stress condition (first week of November to second week of January) with yield of 89.0 t/ha and 37.90 % decrease in yield if grown in irrigated condition (143.3 t/ha) along with resistance to ToLCV under both normal and moisture deficit condition. This hybrid is ready for multilocation testing (Table 3 & Fig. 6).

Table 3: Characters of moisture stress tolerant hybrid CRPVRTH-16-3

Traits	Features
Growth habit	Semi--indeterminate
Days to first picking	80-85
Crop duration	14-150 days
Fruit weight(g)	110-120
Fruit shape	Oval round
Yield (t/ha) in irrigated condition	14.33
Yield (t/ha) in moisture stress condition	8.91
% decrease in yield	37.90
Locule number per fruit	3-4
Pericarp thickness (cm)	0.55
TSS	5.10
Lycopene (mg/100gFW)	6.88
ToLCV reaction	Carrying Ty3 gene
Growing season	Both rainy and winter

(b) Tolerant to Salt: For this objective a total of 32 F_1s were made from 2016-2017 and 24 F_1s were evaluated in 2017 and selected only five F_1s for testing in 2018 under artificial condition (pot culture soil pH 8.5). One set of these F_1s were also grown in normal soil condition to see the yield potential of salt tolerant hybrids. During 2018, five selected hybrids namely CRPVRTH-17-55, CRPVRTH-17-57, CRPVRTH-17-53, CRPVRTH-17-54 and CRPVRTH-17-49 were again tested in soil which pH was maintained at 8.5, none of the hybrid (F_1) along with parent and their F_2 populations could survive. Hence none of the hybrid could confirm tolerance to salt (pH 8.5).

(c) Tolerant to high temperature (Night temperature (35±3^{0}C): For this objective, a total of 317 F_1s were made from 2016-2018 and evaluated in summer of both 2017 and 2018 (transplanting was done in last week of February to first week of March and flowering – fruiting was recorded from second week of May to last week of June). During summer 2017, 12 F_1s CRPVRTH-16-8, CRPVRTH-16-65, CRPVRTH-16-93, CRPVRTH-16-154, CRPVRTH-16-96, CRPVRTH-16-98, CRPVRTH-16-127, CRPVRTH-16-148, CRPVRTH-16-158, CRPVRTH-16-159 and CRPVRTH-16-161 showed flowering-fruiting up to night temperature 35±3°C and continued harvesting up to third week of May, whereas during summer 2018, 11 F_1s namely CRPVRTH-17-85 (Fig. 7), CRPVRTH-17-103, CRPVRTH-17-136, CRPVRTH-17-157, CRPVRTH-17-160, CRPVRTH-17-163, CRPVRTH-17-142, CRPVRTH-17-189, CRPVRTH-17-167, CRPVRTH-16-65 and CRPVRTH-16-93 were superior among all tested hybrids. Overall, only three hybrids namely, CRPVRTH-17-85 (38.9 t/ha), CRPVRTH-17-103 (31.6 t/ha) and CRPVRTH-17-163 (30.9 t/ha) were found high yielder among all the hybrids and fruits were harvested up to first week of June with minimum weight loss in last picking (Table 4).

Fig. 7: CRPVRTH-17-85

Table 4: Best five hybrids performing under high temperature condition (Night temperature at 35±3^{0}C)

Hybrids(F_1s)	FW(g)	NLPF	PT(cm)	TSS (%)	Y(t/ ha)
CRPVRTH-16-154	33.66	2.0	0.34	3.1	21.9
CRPVRTH-17-85	59.5	3.6	0.52	4.16	38.9
CRPVRTH-17-103	48.75	2.2	0.40	3.89	31.6
CRPVRTH-17-157	64.0	4.6	0.41	4.4	28.6
CRPVRTH-17-163	70.0	4.5	0.48	4.6	30.9

Table 5: Promising nutrition rich hybrids of tomato

Hybrids / parents	W(g)	Yt/ha	TSS (%)	Acidity	Ascorbic acid	Lycopene	Beta carotene
CRPVRTH-17-08	45	26.6	6.14	0.45	18.8	7.91	1.10
CRPVRTH-17-30	**25**	**63.3**	**6.66**	**1.15**	**20.0**	**8.10**	**0.86**
CRPVRTH-17-31	125	74.9	5.48	1.22	17.50	6.02	0.91
CRPVRTH-17-36	14	19.9	7.08	0.32	16.3	3.59	1.23
CRPVRTH 17-183	80	129.9	6.10	0.83	18.8	4.77	1.49

Note: FW= Fruit weight; Y t/ha= Yield tonnes/hectare; TSS= Total soluble solids (%); Acidity= in per cent; Ascorbic acid= mg/100g FW; Lycopene= mg/100g FW; Beta carotene= mg/100g FW

Evaluation of nutritional rich tomato: For this objective, a total 30 F_1s were developed and evaluated. The F_1s namely, CRPVRTH-17-08 (TSS=6.14), CRPVRTH-17-30 (TSS=6.66), CRPVRTH-17-31 (TSS=5.48), CRPVRTH-17-36 (TSS=7.89) and CRPVRTH-17-183 (TSS=6.10) were nutrition rich , high yielding and free from ToLCV (Table 5).

Project 4: Network Project on Transgenic Crops (NPTC)

Generation advancement of fruit and shoot borer resistant transgenic brinjal – *Cry1Aa3 gene*: Homozygous T_7 generation plants of three *Cry1Aa3* transgenic brinjal (*cv*. Kashi Taru) events (A2, A3, and A7), developed earlier, were grown in glass house. To advance the generation, flowers of these three events were self-pollinated and T8 generation seed were harvested from the developed fruits.

Fruit and shoot borer resistant transgenic brinjal –*Cry1Ac* gene: *Bt*-brinjal seeds were sown in the pot in containment proof insect house and 20 days old seedlings were sprayed with 100 mg/l of kanamycin. After five to six successive sprays, the *Bt*-positive plants survived, and the non-transgenic plants died. Further, the positive plants of each line were transplanted in net house. Selfing was performed on fully grown plants for multiplication and T_{11} seeds of mature selfed fruits from all the six lines were harvested and stored.

Generation advancement of fruit borer resistant transgenic tomato – *Cry1Ac gene*: Eight best events of transgenic tomato plants *cv*. Kashi Vishesh carrying *Cry1Ac* gene were advanced to T11 generation. Seeds of the best events IVTT-5 and all other events were germinated in glass house. After 30 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 spray showing optimum expression of transgene. Ten seedlings of each event were transplanted in insect proof net house, their flowers were self-pollinated and matured fruits were picked up. Seeds of such fruits were harvested for further multiplication.

Drought, Salt and Cold stress tolerance transgenic tomato- *AtDREB1A:* Transgenic tomato lines D41, D53, D76 and D86 expressing *AtDREB1A* gene were advanced to T9 generation. The seeds of all events were germinated in 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 transgene. Eight seedlings of each event were transplanted in insect proof net house, their flowers were self-pollinated, and matured fruits were picked up. Seeds of such fruits were harvested for further multiplication.

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 T9 generation. The seeds of all events were germinated in 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 transgene. Eight seedlings of each event were transplanted in insect proof net house, their flowers were self-pollinated and matured fruits were picked up. Seeds of such fruits were harvested for further multiplication.

Project 5: CRP on Agrobiodiversity

Okra: 411 okra accessions were screened for YVMV and OELCV diseases and 19 accessions were validated for viral disease resistance in *kharif* 2018. Among 411 accessions, 14 were red fruited, one accession IC-506134 was round fruited, six genotypes showed moderate resistance to YVMV, seven genotypes showed moderate resistance to ELCV, while six exhibited moderate resistance to both the diseases (Table 6). One of the 19 validated genotypes exhibited resistance to any of the two viral diseases of okra under Varanasi condition. The

Table 6: Evaluation of 411 okra accessions

Red fruited	Round fruited	Moderately resistant to YVMV	Moderately resistant to ELCV	Moderately resistant to both YVMV and ELCV
IC-603145 IC-603193 IC-602415 IC-602421 IC-602423 IC-602584 IC-419365 IC-411852 IC-411847 IC-371683 IC-276976 IC-117226-B IC-006101 IC-002523	IC506134	EC-169455 EC-901814 IC-001542 IC-321290 IC-326069 IC-506054	-261032 IC-113876 IC-099757 IC-000586 EC-901950 EC-306741 IC-117226-B	IC-325963 , EC-169359, IC-117310, IC-536676 IC-260039

summary of the evaluation report of 411 okra accessions in *kharif*-2018 has been presented in table 6.

Project 6: 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)

Details of DUS testing of candidate varieties: A total of 29 Bottle gourd, 12 Bitter gourd, 1 Cucumber, 7 Pumpkin, 13 Okra, 2 Cabbage, 7 Brinjal and 15 tomato entries were evaluated under DUS testing.

Varieties maintained/characterized: The reference varieties of tomato, okra, brinjal, cauliflower, cabbage, vegetable pea, French bean, bottle gourd, bitter gourd, pumpkin, cucumber and pointed gourd were collected from different ICAR institute and SAUs. The numbers of varieties of these crops maintained and morphological traits are observed as per DUS descriptors (Table 7).

Table 7: Number of reference varieties maintained and their morphological traits observed

Crops	No. of reference variety	No. of morphological trait observed	Seed received by Institutes/SAU etc.
Tomato	90	46	23
Brinjal	86	47	01
Okra	42	31	01
Cauliflower	03	28	18
Cabbage	02	28	13
Vegetable Pea	41	21	11
French Bean	25	22	13
Cucumber	24	36	11
Bitter gourd	25	33	14
Bottle gourd	31	33	15
Pumpkin	21	32	11
Pointed gourd	21	15	-
Total	**411**	**372**	**131**

Project 7: 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 one day Entrepreneurship Development Programme in Vegetable Seeds on 17 September 2018 at the institute (Fig. 8), which was attended by 34 trained professionals from Agri-business Agri-clinic of Varanasi. In the day long program, the

Fig. 8: Programme on Entrepreneurship Development in Vegetable Seeds for trained professionals from Agri-business Agri-clinic of Varanasi on September 17, 2018

participants were briefed about the activities and achievements of the institute, emphasizing more on the technologies developed by the institute, which can be taken-up by the participants 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, IPR issues in context of Indian Agriculture, and facilities at ICAR-IIVR, Varanasi for agri-business incubation.

Another program on awareness about Vegetable Seed Production and Marketing was organized for the 19 diploma students of seed technology from BHU, Varanasi on 13th March 2019 (Fig. 9). The students were apprised of various seed production, processing and marketing techniques and were given practical training on different aspects related to vegetable seeds. They were also made conversant about the importance and marketing of vegetable seeds.

Fig. 9: Awareness programme on Vegetable Seed Production and Marketing organized on 13 March, 2019 for Diploma students of Seed Technology

An Entrepreneurship development program on Vegetable Seed Production and Hybrid Seed Production was organized for 24 M.Sc. and Ph.D. students of seed technology from CSAUA&T, Kanpur on 19th March 2019 (Fig. 10). The students were told about the techniques of vegetable seed production, processing and testing techniques, and were given practical training on different aspects related to hybrid seed production techniques of vegetable crops. They were also made conversant about the importance of hybrid vegetable seeds to enhance productivity as well as production of vegetables in the country. With the shrinking of per unit land area and for enhancing the production of vegetables, the hybrids are becoming imperative.

Fig. 10: Entrepreneurship development programme on Vegetable Seed Production and Hybrid Seed Production on 19 March, 2019

Towards the commercialization of IIVR technologies, 7 technology commercialization license agreements were executed during this period, as a result of the efforts undertaken in this direction by ABI unit. Overall, revenue of Rs. 23.24 lakhs was generated by the commercialization activities during this year.

One entrepreneur Mr. Vikas Singh got enrolled as an incubates of the ABI unit, ICAR-IIVR, Varanasi during January, 2019.

Project 8: 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.

Fig. 11: Awareness cum training program on IPR organized on 1st June, 2018 at ICAR-IIVR, Varanasi

An awareness cum training program on IPR was organized on 1st June, 2018 at ICAR-IIVR, Varanasi. This program on IPR awareness and searching web based databases was organized for the scientists of the Institute on 1st June 2018 in collaboration with M/s Patracode, Bengaluru who are the channel partners of M/s Questel in India (Fig. 11). The participants were made aware about the importance of IPRs and the ways and tools of searching for IPR databases to ensure that their efforts may not be a duplication of the existing patent.

This unit was instrumental in showcasing the technologies of the Institute for commercialization (Fig. 12) during National Meeting of Indian Academy of Sciences from 2 to 4 November, 2018 at BHU, Varanasi. The program was attended by about 250 scientists/researchers from different fields of science who had come from different parts of the country. The delegates thoroughly observed different technologies displayed there, appreciated the efforts of ICAR in this regard and had a fruitful interaction with the breeders and other scientists of the institute and provided critical and valuable feedback.

The ZTMU organized a market sensitization programme for okra varieties/hybrids and promising lines on 18th September 2018 (Fig. 13). The program was attended by >30 representatives from 18 private sector

Fig. 12: Showcasing the technologies of the Institute for commercialization during National Meeting of Indian Academy of Sciences from 2 to 4 November, 2018 at BHU, Varanasi

Fig. 13: Okra Field Day organized on 18th September, 2018 at ICAR-IIVR, Varanasi

seed companies. The advanced breeding lines having resistance to *Yellow Vein Mosaic Virus* and *Okra Leaf Curl Virus* were the center of attraction for the visitors. This endeavor resulted in licensing of six advance lines of okra to private sector.

A market sensitization programme for varieties/hybrids and promising lines of solanaceous vegetables (Tomato, Brinjal and Chilli) was organized on 19 Jan 2019 (Fig. 14) for promoting the commercialization of ICAR-IIVR technologies. The solanaceous day programme was attended by breeders and marketing strategists from of 10 private sector seed companies dealing in vegetable seeds. The representatives of seed-companies visited the research farm of the Institute, critically observed the promising materials and expressed their desire to get some of the promising hybrids/varieties and advanced breeding lines having a combination of desired quality traits along with yield.

Project 9: Cowpea Golden Mosaic Disease (CPGMD) Resistance:

Agroinfectious clone development, Screening, Genetics of inheritance, Molecular tagging and mapping for CPGMD resistant genes in cowpea by using linked markers

Construction of agroinfectious clones: A partial tandem repeat (1.9 mer) of the DNA A viral genome was constructed in two cloning steps. In the first step, an *EcoRI/KpnI* fragment of ~2.4kb was cut from the plasmid pKSMYMV-A and cloned into the *EcoRI/KpnI* sites of binary vector pCAMBIA 1300 (Cambia) to produce the recombinant plasmid pCAM MYMV AM. In the second step, the ~2.7kb KpnI fragment was cut from the plasmid pKSMYMV-A and cloned into the KpnI site of pCAM MYMV AM to produce the recombinant plasmid pCAM MYMV AD. Similarly a partial tandem repeat (1.5 mer) of the DNA B viral geneome was also constructed in a two step cloning procedure. In the first

Fig. 14: Solanaceous Day organized on 19th January, 2019 at ICAR-IIVR, Varanasi

step, a ~1.4 kb *HindIII/BamHI* fragment was cut from the plasmid pKSMYMV-B and cloned into pCAMBIA 1300 to produce the recombinant plasmid pCAM MYMV BM. In the second step the *BamHI* fragment was cut from the plasmid pKSMYMV-B and cloned into the *BamHI* site of the plasmid pCAM MYMV BM to produce the recombinant plasmid pCAM MYMV BD. A head to tail arrangement of the constructs was confirmed through restriction digestion analysis.

Agroinoculations of plants and detection of the DNA components: Chemically competent cells of *Agrobacterium tumefaciens* strain EHA105 were prepared and transformed with the infectious plasmids pCAM MYMV AD and pCAM MYMV BD. Transformed Agrobacterium cultures were grown at 28°C for 48 h were pelleted and resuspended in agroinoculation buffer (10 mM $MgCl_2$, 10 mM 2-(N-Morpholino) ethanesulfonic acid (MES) pH 5.8 and 2.25 mM acetosyringone) to a final OD600 of 1.0, and equal volumes of DNA-A and DNA-B cultures were mixed before inoculation. Cowpea seeds of susceptible line (VRCP-144-5) were soaked in sterile water overnight at 37 ^{0}C, the seed coats were removed near collar region and seeds finely pricked with fine needle in the collar region and immediately submerged in the appropriate innocula prepared. Inocula containing pCAM MYMV AD and pCAM MYMV BD were also inoculated separately on five seeds each. Also cowpea plants inoculated with *Agrobacterium tumefaciens* strain EHA105 harbouring blank pCAMBIA 1300 were also maintained as mock. Inoculated plants were maintained in an insect-proof growth chamber (25-26 °C constant temperature, with a 16-h light) for 60 days post inoculation. Total genomic DNA isolated from agro-inoculated plants were subjected to semi-quantitative PCR assay using universal primer pairs targeting DNA A and DNA B of MYMV to examine the viral accumulation in the inoculated test plants.

Field screening: Based on field screening of 217 genotypes of cowpea along with advanced breeding lines during *kharif* 2017 and Summer 2018 (Fig. 15), 21 genotypes and 10 advanced breeding lines were found highly resistant/immune to cowpea golden mosaic disease. The twenty one genotypes that are highly resistant/immune to CPGMD under Varanasi conditions were EC390242, EC390213, EC390252, EC1738, EC9135-B, IC201081, IC202776, IC249588, IC39095, IC334740, IC202717, IC559396, IC337931, IC3009, IC259063, IC34009, IC253277, IC201075, EC528398, Jaipur AC-1, BC244002. The ten advanced breeding lines *viz*., VRCP-65-8, VRCP-80-4, VRCP-143-2, VRCP-147-2, VRCP-159-4, VRCP-174-3, VRCP-175-3, VRCP-187-6, VRCP-198-4, VRCP-199-2 were also found highly resistant/immune to the CPGMD under Varanasi conditions. The genotypes which showed immune/highly resistant to the CPGMD causing virus under field condition is being checked under protected conditions using the developed agroinfectious clone for further selecting the highly resistant/immune genotype(s).

Fig 15: Symptoms on leaves of inoculated seeds

Screening of cowpea lines for golden mosaic disease resistance using Agroinfectious clone: Fifteen cowpea lines showing field resistance along with moderately resistant and susceptible lines were selected for artificial screening under glass house conditions using above standardized protocol. Scoring was done with 0-4 scale. Seeds inoculated with mixture of DNA A and DNA B culture produced symptoms whereas seeds inoculated with DNA A and DNA B separately and mock inoculation failed to produce symptoms. Inoculated seeds of VRCP-144-5 produced initial symptoms on 42 days after inoculation. Upon screening of germplasm lines, 7 were resistant, 4 were moderately resistant, 3 were susceptible and 1 highly susceptible.

Project 10: Efficient water management in horticultural crops under Agri-CRP on Water project

Vegetable-based cropping sequences were studied for standardization of crop geometry under micro-

irrigation and fertigation. Three cropping sequences under study were, i) cowpea- summer squash-amaranth, ii) okra- sweet pepper- baby corn, iii) okra-pea- bitter gourd. The studies were conducted with single, two, three and four plants to be irrigated by each emitter of different laterals. Crops were sown on raised bed and applied with 80%, 100%, 120% and 140% of recommended dose of NPK for each lateral row with 1, 2, 3 and 4 plants geometry configuration. Water was applied to the crops as per irrigation scheduling based on the crop water requirement.

Yield and water use efficiency

Summer squash: Maximum yield of summer squash was obtained with 3-plant geometry configuration and drip irrigation with 140% NPK fertigation (52.19 t/ha) and minimum 21.6 t/ha under control. The maximum WUE of 2.31 t/ha-cm was observed under 3-plant geometry with 140% NPK, while minimum WUE of 0.62 t/ha-cm was recorded under control. Increase in WUE was 0.73 to 2 times due to fertigation in single plant and 3-plant geometry configuration. Yield of summer squash was enhanced by 12.3-94.7% with 80-140% fertigation over control and 17.6 - 91.1% with 2 and 3-plant over single plant geometry.

Sweet pepper: Maximum yield and WUE of sweet pepper was realized with 3-plant geometry configuration as 35.8 t/ha and 0.085 t/ha-cm, respectively at 120% NPK. The minimum yield 11.55 t/ha and WUE 0.012 t/ha-cm was observed under control. Yield enhanced by 42.9-90.6% with 2, 3 and 4-plant geometry configuration over single plant geometry, and 34.7-95% with fertigation. WUE enhanced by 59.1-71.4% with 3-plant geometry.

Pea: Maximum yield of pea was recorded 10.53 t/ha with 3-plant geometry configuration with 140% NPK fertigation. Minimum yield was recorded 3.6 t/ha under control. There was 33.9-101% increase in yield with drip fertigation over control. There was 31.4 to 86.3% increase in yield with 2 to 3-plant geometry configuration. Maximum WUE of 0.554 t/ha-cm with 3-plant configuration and 140% NPK against 0.107 t/ha-cm with single plant under control

Bitter gourd: Yield of bitter gourd was found maximum 13.5 t/ha with 2-plant geometry and 140% NPK fertigation and minimum 6.88 t/ha with control. Increase in yield and WUE were 9-70.3% and 77.0–268% with fertigation over control; and 8.5-17.9% and 16.5-48.3.3%, respectively with 2 to 4-plant geometry configuration.

Amaranth: Maximum leaf yield (22.96 t/ha) was realized with 4-plant geometry and 140% NPK fertigation. Minimum yield (8.1 t/ha) was found under control. Yield and WUE of amaranth enhanced by 31.7 - 55.7% and 24.8-55.3%, respectively with 2 to 4-plant geometry. However, with drip fertigation of 80-140% NPK, these were 16.4 to 91.5% and 2.18-2.64 times higher, respectively over control.

Okra: Maximum yield of okra was 15.95 t/ha with 3-plant geometry configuration and 140% NPK fertigation and minimum in control (7.82 t/ha). Increase in yield and WUE was 15.4-67.6% and 1.56-2.99 time, respectively with fertigation over control. Increase in yield and WUE by 2.9-52.4% and 21.9-37.5%, respectively was noted with 2 to 4-plant over single plant geometry.

Cowpea: Maximum yield of 15.2 t/ha was realized with 3-plant geometry configuration and 140% NPK fertigation while minimum 3.21 t/ha was found in control. Yield enhanced by 80-210% with 80-140% fertigation over control and 23.1-118% with 2, 3 & 4 plant over single plant geometry configuration.

Baby corn: Maximum yield of 30.17 t/ha was realized with 3-plant geometry and 140% NPK fertigation while minimum was 9.16 t/ha noticed under control. The yield was lower at 4-plant geometry as compared to 2 and 3-plant geometry. Increase in yield and WUE was 19.6-88.8% and 33.2-88.8%, respectively with 2 to 4-plants geometry over single plant geometry. Increase in yield and WUE with fertigation varied from 21-100% and 1.64-3.48 times, respectively over control.

Equivalent yield: Based on the price of various vegetables, the equivalent yield of all three vegetable sequences was calculated in terms of cowpea. It was found that crop sequence 'okra- sweet pepper- baby corn' was superior with maximum cowpea equivalent yield (140 t/ha) with irrigation system and land under use for 350 days annually. Vegetable crop sequence cowpea- summer squash- amaranth had equivalent cowpea yield of 100.4 t/ha in 280 days. The crop sequence okra-pea- bitter gourd had the lowest cowpea equivalent yield of 43.7 t/ha during 325 days.

Project 11: Development of shelf stable intermediate moisture leafy vegetables using radiation processing

Leafy vegetables such as amaranth, cabbage, spinach were dried to intermediate moisture (IM) range of 16-20%. Dried leaves were packaged in polypropylene pouches and were sent to BARC for radiation treatment of 1 kGy and 2 kGy dosage. The

treated leaves were assessed for sensory, biochemical and microbiological analysis during 15 days interval at storage temperature of 10°C. Moisture content decreased during storage in IM amaranth leaves in all the treatments. The decrease in ascorbic acid was 42.8% and 46.2% during 150 days of refrigerated storage at 10°C in 1 kGy and 2 kGy, respectively. Total phenol contents also decreased to 42.6% and 66.0% after 150 days of refrigerated storage in 1 kGy and 2 kGy, respectively. Antioxidant activity also decreased and the decrease in IM amaranth leaves was 44.85% and 29.13% during 150 days of refrigerated storage in 1 kGy and 2 kGy, respectively as compared to the loss of 33.2% in control IM amaranth leaves during refrigerated storage of 150 days. Sensory score of IM amaranth leaves decreased during refrigerated storage and 1 kGy and 2kGy IM amaranth leaves were acceptable to judges for flavour, colour and appearance, body and texture and overall acceptability for 150 days and 120 days, respectively during refrigerated storage.

Moisture content in 1 kGy and 2 kGy treated cabbage leaves decreased during refrigerated storage. There had been 53.4% and 54.1% decrease in ascorbic acid during 210 days of refrigerated storage in 1 kGy and 2 kGy treated IM cabbage leaves. Total phenol contents also decreased and the decrease was 55.7% and 61.2% in 1 kGy and 2 kGy treated cabbage leaves, respectively during 210 days of refrigerated storage. Similarly antioxidant activity also decreased and the decrease was 35.5% and 37.3% in 1 kGy and 2 kGy treated IM cabbage leaves, respectively during 120 days of refrigerated storage as compared to the losses of 48.1% control IM cabbage leaves. Sensory score also decreased during storage in IM cabbage leaves during storage. Radiation treated 1 kGy and 2 kGy cabbage leaves had the overall acceptability sensory score for 90 days at refrigerated storage.

There had been a decrease in moisture content from 16.28-13.71% and 16.39-13.15% in 1 kGy and 2 kGy IM spinach leaves, respectively after 120 days of refrigerated storage. Ascorbic acid decreased to the extent of 59.7% and 60.8% in 1 kGy and 2 kGy treated IM spinach leaves, respectively during 120 days of refrigerated storage. There had been 42% and 38.8% losses in total phenol content in 1 kGy and 2 kGy IM spinach leaves, respectively during 120 days of refrigerated storage. IM radiation treated spinach leaves had consumer acceptability during 45 days of refrigerated storage as compared to consumer acceptability of 75 days during refrigerated storage.

Project 12: Farmer FIRST program on Intervention of improved agricultural technologies for livelihood and nutritional security adhering local resources and working knowledge of the farmers

This project was operated in 06 villages of Araziline block in Varanasi district of U.P. namely, Upadhyaypur, Baburam Ka Pura, Paniyara, Dhanapur, Rajapur and Laskariya with a mission to provide the farmers different livelihood options or strategies for sustainability through different interventions under horticulture, food grain and enterprise based modules.

Horticulture based module: Okra cv. Kashi Kranti and cowpea cv. Kashi Nidhi were demonstrated at 437 farmers' fields of Paniyara, Dhanapur, Rajapur and Laskariya villages in an area of 65.0 ha during summer and rainy seasons, which fetched an average yield of 13.0 t/ha and 10.3 t/ha respectively. Similarly, chilli (Kashi Anmol), brinjal (Kashi Sandesh) (Fig. 16) and tomato var. Kashi Aman were successfully demonstrated at 403 farmers' field in an area of 58.3 ha in Paniyara, Dhanapur, Rajapur, Upadhyaypur and Laskariya villages of Araziline block in Varanasi. During rainy season, bottle gourd cv. Kashi Ganga, sponge gourd cv. Kashi Divya and pumpkin cv. Kashi Harit were demonstrated in an area of 31.7 ha at 331 farmers' fields in Paniyara, Dhanapur Rajapur and Laskariya villages. The farmers were happy with the demonstrations particularly in case of pumpkin, which yielded upto 38.7 t/ha with average fruit weight of 1.91 kg. The average productivity of demonstrated bottle gourd and sponge gourd was 33.1 t/ha and 11.6 t/ha, respectively. During winter season, vegetable pea and French bean (Kashi Rajhans) were demonstrated at 211 farmers' fields in an area of 15.3 ha in Baburam Ka Pura, Paniyara, Rajapur, Dhanapur and Laskariya villages. The sowing of vegetable pea cv. Kashi Nandini and

Fig. 16: Demonstration of brinjal var. Kashi Sandesh in village Lashkarya

Fig. 17 : Demonstration of pea var. Kashi Udai in village Paniyara

Kashi Udai (Fig. 17) was done during 25 October to 10 November. These fetched an average yield of 8.1 t/ha and 10.2 t/ha, respectively. The farmers were very happy with Kashi Nandini variety as produce reached in the market by the 20th December fetching higher price upto Rs. 70-80 per kg. Radish (Kashi Hans) and spinach (All Green) were also demonstrated in an area of 2.0 ha in Upadhyaypur, Paniyara, Dhanapur and Laskariya villages among 40 beneficiaries.

Crop based module: After the successful demonstrations of HUR-917, CSR-43 in paddy during 2017-18, this year high yielding Sambha Mansoori variety of paddy was demonstrated at 118 farmers' fields in an area of 50 ha at Upadhyaypur, Baburam Ka Pura, Paniyara, Dhanapur and Laskariya villages, which fetched an average yield of 4.1 t/ha. Similarly, HD-2967 variety of wheat, which resulted in 24% higher yield than control in 2017-18 was once again demonstrated for seed multiplication at 27 farmers' fields in an area of 5.0 ha, which was procured by other growers of surrounding villages. This year high zinc variety of wheat cv. CBW-38, WB-2 & DBW-39 were successfully demonstrated in all the selected villages at 207 farmers' fields in an area of 20.0 ha, which not only fetched an average productivity of 4.9 t/ha but also had good bread quality.

IFS based module: Success of bamboo made shade-net house (50 sq meter area) in previous year attracted more farmers to adopt this low cost technology. This year, 20 such structures were constructed for demonstrations in Rajapur and Dhanapur villages, which not only helped in raising healthy vegetable nursery but was also useful in producing quality produce of capsicum, cucumber, indeterminate type tomato etc (Fig. 18 & 19). Considering the importance of nutritional security among farm families under Farmers FIRST Programme, kitchen garden were promoted by providing 1600 kitchen garden packets consisting quality seeds of tomato, brinjal, chilli, *sem*, radish, palak, carrot, cowpea, okra, cucumber, bottle gourd, sponge gourd and pumpkin suitable for different seasons. Besides, grafted guava (cv. Lalit) and tissue culture banana (G 9) plants were given to 140 households for planting in their kitchen gardens. Turmeric variety Megha-1 was also demonstrated at 18 farmers' fields in 1 ha area for seed multiplication.

Fig. 18: Dr. A.K. Singh, DDG (Hort.) monitoring shade net house in Paniyara village

Fig. 19: Nursery raising in shade net house in Dhanapur village

Enterprise based module: 127 households of Paniyara, Dhanapur and Laskariya villages were trained and 7118 (day old) chicks (CARI-Devendra, CARI-Karaknath and CARI-Nirvik) along with starter feed, feeder and vaccine were provided for backyard poultry enterprises (Fig. 20). This not only provided additional income to the rural communities through selling of eggs and meat (Rs. 11898.00 per family) but also gave employment to the marginal farmers and landless labourers. Similarly, in the process of promoting marigold cultivation for farm women in

Fig. 20: Promotion of backyard poultry in Dhanapur village

Paniyara and Dhanapur villages as it requires proper care, nurturing, picking and packing in which the female workers have an edge over the male counterparts, successful demonstrations of marigold variety Pusa Narangi and Pusa Basanti was conducted at 38 farmers' field in an area of 6.0 ha resulted in an additional income upto Rs. 10000/- per household. Besides, rural youth of Dhanapur village were also trained for preparation and marketing of vermi-compost for which 20 demonstrations were conducted in vermi-pit bags (Fig. 21).

Fig. 21: Demonstration of vermicompost preparation in Dhanapur village

Apart from the demonstrations, 21 Farmers-Scientists interaction programmes were organized in all the selected villages during different cropping seasons in which farmers, farm women and Gram Pradhan of concerned villages participated and discussed the needs and performance of demonstrated interventions under the objectives of FFP. Four training programmes on backyard poultry farming & management, marigold cultivation and pest management in paddy cultivation were organized in which 269 farmers/landless labourers participated. One Krishak Jagrukta Abhiyan on 'Doubling Farm Income for Livelihood Security' was also organized on 24th November, 2018 in Paniyara village in which more than 800 farmers participated.

Project 13: Scheduled tribes component (earlier Tribal Sub Plan) for tribals of Sonbhadra district in Uttar Pradesh (National Assignment by Department of Agricultural Research & Education, Ministry of Agriculture and Farmers Welfare, Govt. of India)

Scheduled tribe component (earlier TSP) was initiated by the institute with an objective to reduce the poverty and unemployment of the tribals by improving the livelihood and nutritional status of selected 1512 tribal households of Chopan block in Sonbhadra district. In this process, demonstrations of cucurbits *viz.*, bottle gourd (Kashi Ganga), sponge gourd (Kashi Divya) and pumpkin (Kashi Harit) in rainy season were conducted at 623 tribals' fields in an area of 37.8 ha, which fetched an average increase of 31.3% quality yield as compared to the local cultivar. Similarly, demonstrations of tomato (Kashi Aman; Fig. 22), brinjal (Kashi Uttam) and chilli (Kashi Anmol and Kashi Tej) were conducted at 514 tribals' fields in an area of 19.2 ha, 20.0 ha and 23.5 ha, respectively which showed an increase in yield upto 38% as compared to the local cultivar with much superior quality. Demonstrations of legume vegetables *viz.*, cowpea (Kashi Kanchan), *sem* (Kashi Haritima), pea (Kashi Udai and Kashi Nandini) and French Bean (Kashi Rajhans) were conducted at 543 tribals' fields in an area of 33.7 ha whereas demonstrations of root crop and leafy vegetables *viz.*, radish (Kashi Hans), carrot (Kashi Arun) and palak (All

Fig. 22: Demonstration of Kashi Aman variety in tomato at Dhakudandi tribal village

Green) were conducted at 41 tribals' fields in an area of 8.0 ha showed a significant increase in quality and yield as compared to the previous year. This year efforts were also made to demonstrate potato cv. Kufri Jyoti, Kufri Khyati and Kufri Pukhraj in an area of 3.0 ha at 140 tribals' fields, which surpassed all the local varieties and fetched an average yield of 25.0 t/ha. Apart from vegetables, demonstrations of *haldi* (Megha-1), *arhar* (Chamatkar) and paddy (Swarna Mansuri) were conducted at 604 tribals' fields in an area of 61.0 ha, which fetched a better yield and quality as compared to the existing cultivar.

Considering the importance of nutritional security, 4700 kitchen garden packets containing seeds of tomato, brinjal, chilli, cowpea, radish, okra and cucurbits were provided to selected tribal households as well as neighboring tribal during different cropping seasons in 2018-19. Ten on/off campus training programmes were also organized on different aspects of agriculture, which were attended by 1574 tribals. Knap sack sprayers and vermicompost making bags were also provided to 216 tribal households after adequate training. Considering the success of backyard poultry demonstrated during 2014-15, this year also efforts were made to provide 3400 chicks (day old) of CARI-Devendra and CARI-Nirbhik to tribals (Fig. 23).

Fig. 23: Backyard poultry demonstration at Bhalukudar tribal village

Project 14: Establishment of Integrated Beekeeping Development Centre (IBDC)/Centre of Excellence (CoE) on Beekeeping at ICAR-IIVR, Varanasi

Establishment of Honey Processing Plant along with bottling machine at IBDC: Integrated Beekeeping Development Centre (IBDC) on Honey Bee has been established at ICAR-IIVR, Varanasi wherein honey bee disease diagnosis laboratory facility as well as extracting and processing unit for honey and other honey bee products were developed. Laboratory facility is being established for pesticide residue analyses in honey and honey products. Honey processing plant along with bottling machine has been successfully installed on 23rd October, 2018 (Fig. 24). The processing plant is semi-automatic and it can process up to 500 kg honey per day. The plant is being utilized periodically for processing of honey. Besides these, it can be utilized for the training purpose to the farmers, bee-keepers and other stakeholders involved in bee-keeping. In addition, processing plant and bottling machine can be utilized on a service basis to stakeholders of this region. The honey processed from this plant is free from wax and other impurities and it can be directly utilized for commercial sale.

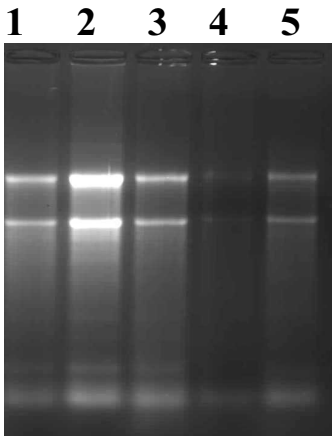
Fig. 24 : Installation of honey processing plant

Apiary management in IBDC: Disinfection of empty combs and equipment's with 80% acetic acid @150 ml/hive body, disinfection of bee box with flame thrower (Fig. 25), dipping of contaminated equipments, combs in soap solution containing 7% formalin for 24 hours, then washing the treated material with water, dried and used. Formic acid 1ml/box, methyl salicylate or ajwain extract 3ml/box for mite or when honey bee flying capacity declined, Sulphur powder 0.5 g/bee

Fig. 25: Extraction of Honey A. Removal of frames laden with honey from bee hives, B. Decapping of comb cells filled with honey and C and D. Honey extraction using extractor under caged condition

frame for general hygiene, small amount of ajwain powder near outlet.

Detection of viruses in dead honey bees: Total RNA has been extracted from dead honey bees collected near to the bee hives using Trisol method (Fig.28). Total RNA was used to synthesize the cDNA using Revertaid first strand synthesis kit (Thermo Scientific, USA) as per manufacturer's instruction. PCR analysis has been performed with the cDNA as template using the primers specific to deformed wing virus and sac brood virus. But there were no virus specific amplification observed. This PCR analysis confirms that there is no association of deformed wing virus and sac brood virus with the dead honey bee samples.



1 -5 Total RNA from dead honey bees

Fig. 26: Agarose gel electrophoresis showing total RNA extracted from honey bees

Floristic studies in relation to honey bee, *Apis mellifera*: In continuation to last year data regarding the bee visits to various vegetables is recorded. Flowering of different vegetable crops belonging to various family viz., was observed round the year except in June and July. Honey bee foraging was observed on all crops except chilli and amaranths.

Honey bee foraging activity study: The peak activity of honey foraging (visit per flower) on four vegetable crops namely mustard, dolichus bean, radish and pea was recorded periodically at two days interval from January to March 2019

Checklist of arthropod pollinators visiting different vegetables: A checklist of major arthropod pollinators was prepared from the vegetable ecosystem. The major pollinator from the region was observed as honey bee. All the four species of honey bees *viz., Apis mellifera* Linnaeus, 1758, *A. dorsata* Fabricius, 1793, *A. ceranaindica* Fabricius, 1798 and *A. florae* Fabricius, 1787 were recorded during the observation.

Foraging behaviour of different insect fauna visiting sponge gourd: Diurnal activity of different insect fauna was also observed (Fig. 27) during the summer months to know about activity of different pollinators, the dominant pollinator and the time of maximum activity of the pollinators. The observations indicate that the maximum pollinators' activity was recorded during 6 to 10 AM. Pollinators included honeybees, bumblebees, carpenter bees, solitary bees, hover flies, beetles, butterflies and moths. The dominant honey bee species was *Apis florea*.

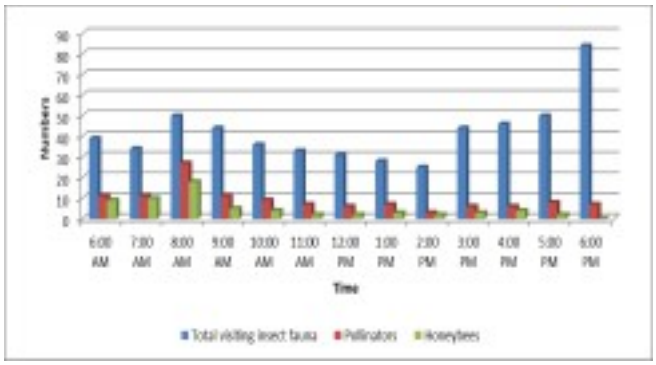


Fig. 27: Diurnal activity of different insect fauna on sponge gourd

Among the four crops, mustard was recorded with higher honey bee visit during the observation period. The pea crops provided least period for honey bee foraging which ended in the last week of the February (Fig. 28).

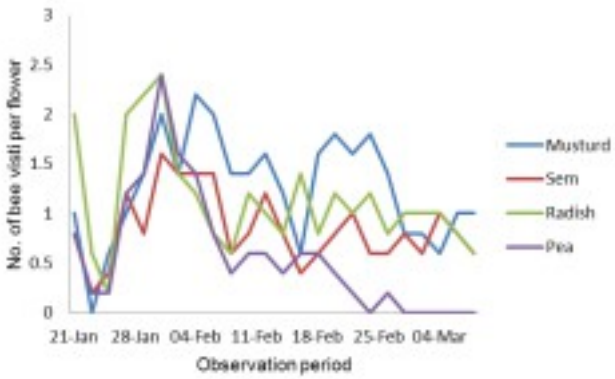


Fig. 28: Honey bee foraging activity study

Beekeeping awareness lecture under institute training programme: With an aim of promoting Beekeeping, the 05 scheduled training programmes on vegetable production were given complete one day hands on training on scientific bee keeping. The bee keeping training and awareness programmes were organized on 14 September 2018, 17 November 2018, 11

Fig. 29: Practical demonstration on honey bee keeping in IBDC

January 2019, 25 January 2019 and 16 March 2019. This training cum awareness programme was attended by 81 farmers from Samastipur, Madhubani, Darbhanga, Muzaffarpur districts of Bihar and 20 farmers from Kangra district of Himachal Pradesh. The participants were aware with benefits and advanced technologies of beekeeping with both theoretical and practical experience (Fig. 29).

Project 15: Agro infectious clones development for probing resistance to chilli leaf curl diseases caused by begomoviruses and devising integrated management strategy

Diversity of leaf curl viruses infecting chillies in India: Among the samples collected from 7 different states of India, chilli leaf curl disease is found associated with chilli leaf curl virus (22%), tomato leaf curl New Delhi virus (51%), tomato leaf curl Joydebpur virus (26%) and other (22%). Among 32% of samples tested were found mixedly infected with more than one virus species. ToLCNDV is found to be prevalent among all the 7 states of survey, where as ToLCJoV is restricted to 4 states (Tamil Nadu, Uttar Pradesh, Rajasthan and Andaman) and ChiLCV in UP, Bihar, Madhya Pradesh and Andhra Pradesh. In addition other viruses such as pepper leaf curl Bangladesh virus is found restricted to UP. Nearly 55% of the samples were also found detected with association of either α-satellite or β-satellite or both which are known to increase the symptom severity on crop plants (Fig. 30).

Development of Agroinfectious clones: Based on the sequencing data, tomato leaf curl Joydebpur virus is found to be predominant in causing leaf curl disease on chilli. In addition to one sample from UP (C11), two samples CH82 and CHVNS were chosen for the infectious clone development. Initially RCA restricted product resolved on gel showed ~2.7kb fragment with *Xba*I and *Kpn*I enzyme and has been cloned in pBluescript II K^+ vector and sequenced. After sequencing for monomer construction for sample CH82 monomer prepared based on the enzyme digestion *Xba*I and *Kpn*I and CHVNS with *Kpn*I and *Bam*HI. Dimer also prepared by tandem construct for both the samples. Positive clone has been subjected to plasmid isolation and extracted plasmids were transformed into *Agrobacterium tumefaciens* strain EHA105 and the infectious clone has been produced. Further it was been confirmed with the PCR analysis using universal primer pair and restriction analysis. Similarly additional one dimer has been constructed for beta satellite (tomato leaf curl Bangladesh betasatelitte). Agrobacterium culture having the construct has been inoculated on the *Nicotiana benthamiana* plants for testing the infectivity and the plants were not produced any symptoms. Hence inoculation buffer has been with acetosyringone, $MgCl_2$ and MES and the clones were inoculated on *N. benthamiana* plants and are under observation. It was also mixedly inoculated with the ToLCJoV dimer clones. Out of 10 plants inoculated, only one plant produced symptoms on *N. benthamiana* plants. Plant need to be tested for virus.

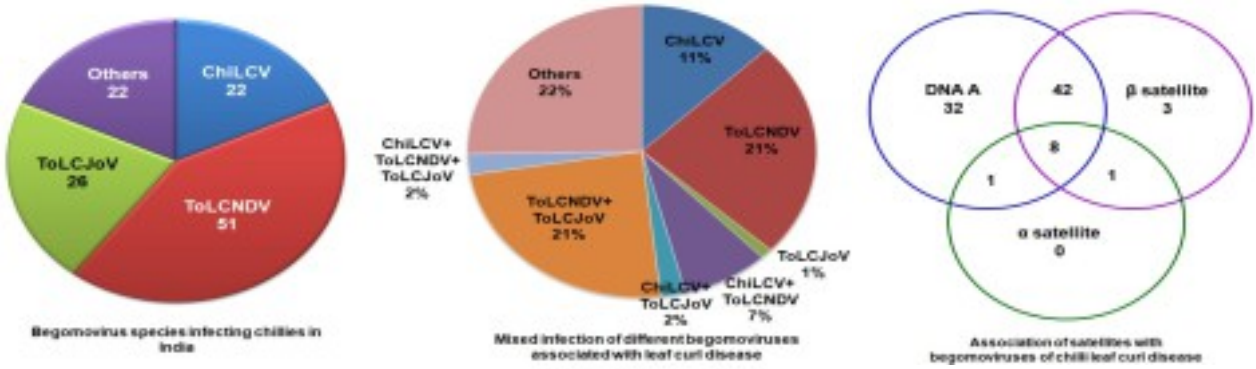


Fig.30: Scenario of species distribution of begomoviruses associated with chilli leaf curl disease in India

LAMP Assay: For the quick diagnostics of tomato leaf curl Joydebpur virus causing chilli leaf curl disease, LAMP primers were designed targeting AC1 gene. Details of the primers designed are:

ID	5′-3′	LOCATION	nt
FLOOP	GCCCACTCTACTCAGGTTCCA	1495-1864 (AC1 and AC2 region)	21
BLOOP	CTTTAATTTGAACTGGCTTTCCG		23
F3	GCGATGAARTATGAACAGC		19
B3	TGGTACAACGTCATTGATGAC		21
FIP	TGCGACCTTCATCACCCTCTAGCCTGTGCTGGACTTTG		38
BIP	TCCTGGATTGCAGAGGAAGATAGTTAAAGAATTCATGGGGGC		42

Assay has been validated with the infected samples. Infected samples were detected with virus where as other samples infected with other begomoviruses such as mungbean yellow mosaic India virus, tomato leaf curl New Delhi virus were not detected with this assay (Fig.31).

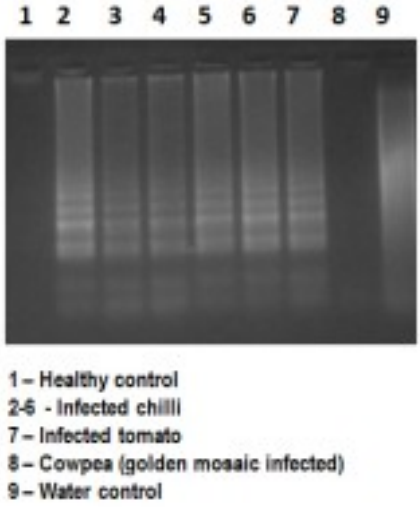


Fig. 31: Agarose gel showing LAMP assay performed with chilli samples for specific detection of ToLCJoV

Field study; Integrated Disease Management (IDM) module has been devised for the management of leaf curl disease on chilli. Components used in the modules are as follows: Seed disinfection using Virkon S @ 5g/l for 20 mins; Seed treatment with imidacloprid; Covering of nursery seedlings with insect proof net; Soil application with bioconsortia formulation @ 5g/l; Seedling dip with imidacloprid @ 0.5 ml/lit followed by carbendazim + mancozeb @ 2.5g/l for 20 mins each; Soil application of FYM enriched with bioconsortia formulation; Black silver mulching; Soil application of neem cake @ 5 g/plant; Raising of bajra as border crop; Installation of yellow sticky traps @ 20 nos./acre; Periodical spraying with micronutrient mixture and Salicylic acid (2mM); Soil drenching with humic acid @ 5ml/l; Need based application of insecticides such as neem oil, cyzpyr, Intrepid, flonicamid, chlorantraniliprole and flupyridifurone. Among the different module, integrated module with black silver mulching (Module 2) is performing better than other module in recording highest chilli yield. Due to minimum natural incidence of leaf curl disease (2017-18), effect of different module on leaf curl disease could not be seen. But for yield point of view, module 2 performs better than other modules on susceptible cultivar Pusa Jwala. Same experiment is repeated for the second year (2018-19) to observe the performance. Trial has recorded 62.96% reduced leaf curl disease incidence in IDM module with mulching (Module 2) in comparison with control. Same module has recorded higher chilli yield (44.53q/ha) with greater average plant height (40.99 cm) (Table 8).

Table 8: Effect of different modules on chilli leaf curl disease incidence and yield

Module	2017-18	2018-19			
	Yield (q/ha)	Average disease incidence	% reduction of disease over control	Average plant height	Yield (q/ha)
IDM without mulching	36.16	13	51.85	37.55	38.78
IDM with mulching	53.83	10	62.96	40.99	44.53
Farmers practice	33.50	18	33.33	33.59	29.06
Untreated control	33.0	27	-	31.81	22.07

New Observations: First report of tomato leaf curl Joydebpur virus causing leaf curl disease in Andaman and Nicobar Islands has been characterized and documented for the first time. Leaf samples from 15 symptomatic plants collected from 6 different locations of islands were first tested for begomovirus infection using squash leaf curl virus (SLCV) antiserum through Dot-IBA. Thirteen out of fifteen symptomatic samples showed positive reaction for begomovirus infection. To characterize the virus identity, total DNA isolated from the symptomatic and asymptomatic samples were tested using a PCR assay with universal primer pairs, amplifying ~1200 bp of DNA-A. All samples tested positive in Dot-IBA were positive in PCR assay also. Nucleotide sequences of amplicons from 8 samples showed 98% identity with tomato leaf curl Joydebpur virus (ToLCJoV) isolates of Bangladesh and India in BLAST analysis. DNA from one representative positive sample was subjected to rolling circle amplification followed by RFLP analysis for complete genome characterization. Fragment size of ~2.7kb upon digestion with *Bam*HI and *Hind*III were cloned and four clones were completely sequenced through primer walking. All the four sequences shared 99% identity with each other and the consensus sequence of 2761 nt long was submitted to GenBank database (Accession no. MK330665). The sequence exhibited 98.23% nucleotide identity with the complete DNA-A sequence of ToLCJoV isolate from Bangladesh infecting tomato. Further PCR assays with the β01/02 primer pair followed by sequencing confirmed the association of tomato leaf curl Joydebpur betasatellite (ToLCJoB) with >92% identity with earlier reported strains.

All India Coordinated Research Project on Vegetable Crops

During the year 2018-19, a total number of 2143 trials were conducted at 36 regular and 24 voluntary centres of AICRP on Vegetable Crops.

The following recommendations under Crop Improvement, Crop Production and Crop Protection were made during 36th Group Meeting of AICRP (VC) held at ICAR-RARI, Durgapura from 18-21st May, 2018 (Table 1, 2 &3).

Crop Improvement

Variety evaluation trials: Seven entries of 6 crops were identified for release and notification for different agro-climatic zones of the country.

Hybrid evaluation trials: Three entries in three crops were identified for release and notification for different agro-climatic zones of the country.

Table 1: Varieties identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Brinjal Long	2014/BRLVAR-3	DBL-175	IARI	**VI** (Rajasthan, Gujarat, Haryana and Delhi), **VII** (Madhya Pradesh, Maharashtra & Goa)
2.	Brinjal Round	2014/BRRVAR-3	IC-0598429	CHES, Bhubaneswar	**V** (Chhattisgarh, Telangana, Orissa & A.P.)
3.	Cowpea (Bush Type)	2014/COPVAR-4	CP-55	IARI	**VI** (Rajasthan, Gujarat, Haryana and Delhi)
4.	Dolichos Bean (Pole Type)	2014/DOLPVAR-1	DB-10	IARI	**VII** (Madhya Pradesh, Maharashtra & Goa)
5.	Sponge gourd	2014/SPGVAR-1	VRSG-1	IIVR	**IV** (Punjab, Uttar Pradesh, Bihar and Jharkhand)
6.	Cucumber	2014/CUCUVAR-1	DC-83	IARI	**IV** (Punjab, Uttar Pradesh, Bihar and Jharkhand)
7.	Mustard Green	2014/MGVAR-1	UHF VR-12-1	Ranichauri	**III** (Meghalaya, Nagaland, Anandman & Nicobar & A.P.)

Table 2: Hybrids identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Chilli	2014/CHIHYB-3		-	**IV** (Punjab, Uttar Pradesh, Bihar and Jharkhand)
2.	Bitter gourd	2014/BIGHYB-2	NBIH-2009	Nuzi Veedu Seeds	**IV** (Punjab, Uttar Pradesh, Bihar and Jharkhand)
3.	Sponge gourd	2014/SPGHYB-2	VRSGH-1	IIVR	**IV** (Punjab, Uttar Pradesh, Bihar and Jharkhand)

Table 3: Resistant varietal trials identified for release and notification

S. No.	Crop	Code	Name of the entry	Source	Zone
1.	Tomato (ToLCV)	2014/TOLCVRES-5	-	-	**VIII** (Kerala, Tamil Nadu, Karnataka, Pondicherry)

Resistant evaluation trials: One entry of tomato was identified as tomato leaf curl virus for release and notification for Zone No. VIII.

Production Technologies Developed

Vegetable Production

Drip Irrigation Studies

- Under the tropical sub humid laterite soil of Kerala, irrigation at 0.5 bar along with black polythene mulch gave highest yield (387.5q/ha) and C:B ratio (1:1.9) in oriental pickling melon.
- 100% application of water soluble fertilizers (18:18:18 NPK) through drip irrigation in hybrid chilli var. Kashi Surkh, recorded the maximum fruit yield of 110.33q/ha with maximum C:B ratio of 1:2.35 under Varanasi condition.

Weed Management Studies

- Mulching with black-silver polythene (double coated 30 micron) recorded maximum green chilli yield of 119.34 q/ha and 87.7 q/ha with maximum C:B ratio of 1:1.40 and 1:1.82 in chilli varieties cv. Kashi Tej and Kashi Anmol, respectively at Varanasi and Hisar conditions. However at Ludhiana, the same treatment recorded highest yield of 317.9 q/ha with C:B ratio of 1: 3.05.
- Pre-emergence application of Pendimethalin @ 6ml/L + one hand weeding at 35 days after sowing gave maximum fruit yield of 81.26 q/ha with highest C:B ratio 1:2.48 in Okra cv. Arka Anamika under Kalyanpur condition.
- Pre emergence application of Pendimethalin @ 6 ml/L along with one hand weeding gave highest okra yield (129.5 q/ha) with highest C:B ratio of 1: 1.61 under Ludhiana condition.

Integrated Nutrient Management

- Application of vermicompost @ 2.5t/ha + 1/2 recommended dose of NPK (150:50:100 kg/ha)gave maximum yield (164.56 q/ha) with maximum C:B ratio of 1: 3.16 in broccoli under Bhubaneswar condition.

Organic Trials

- Application of vermicompost @ 5 t/ha + PSB + Azospirillum (each 5 kg/ha) gave maximum fresh leaf yield (145.93 q/ha) in amaranth. However, the highest net return (Rs. 1,58,860) and maximum C:B ratio (1:3.38) was recorded with application of FYM 20 t/ha + PSB + Azospirillum (each 5 kg/ha) under Nagaland condition.

Seed Production

- Based on three years data it was concluded that transplanting of 24 or 27 days old seedlings of brinjal cv. Gulabi resulted in maximum and on par seed yield (7.59 q/ha and 7.51q/ha, respectively) under Hyderabad condition. Hence, it is recommended for agro-climatic condition of Zone V.
- Sowing of palak cv. All Green in the first fortnight of October with one leaf cutting produced the highest seed yield of 29.21 q/ha with higher seed quality at Pantnagar. Hence, it is recommended for agro-climatic condition of Zone I.
- Sowing of palak cv. All Green during October with one cutting gave a significantly higher seed yield (15.66q/ha) along with highest seed quality at Varanasi. The C:B ratio was also higher. Hence, it is recommended for agro-climatic condition of Zone IV.
- Pre-emergence application of Pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS produced maximum seed yield (14.7 q/ha) with C:B ratio of 1:2.11 in green pea cv. Arkel at Pantnagar condition. Hence, it is recommended for agro-climatic condition of Zone I.
- At the end of three year experiment, highest seed yield (9.55 q/ha) was recorded in chilli cv. LCA-334 in weed free plot followed by straw mulch (8.12q/ha) at Hyderabad condition. Hence, it is recommended for agro-climatic condition of Zone V.
- Mulching with black polythene in chilli cv. LCA-620 recorded highest seed yield (13.9q/ha) along with C:B ratio (1:1.02) at Lam. Hence, it is recommended for agro-climatic condition of Zone V.
- Based on three years experimental results, better germination percentage with other quality traits with C:B ratio of 1:1.92 were observed in seed coating with Carbendazim @2g/kg seed + Imidachloprid @2ml/kg seed + Diammonium phosphate @30g/kg seed + IIHR micronutrient mixture @ 20g/kg seed in chilli cv. LCA-625 at Lam. Hence, it is recommended for agro-climatic condition of Zone V.
- Foliar spray of growth retardant Cycocil @ 500ppm and spacing at 60 x 30 cm increased the seed yield and quality in Okra cv. Phule Utkarsh during kharif season at Rahuri. Hence, it is recommended for agro-climatic condition of Zone VII.

- Highest seed yield of 270.09 kg/ha was recorded with foliar spray of NAA 30 ppm at 5 days before transplanting in nursery, 25days, 45days and 65 days after transplanting in Chilli cv. Phule Jyoti at Rahuri. Hence, it is recommended for agro-climatic condition of Zone VII.
- High quality seeds (germination percentage, seed weight, speed of germination, vigor index, etc.) were extracted when fruits were harvested 45 days after anthesis and allowing post-harvest ripening for 10 days before seed extraction from fruits of pumpkin cv. Punjab Samrat at Ludhiana. Hence, it is recommended for agro-climatic condition of Zone IV.

Protected Cultivation

- At Jabalpur, maximum yield (865.94 q/ha) net return (Rs. 8,53,717/ha) and C:B ratio (1:4.14) was recorded in the treatment V1S1P1 (Hybrid Sun Cherry Extra Pure+ 100X 45 cm + pinching & staking) in naturally ventilated polyhouse condition. Hence it is recommended for Keymore Plateau & Satpura Hills of Madhya Pradesh in Agro-climatic zone VII.
- At Jabalpur, it is observed that the maximum yield (200.0 q/ha) along with a net return Rs. 2,27,680/ha and C:B ratio of 1:4.15 was recorded when hybrid tomato Arka Rakshak was grown under rain shelter with a spacing of 100cm x 60 cm. Hence, it is recommended for Keymore Plateau and Satpura Hills of Madhya Pradesh Agro-climatic zone VII.

Physiology, Biochemistry and Processing

- PAU, Ludhiana, carried out biochemical estimation of antioxidant components in tomato, pumpkin, bitter gourd and muskmelon genotypes during 2017-18. Various quality parameters such as vitamin C, TSS, carotenoids, phenols and total sugar contents were reported in different genotypes of vegetable crops. Tomato Determinant Variety -3 exhibited highest vitamin C (40.62 mg/100g) and lycopene (2.28 mg/100g) content.
- Oxalate content in tomato varieties was reported at PAU, Ludhiana and IIVR, Varanasi. Both centres estimated oxalate content and citric acid in different AVT-I and AVT-II varieties of AICRP trials during breaker, turning, ripe and fully ripe stage of harvest. Maximum oxalate content and acidity in tomato varieties were recorded at breaker stage and minimum at fully ripe stage.
- Under processing trials during 2017-18, assessment of tomato varieties under AVT-I and AVT-II for processing quality traits were carried out at IIVR, Varanasi, PAU Ludhiana and IIHR Bangalore. Tomato Determinant-7 (AVT-I) had maximum ascorbic acid, TSS and lycopene content whereas Tomato Determinant-5 (AVT-I) had minimum lycopene content in all stages of harvest of breaker, turning, ripe and fully ripe stages of harvest.

Protection Technologies

Integrated Disease Management

- Nursery disease management using bioagents and new fungicides (8.18) at Hyderabad: Three years data have been concluded at Hyderabad centers and found that in tomato among the different treatments tested for the nursery disease management, *Trichoderma viridae* was found effective among the bioagents in management of damping off. In Brinjal among the different bioagent tested, *Trichoderma viridae* was found effective in management of damping off. In Chilli among the tested bioagents, minimum damping off was recorded in *Pseudomonas flourescence* treated plot.
- Integrated management of vector borne virus diseases of chilli (Veg 8.19) at Kalyani, Sabour, Solan and Rahuri: Treatment T_5 involving application of neem cake @ 1.0kg/m^2in the seed bed, spraying of Cyazpyr @ 1.8ml/L 2-3 days before transplanting, seed treatment with Imidacloprid @ 8g/kg, seedling dip of Imidacloprid @ 0.5ml/L and growing of two rows of maize as border crop in the main field along with silver agrimulch sheet + rotational spraying of insecticides (Acephate @ 1.5g/L+ neem oil @ 2.0ml/L) followed by (Fipronil @ 1.0 ml/L+ neem oil @ 2.0ml/L), (Imidacloprid @ 2 g/15L+neem oil @ 2.0ml/L) and (Cyazypyr @ 1.8ml/L) at 7 days interval till fruit formation was found very effective and significantly reduced chilli leaf curl disease, white fly and thrips populations, while increased the fruit yield. The ICBR was 3.46 at Kalyani on cultivar Sel-4, 3.42 in cultivar DKC-8 at Solan, whereas, C:B ratio 1:2.2 at Sabour, 1:1.76 on cultivar Phule Jyoti at Rahuri. However, the samples of marketable green chilli analyzed at Kalyani for pesticide residues and no pesticides have been detected and quantified.
- IDM package for tomato diseases (Veg 8.20) at Bhubaneswar, Hyderabad, Junagadh, Solan and

Kalyani: Treatment T_5 integrated management practice involving seed priming with Seed Pro @ 4g/kg of seed followed by soil application of Seed Pro @ 10g/kg of soil while filling of protrays and soil drenching of Seed Pro @ 5% after seed germination followed by covering with 50- mesh nylon net of nursery bed supplemented with border row planting (2 rows) of maize at least 15 days before transplanting of seedlings in the main field followed by seedling dip with 0.1% (Carbendazim 12%+Mancozeb 63% WP) at the time of transplanting and sequential spraying with Acephate 75% WP @ 1.5g/l on 10 DAT, Fipronil 5% SC @ 1.5ml/l on 20 DAT, Copper hydroxide 77% WP (2.0g/l) on 25 DAT, Imidacloprid 70% WG @2g/15l on 40 DAT, Fenamidone 10% + Mancozeb 50% WDG (0.25%) two to three times from 45 DAT at 10 days intervals was highly effective in the management of tomato diseases and maximum fruit yield. The C:B ratio 1:4.0 on variety Utkal Kumari at Bhubaneshwar, 1:1.75 in variety Arka Vikas at Hyderabad, whereas, ICBR 5.2 on cultivar JT- 3 at Junagarh, 6.16 on variety Naveen at Solan, 5.7 on hybrid L-37at Kalyani was recorded. Pesticide Residue Analysis at Kalyani for this treatment revealed that no pesticides have been detected.

- However, at Rahuri chemical module T4 comprising of seed treatment with Captan 50% WP (2g/kg) + drenching of nursery by fosetyl Al 80% WP @ 0.1% immediately after germination, foliar spray of nursery with copper hydroxide 77% WP (2.0g/l) at 3-5 leaf stage and in main field seedling dip with 0.1% (Carbendazim 12% + Mancozeb 63%WP), spray of Acephate 75% WP @ 1.5 g/l on 10 days after transplanting, spray with Fipronil 5% SC @ 1.5 ml/l on 20 DAT after transplanting, spray with Copper hydroxide 77% WP (2.0g/l) on 25 DAT, spray with Imidacloprid 70% WG @ 2g/l on 40 DAT and spray with Fenamidone 10% + Mancozeb 50% WDG (0.25%) two times was effective. The C: B ratio was 1:1.74 on cultivar Phule Raja which may be recommended.
- IDM packages for cucurbit diseases (Veg 8.22) at Kalyani and Rahuri: Integrated IDM moduleT_5 involving growing of two rows of maize as border crops and use of agrisilver 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 against gummy stem blight, powdery mildew and downy mildew with maximum fruit yield. The ICBR 8.9 in bottle gourd cv. Jorabota (Local) was recorded at Kalyani, C:B ratio 1:3 in cucumber variety Himangi was recorded at Rahuri. The marketable bottle gourd fruits analyzed for pesticide residue at Kalyani and no pesticides have been detected.

Integrated Insect Pest Management

- Spraying Neem Seed Powder Extract (40 g/litre) at an interval of 10 days starting from 25 DAT in cabbage (cv. Unnati) was found most effective for the management of Diamond Back Moth (DBM) with lowest cumulative DBM count of 0.95/plant compared to 6.15 in untreated control. The increase in marketable yield was 89.3% over untreated control with benefit cost ratio of 5.53 at Bangalore.
- Cyantraniliprole 10.26% OD @ 1.8 ml/litre at 10 days intervals starting from appearance of *Tuta absoluta* in tomato (cv. Arka Rakshak) was found most effective for the management of the pest with fruit damage of 2.9% compared to 35.8% in untreated control. The marketable yield was 88.5 t/ha in this treatment compared to 43.3 t/ha in control with C:B ratio of 1:5.71 at Bangalore.
- For the management of leaf hoppers and whiteflies on okra (cv. Phule Utkarsha) two sprays of Flupyradifurone 200 SL @ 200 g a.i. /ha (2ml/litre) at an interval of 10 days starting from the pest infestation of leaf hoppers and whiteflies, with highest yield of 197.85 q/ha and C:B ratio of 1:2.75 at Rahuri.
- For the management of thrips and mites in chilli, Spiromesifen @ 0.6 ml/litre was effective against mites followed by Emamectin benzoate @ 0.5 g/litre and for the management of thrips, Fipronil @ 0.35 g/litre was effective followed by Emamectin benzoate @ 0.5 g/litre. Highest yield (64.4 q/ha) was obtained in Emamectin benzoate treatment with B:C ratio of 1.65 at Hyderabad.

- Studies on the management of brinjal shoot and fruit borer under protected and open conditions indicated that the pest infestation under net house conditions reduced significantly and yield increased about 2.36 times *i.e.*, 136% in comparison with open conditions in Punjab.
- IPM module in cucurbits cv. MH 27 indicated Module 4 (seed treatment with Imidacloprid 48 FS @ 5-10g/kg seed, removal of cotyledon leaves 7 days after germination, spraying Emamectin benzoate 25 WG @ 0.04 g/litre, spraying neem oil 3000 ppm@ 5ml/litre and installation of cue lure traps 15 /acre and spraying Spinosad 45 SC 0.3 ml/ha) indicated 56.64 per cent reduction in fruit fly population with fruit yield of 155.82 q/ha at Punjab.
- In okra cv. Kashi Pragati seed treatment with *Pseudomonas putida* 1% A.S. @ 10 ml/ kg seed + application of 20 tons of FYM enriched with 5 lit of *Pseudomonas putida*/ha was found effective with reduction in 68.5% root knot nematode, *Meloidogyne incognita* final population, root knot index 1.3 and 42% increase in marketable yield with B: C ratio of 1.25 under open field condition at Varanasi.
- In tomato cv. Kashi Aman, nursery drenching (substrate treatment with 5 ml of *Bacillus amyloliquefaciens* 1% A.S. / kg of coco peat for producing seedlings of tomato in portrays) + application of 20 tons of FYM enriched with 5 lit of *B. amyloliquefaciens* 1% A.S /ha was found effective with 70% reduction in final population of root knot nematode, *Meloidogyne incognita*, root knot index 1.8 and 24.7% increase in marketable yield with B: C ratio of 1.18 under open field condition at Varanasi.
- **Breeder Seed Production:** During the year 2018-19, a total of 41929.390 kg Breeder Seeds produced against the indent of 20615.990 kg for 198 varieties of 35 vegetable crops by 21 coordinating centres. During the year 2018-19, an indent of 14125.960 kg breeder seed for 185 varieties of 34 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GoI, New Delhi and the same have been allotted to 21 coordinating centres for under taking the production. A total of 14402.010 kg of Breeder Seeds has been produced against the indents. However, the final production figures are awaited from many centres for some vegetable crops.

ICAR- KRISHI VIGYAN KENDRA, BHADOHI

Training Programme: KVK-Bhadohi conducted 106 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 2308 beneficiaries including 1387 male and 719 female participants (Table 1 & Fig. 1).

Table 1: Training programmes organized

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	95	1252	584	1836
Rural youths	06	31	74	105
Extension functionaries	05	104	61	165
Total	**106**	**1387**	**719**	**2308**

Fig. 1: Training Farm Women

Fig. 2: CFLD on Mustard (RH-749)

Fig. 3 : OFT- Cropping System

Front Line Demonstration on agricultural discipline: A total of 21 front line demonstrations (FLDs) on pulses, oilseeds, paddy, wheat, vegetables and fodder crops were conducted in 126.39 ha area in order to establish the production potential of improved technologies at the 556 farmers' fields (Table 2 & Fig. 2).

Front Line demonstration on livestock: Under livestock production, a total 02 demonstrations were conducted i.e. on disease management (Table 3).

FLD on Other Enterprise: A total no. of 02 demonstrations on kitchen gardening conducted at 20 farmers' field as details given in (Table 4).

Technology Assessment and Refinement: A total of numbers of 06 On Farm trials (OFTs) were conducted in different villages of KVK Bhadohi for assessment of selected technologies in agriculture & allied subjects.

- **Low income from rice-wheat cropping system:** Mostly farmers of the district follow rice-wheat cropping system. New intervention in a trial was formulated with Urdbean + Vegetable Pea + Wheat (late sown) against farmer practices rice-wheat. In trials Urd + Vegetable Pea + Wheat (late sown) gave a yield of 12.80, 12.20&16.35 q/ha as against farmers practice Rice + Wheat 48.8 & 44.2 q/ha respectively. However, the total net income (Rs. 170954.00 / ha.) and C:B ratio (1:2.41) from new intervention as

Table 2: Front Line Demonstration on crops

Crop	Variety	No. of Farmers	Area (ha)	Yield (q/ha)				% Increase in yield
				Demo			Check	
				High	Low	Average		
Mustard	RH-749	77	30.0	33.75	22.50	27.80	17.90	55.31
Sesame	Pragati	45	20.0	6.5	3.9	5.5	4.7	17.02
Mustard	P-30	15	2.5	21.25	16.20	19.9	17.9	11.17
Chickpea	GNG-1581	32	10.125	28.5	18.40	21.55	17.20	25.29
Field pea	Aman	78	20.0	29.45	16.80	20.75	16.65	24.62
Lentil	PL-08	22	10.0	21.66	12.15	16.35	11.0	48.63
Pigeon pea	NDA-2	21	10.0	21.66	12.15	16.35	11.0	48.63
Urdbean	Pant Urd-4.0	26	10.0	9.8	5.4	6.9	5.6	23.21
Pigeon pea	P-991	05	0.533	9.7	5.5	8.2	7.6	7.8
Paddy	P-2511	15	2.0	59.9	44.5	54.8	32.6	69.37
Paddy	P-44	02	0.375	58.35	50.25	55.50	48.80	15.7
Wheat	HD-2967	22	2.8	68.00	55.30	62.10	48.20	28.84
Bajra	NBH-4903	11	2.0	26.80	16.30	22.20	16.20	36.42
Cowpea	Kashi Nidhi	31	1.0	138.6	107.7	128.2	99.7	28.6
Tomato	Kashi Aman	35	1.0	473.7	382.6	457.2	273.7	67.0
Chilli	Kashi Anmol	32	1.0	168.4	123.1	153.6	124.7	23.2
Vegetable Pea	Kashi Mukti	44	1.0	146.7	112.2	128.8	113.9	13.0
Berseem	Vardan	31	2.0	1240	810	986	701	40.65
Hybrid Napier	HN	3	0.039	1725	1455	1580	0	0
Azolla	Azolla	9	0.0125	486q/ 125 sq m/HY	398q/ 125 sq m/HY	456q/ 125 sq m/HY	0	0

Table 3: Front Line Demonstration on livestock

Category	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	Control of Liver Fluke infestation in Cattle	75	154	Survivality, Milk Production and Growth Parameter		99% animal are disease free
Sheep & Goat	Control of Liver Fluke infestation in Sheep/ Goat	48	1767	Survivality and Growth Parameter		99% animal were disease free

Table 4: FLD on Nutritional Security

Category and Crop	No. of Farmer	No. of Units	Area (ha)	Yield (Kg)		% change in yield
				Demonstration	Check	
Kharif	10	10	0.025	6066.0	4670.8	47.5
Rabi	10	10	0.025	1415.1	900.78	55.88

against farmers practices (Rs. 121435 / ha.) and 2.35 respectively. Hence it may concluded that in the trial Rs. 49519.00 per ha was obtained extra income against farmer practices (Fig. 3).

- **Qualitative and quantitative improvement of sheep wool by crossing improved cross breed Nali X Marino :** In trial 15 sheep farmers were selected and given male sheep cross breed Nali X Marino brought from Sheep Breeding Farm, Naugarh before distribution, all the male sheep were dewormed with broad spectrum anthelmintic drugs. The lamb born by cross bred male sheep have better wool quality, survivability and diseases incidences were also lowered like abortion in herd against the farmers practices (Fig. 4)

Fig. 4: OFT- Qualitative and quantitative improvement of sheep wool and hair

- **High incidence of anestrus in dairy animals due to deficiency of micro and macro nutrients:** In dairy cattle due to deficiency of micro and macro nutrient the animals does not come into heat & show the estrus, which is a great loss for the dairy owners. Keeping in view UMMMB (Urea Molasses Mineral Mixture Block) were used to active the hormones responsible for the cycle again with normal physiology. Under trial 60% animals come into heat & conceived as against zero percent in farmers practices. In lactating animal the use of UMMMB daily the milk production were increased about 0.79 litre per day per animal. The additional cost Rs. 2-3 per day/ animal against farmers practices.
- **Intercropping of turmeric in established mango orchard after center opening:** An OFT was conducted at 05 farmers fields in mango orchard after centre opening. The turmeric varieties Megha was shown in month of April 2018. The yield of turmeric was recorded as 171.6 q/ha and net income was Rs. 106364.00 / ha as additional income from the new intervention of turmeric intercropping in mango orchard. Whereas under farmer practice, they grow orchard for mango production. The C:B ratio was 1: 2.63.
- **Assessment of drudgery reduction and enhancing work efficiency of farm women during harvesting of paddy through serrated sickle:** Five trials were conducted on harvesting of paddy with serrated sickle. Serrated sickle was provided. Farmers practice was also recorded. It was observed that using serrated sickle is more effecting in reducing drudgery, saving time and safety in use. The harvesting rate was 19.05 m^2/hour with serrated sickle and 16 m^2/hour with non-serrated sickle. Working heart rate was 86 beat/ minute with serrated sickle and 93 beat/min with non-serrated sickle.
- **Assessment and enhancement in work efficiency and reducing high drudgery of farm women involved in okra plucking:** Ten trials on okra plucking was conducted at farmers field. Okra pluckers and hand gloves were provided to the farmers. It was observed that plucking of okra with hand gloves and plucker reduced drudgery, safe from direct contact to pesticides and extended work efficiency of farm women. The working efficiency was 4.75 kg/hrs with plucker and hand gloves and 2.25 kg/hrs without plucker and hand gloves.

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 09 special days like Kisan Diwas and Mahila Krishak Diwas involving 628 beneficiaries. For the dissemination of the technology at rapid mass KVK has organized 09 field days on Cow Pea (Kashi Nidhi), Paddy(Pusha Sugandha-5), Vegetable Pea(Kashi Mukti), Chilli(Kashi Anmol), Mustard (RH-749), Lentil(PL-08), Chick Pea(GNG-1581), Pigeon Pea(NDA-2), and Wheat(HD 2967), where 418 farmers & farm women participated. Besides these, KVK organized Kisan Mela, Animal Health Camp, Field Visit and field day, Diagnostic Visits and exposure visit involving 13853 participants. (Fig. 5 & 6)

Fig. 5: Field Day on Mustard (RH-749)

Fig. 6: Field Day on Chickpea (GNG-1581)

ICAR-KRISHI VIGYAN KENDRA, DEORIA

Training programmes: To increase the income of farming communities, a total of 78 including on and off campus training courses were organized in different thematic areas in which 1630 farmers & farm women benefitted. In addition, 10 training programmes on agriculture entrepreneurship for rural youth / school dropout were organized at on and off campus in which 215 rural youth participated (Table 5 & Fig.7 & 8)

Table: 5 Details of Training Programmes

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	78	1264	366	1630
Rural youths	10	91	124	215
Total	**88**	**1355**	**490**	**1845**

Front Line Demonstration: FLD programme under oilseed, pulses, cereals, vegetables, livestock, other enterprises a total of 121.41 ha. and 383 units/animals were the conducted during the year at 600 beneficiaries farmers fields (Table 6 & Fig. 9 & 10).

Fig. 7: Training Farm Women on Mushroom

Fig. 8: On Campus Training Programme

Table 6: Front Line Demonstrations

Crop	Variety	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase in yield	Economics of demonstration (Rs./ha)	Economics of check (Rs./ha)
				Demo	Check		B:C ratio	B:C ratio
Groundnut	K-6	25	12	13.32	10.3	37.3	1.8:1	1.5:1
Mustard	RH 749	12	04	20.6	16.9	19.5	2.6:1	2.2:1
Mustard	PM 30	05	02	20.4	17.5	16.6	2.6:1	2.3:1
Mustard	Pusa Tarak	103	36	21.44	18.4	16.52	2.7:1	2.4:1
Pigeon pea	NA 2	25	10	18.6	14.2	30.98	3.6:1	2.7:1
Chickpea	Pusa 547	29	10	19.5	14	42.3	2.5:1	2.0:1
Chickpea	GNG-1581	14	1.5	15.0	12.9	15.30	2.44:1	2.02:1
Field pea	Prakash	61	20	18	13	38.46	2.2:1	1.8:1
Lentil	PL 8	34	10	15.5	14	37.78	2.0:1	1.7:1
	Pusa Shivalik	03	0.34	15.5	11.5	34.78	2.0:1	1.7:1
Paddy	Pusa 44	01	0.32	58.2	44.9	29.62	2.0:1	1.5:1
	PS 2511	04	1.6	55.7	44.9	24.05	1.97:1	1.5:1
Wheat	HD 2967	06	2.5	51	41.5	22.89	2.4:1	1.2:1
Wheat timely sown	HD 2967	13	5	57.6	51.2	12.5	2.3:1	1.7:1
Cowpea	Kashi Nidhi	8	1.0	160.62	134.0	19.86	4.27:1	3.56:1
	Kashi Nidhi	11	1.09	155.14	130.8	11.77	4.24:1	3.57:1
Tomato		11	1.0	300	240	25.0	5.33:1	4.53:1
Chilli		10	1.0	148	112	32.14	6.1:1	4.5:1
Vegetable pea	Kashi Mukti	13	1.01	117.38	100.4	16.98	4.78:1	3.87:1
Cauliflower	Sabour Agrim	08	1.05	112.37	90.4	24.31	5.06:1	4.07:1
Total		**396**	**121.41**					

Fig. 9: FLD on Paddy (PS-2511)

Fig. 10: FLD on Chickpea (GNG-1581)

Technology Assessment and Refinement

Low yield in pigeon pea due low moisture during pod filling: An on-farm trial was conducted to assess the irrigation management in pigeon pea at pod formation stage at 6 deference locations. The results indicated that the application of irrigation at pod formation stage in raised bed sown pigeon pea crop gave 101.88 per cent increase in yield over no irrigation at pod formation stage and 43.6 percent increase in yield over irrigation at pod formation stage in broadcasted sown of pigeon pea crop.

Low yield in wheat due to low moisture conservation: KVK, Deoria Uttar Pradesh conducted an on-farm trial to assess on performance of Hydro gel in wheat crop at 6 deference locations. The results indicated that the application of three irrigation at 20, 60 and 85 days after sowing of wheat crop gave 61.58 percent increase in yield over one irrigation at 20 days after sowing of wheat crop and 4.6 percent increase in yield over application of one irrigation at 20 days after sowing + hydro gel in wheat crop

Low income due to sowing of Sugarcane as mono crop: Today, intercropping has play 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 income through intercropping. The intercropping of cowpea in double row with sugarcane gave maximum yield of sugarcane (886.12 q/ha.) and cowpea (74.2/ha) along with highest C:B ratio (1:4.28). It is also observed that due to intercropping of cowpea which is a leguminous crop the yield of sugarcane also increased 11.72 and 24.04 percent over check in single and double row planting respectively.

Low yield due to pod borer in infestation in pigeon pea: Pigeon pea is an important pulse crop of Deoria Uttar Pradesh and high infestation of pod borer resulting in yield loss. Use of NPV 250 LE/ha + use of bird perches + spraying of Emamectin benzoate @ 100 gm/ha reduced the percentage of pod damage from 15 to 7 and yield was increased by 4.76%.

Table 7: Front Line Demonstration on Livestock

Category	Thematic area	No. of Farmer	No. of Units (Animal	Major parameters		% change in major parameter	Economics of Demo. (Rs.)	Economics of check (Rs.)
				Major parameters	Major parameters			
Cattle	Disease	68	85	7.72	6.28	22.93	1.96	1.62
	Management	56	152	6.90	6.30	9.52		1.64
	Breeding	10	10	07	03	133.33	1.73	1.28
	Management	07	07	638.2 q/ha	542 q/ha	17.75	2.29	2.02
		05	05	384.4q/ha	278 q/ha	38.27	2.25	2.13
Goat	Disease management	34	78	18.8	12.10	55.37	3.45	2.21
	Nutrition management	24	46	16.20	12.45	30.12	3.42	2.82
	Total	**204**	**383**					

Table 8: Extension Programme

Activities	No. of programmes	No. of farmers	No. of Extension Personnel	TOTAL
Advisory Services	33	146	0	146
Diagnostic visits	160	275	0	275
Field Day	3	68	07	75
Kisan Ghosthi	9	856	28	884
Kisan Mela	1	3150	50	3200
Exhibition	8	5000	72	5072
Scientists' visit to farmers field	287	389		389
Celebration of important days	6			0
Special day celebration	3	1200	28	1228
Animal Health camp	01	82	06	88
Total	**511**	**11166**	**191**	**11357**

Low yield of paddy due to false smut infestation: Rice is an important crop of Eastern Uttar Pradesh and high infestation of false smut resulting in yield loss. 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) reduced the no. of infested ears / m^2 from 9 to 2 and yield was increased by 5.1%.

Fig. 11: Address by Hon`ble Agriculture Minister U.P. Govt. during kisan mela

Fig. 12: Mahila Kisan Diwas celebration at KVK Deoria

Extension Activities: A total of 511 extension activities were organized during the period 2018-19 by the KVK. (Table 8 & Fig. 11 &12)

ICAR- KRISHI VIGYAN KENDRA, KUSHINAGAR

Training Programmes: Krishi Vigyan Kendra, Kushinagar organized 75 need based on and off–campus training programmes under human resource development comprising diverse aspects of production technologies of cereals, oilseeds, pulses, vegetables, livestock, soil health management, value addition, household food security, and women empowerment benefitting a total of 1545 participants comprising 313 female and 1232 male farmers, rural youth and extension functionaries (Table 9 & Fig. 13).

Table 9: Training programmes organized by KVK, Kushinagar.

Clientele	No. of Courses	Male	Female	Total participants
Farmers & Farm Women	68	1119	282	1401
Rural Youths	6	78	31	109
Sponsored Training	1	35	-	35
Total	**75**	**1232**	**313**	**1545**

Fig. 13: Training on Value Addition

Frontline demonstration: Front line demonstration were conducted in 100.93 ha area at 908 farmers field on paddy, mustard, lentil, cauliflower, onion, green gram, field pea, marigold, maize sheller, kitchen garden and drumstick plant (Table 10 & Fig. 14).

Fig. 14: FLD on onion Var.- Agri- found Light Red

Technology Assessment and Refinement

Effect of planting method on yield of Maize; KVK, Kushinagar assessed the technology during rabi 2017-18 on effect of planting method on maize. Result showed that planting of maize on raised bed (T_1) gave higher yield i.e., .60.75 q/ha with C:B ratio 1:3.47 in comparison to flat bed sowing (T_0) i.e. 42.35 q/ha with C:B ratio 1:1.83. Sowing of maize on raise bed save seed, fertilizer, fuels, water and man power and increases the productivity of crop (Fig. 15).

Fig. 15: Maize on raised bed (T_1)

Supplementary feeding of the children (2-5 year age): Krishi Vigyan Kendra conducted On Farm Trial on supplementary feeding covering 15 children of age group 2-5 years. To conduct the OFT the under nourished children were identified with the help of Anganwadi workers of different villages like Persaun, Davnaha,Dhaurahara and Premwalia and then village Premwalia was selected for OFT as the desired number of under nourished children were available in the village. Same number of control group was also selected to whom the supplementary food was not provided .The supplementary food consist of Whole Wheat Flour :Green Gram and Til in the ratio of 70:25:5 was given to the children as a trial two and the supplementary food consist of whole wheat flour : soyabean and till in the

Table 10: FLD organized by KVK, Kushinagar

S. No.	Crop	Technology demonstrated	Horizontal spread of technology				
			No. of farmers	Area in ha	Demo Yield	Check Yield	Yield Increase %
1	Green gram	Line sowing	111	30.0	10.3	7.35	28.64
2	Pigeon pea	Line sowing	21	10.0	20.25	13.75	32.10
3	Field pea	Line sowing	220	20.037	20.31	18.6	9.19
4	Lentil	Line sowing	25	10.00	10.50	5.50	47.62
6	Mustard	Line sowing	55	12.00	11.50	6.5	43.48
7	Paddy	Drum seeder	9	1.5	53.75	34.6	38.12
8	Paddy	Drum seeder	2	1.0	42.35	31.5	34.44
9	Onion	Agrifound Light Red	27	1.0	223.6	181.3	23.33
10	Potato + Sugarcane	(K.Sinduri) + (CO-0238)	6	0.48	74.0 + 668.2	680.2	9.11
11	Marigold	Pusa Narangi	2	0.04	168.4	138.3	21.76
12	Cowpea	Kashi Kanchan	16	16	6.80	5.71	18.96
13	Maize Sheller	Use of maize sheller (manual)	11	1.39 ha	19.2 Kg./hr shelling,	7.6 Kg. / hr Shelling	215 %
14	Nutritional garden	Balance Diet	9	9 (150 m^2)	411	281	46.26

ratio of 70:25:5 was given to the children as a trial three. The result of trial three showed the maximum increase in health parameters of children. (Fig. 16).

Fig. 16: OFT on Supplementary Feeding

Extension Activities: To expedite the process of transfer of technology programme the KVK, organized 5 kisan gosthis where in 377 farmers participated. One field day were organized covering 33 farmers for demonstration of technologies. One kisan mela was organized covering 2256 farmers. KVK participated in 5 exhibitions for awareness creation of farmers benefitting a total of 6625 farmers. A total 376 scientific visits to farmer's field visits by KVK officials and 376 diagnostic visits were made by the KVK scientists and SMS for the benefit of 3072 farmers. Three soil health camp were undertaken to the ultimate benefit of 150 farmers. 34 lectures were delivered as resource person benefitting more than 6625 farmers of kushinagar and adjoining districts. 2548 farmers visited KVK during 2018-19. (Table 11, 12 & Fig. 17 &18).

Table 11: Mobile Advisory Services

No. of KVKs	No. of SMSs sent	No. of farmers benefited
1	11	201930

Table 12: Seed and Planting Material

Samples	Quintal/Number	Farmer
Seed (q)	1891.012	948031.71
Planting material (No.)	11584	172236
Bio-Products (q)	12.57	8718
Fish Production	12.625	177721.6

Fig. 17: Mahila Kisan Diwas

Fig. 18: Swachata hi Sewa

Institutional Activities

TRAINING PROGRAMME AND OTHER ACTIVITIES

Badalta Banaras - Farmers Welfare Workshop was inaugurated by Hon'ble Union Agriculture and Farmers Welfare Minister

Hon'ble Union Minister Agriculture and Farmer Welfare, Shri Radha Mohan Singh Ji inaugurated 'Badalta Banaras-Farmers Welfare Workshop' on 1st September 2018 organized by the institute at Deen Dayal Hastkala Sankul, Trade Facilitation Centre & Museum, Badalalpur, Varanasi. About 6300 farmers from Araziline, Sevapuri and Kashi Vidyapeeth blocks of Varanasi had participated in this mega workshop. On this occasion, 13 stalls of different Central and State Government departments were set up for displaying their technologies to the farmers and other stakeholders.

Addressing on this occasion, Hon'ble Union Minister of Agriculture and Farmer Welfares emphasized on several ambitious projects of Government of India for the farmers, such as Crop Insurance Scheme, Soil Health Card Scheme, Gokul Gram Yojana, Livestock Insurance Scheme, National Agricultural Market, Bee keeping, Milk, Fisheries and Farmer Producers Companies and discuss the benefits that farmers are getting under these organization plan. The Minister said that the use of neem coated urea has reduced the consumption of urea by 10 percent. He also said that 10 thousand laboratories are being run in the country for soil health management and providing soil health card to the farmers. Under the traditional agricultural development plan, the areas of organic farming need to be increased, so that the farmers can get premium prices of their produce in the market. Farmers are requested to include the cultivation of farming and fishery in rice-wheat cultivation. Under the National Gokul Mission, promotion of Ganga-Tiri cows are made by using the 'frozen surated semen' for the upgradation of the breed.

The Minister also heard the problems of farmers & beneficiaries during scientists-farmers interaction meeting. He said that farmers should realize the dreams of Hon'ble Prime Minister of doubling farm income by the year 2022 and strengthening the food and nutrition security of the country by adopting farming professionally. Progressive farmers also shared their success stories related to vegetable production, fisheries, milk production, bee keeping etc.

Certified Farm Advisor (Module – II) Training Programme for Agriculture and Extension Officers of State Agriculture Departments

ICAR-IIVR, Varanasi has successfully organized 02 Certified Farm Advisor (Module – II) training programme on "Advanced vegetable production technologies for enhancing productivity and nutritional

security" during 1-15 October 2018 and 27 November - 11 December 2018. These CFA training programme was sponsored by National Institute of Agricultural Extension Management (MANAGE), Hyderabad. There were total 13 participants in 1st batch from 06 states (Himachal Pradesh: 03; Andhra Pradesh: 04; Haryana: 02; Jharkhand: 02; Maharashtra: 01 & Odisha: 01) and 18 participants in 2nd batch from 05 states (Kerala: 07; Himachal Pradesh: 04; Jammu & Kashmir: 04; Jharkhand: 02 & Andhra Pradesh: 01) working as agriculture and extension officers in agriculture departments of their respective state. Training programme covered both theoretical and practical aspects of various advanced production technologies in vegetables. Field visits were also arranged to Seth Dheen Dhayal Jalan organic farm, Dhagmagpur, Institute of Agricultural Sciences, Banaras Hindu University (BHU) and National Seed Research & Training Centre (NSRTC), Varanasi.

Field Day on Solanaceous Vegetables

Field day on Solanaceous Vegetables" was organized by Zonal Technology Management Unit of ICAR-IIVR, Varanasi on 19th January, 2019 to showcase and commercialize the promising varieties and

advanced lines of tomato, brinjal and chilli developed by the Institute. The programme was attended by more than 30 breeders and marketing strategists from ten private vegetable seed-companies. The representatives of seed-companies visited the research farm of the Institute and appreciated the varieties, hybrids and other advanced breeding lines developed by the Institute. The representatives critically observed the promising materials and expressed their desire to get some of the promising hybrids/varieties and advanced breeding lines having a combination of desired quality traits along with yield. The delegates thoroughly interacted with the breeders of the institute and provided valuable feedback on the current market needs in various vegetables.

Institute Celebrated its 28th Foundation Day

ICAR-Indian Institute of Vegetable Research, Varanasi celebrated its 28th Foundation Day on 28th September, 2018. The ceremony was inaugurated by Chief Guest Dr. Mangla Rai, Former Secretary, DARE & Director General, ICAR, New Delhi. On this occasion, Dr. Rai emphasized the benefits of processing, value addition and seed production in vegetables. He appreciated the expected growth in the fields of

agriculture, horticulture, milk production, egg and fish production and requested to do research work towards increasing the income. He further emphasized on the need for micro-elements and the importance of bacteria for the health management of soil. In order to manage the adverse effects of climate change on agriculture, he advised to undertake research work for the application of microorganisms in agriculture. Founder Director and Former Deputy Director General (Hort. Sci.), ICAR, New Delhi, Dr. Gautam Kalloo said that the productivity of vegetables can be increased by protected farming. He also urged to put in place the antifungal varieties by describing the economic damage caused by the outbreak of viruses in tomato crop.

On this occasion Dr. B. Singh, Director, Indian Institute of Vegetable Research, welcomed the guests and highlighted the achievements of research and developmental works so far made by the institute since its inception. He told the benefits extended to farmers through scientific research and extension programs like Mera Gaon Mera Gaurav, Tribal Sub Plan and Farmers First Project. On this occasion, the Director of South Asian Regional Center, International Rice Research Institute, Varanasi, Dr. U.S. Singh was also present. Apart from the staff of the institute, more than 450 farmers from Varanasi and Sonbhadra districts of Uttar Pradesh were present. On this occasion, progressive farmers Mr. Harinarayan Kushwaha of Malludih village, Kushinagar; Mr. Prem Kumar Singh of Dhanapur village, Varanasi; Smt. Rama Devi & Mr. Ram Raksha of Bhalukudar village, Sonbhadra and Smt. Sunita Devi of Padrach village, Sonbhadra were honored with the citation and kitchen garden kit, At the end, Dr. A.B. Rai, Principal Scientist (Vegetable Crop Protection), Shri Subhash Chandra, Technical Officer; Mr. Sushil Gupta, UDC and Mr. Jatashankar Pandey, SSS of ICAR-IIVR, Varanasi along with Dr. Rajendra Prasad, KVK, Bhadohi; Dr. A.K. Dubey, KVK, Kushinagar and Dr. Anuradha Ranjan, KVK, Deoria were honored for their outstanding contribution in the development of institute

Krishi Jagrukta Abhiyan in Varanasi : Capacity Building of Farmers & Dissemination of Agriculture Technologies

ICAR- Indian Institute of Vegetable Research, Varanasi carried out one of the biggest outreach programme Krishak Jagrukta Abhiyan in 03 blocks *viz.*, Sewapuri, Araziline and Kashi Vidyapeeth of Varanasi districts in Uttar Pradesh during November-December 2018. Kisan Gosthis cum Farmers-Scientists Interaction Programme were organised under Krishak Jagrukta Abhiyan to solve the grassroots problems of the farmers, sensitize them about good agricultural practices and a path finder towards doubling farmer's income up to 2022 which is a dream of our Hon'ble Prime Minister of India. This programme was conducted in three phases covering 10868 farmers from 36 Nyay Panchyat, 259 Gram Sabha and 463 Villages of 03 selected blocks. In the first phase, 12 Krishak Jagrukta Abhiyan was organized on Naya Panchayat basis during 15-16 November 2018 covering 86 Gram Panchyat and 175 villages of Sewapuri block in which 2650 farmers had participated. Similarly, in the second phase 16 Krishak Jagrukta Abhiyan was organized on Naya Panchayat basis during 28-30 November 2018 covering 117 Gram Panchayat and 216 villages of Araziline block in which 5800 farmers had participated and in the last phase on 14-15 December 2018, 08 Krishak Jagrukta Abhiyan was organized on Naya Panchayat basis covering 56 Gram Panchayat and 72 villages of Kashi Vidyapeeth block in which 2418 farmers had participated.

Under this programme, team of scientists & technical from ICAR-Indian Institute of Vegetable Research, Varanasi visited consecutively to the farmers' fields in selected blocks of Varanasi district and successfully organised Krishak Jagrukta Abhiyan (Kisan Gosthis cum Farmers-Scientists Interaction Programme) to pave the way of modern agriculture in coordination with Institute of Agricultural Sciences, BHU, Varanasi; ICAR- National Bureau of Agriculturally Important Microorganism, Mau, ICAR-Central Institute of Subtropical Horticulture, Lucknow and ICAR- Indian Institute of Wheat and Barley Research, Karnal.

On this occasion, vegetable kitchen garden packets consisting seeds of improved vegetable varieties in 10 crops developed by ICAR-IIVR were provided to the farmers. Apart from high yielding vegetables, seeds of fortified wheat, chick pea, garden pea, saplings of plantation crops like tissue cultured banana, grafted mango and guava were provided to the farmers as per their need and interest. As a result of this mega Krishak Jagrukta Abhiyan, farmers of Varanasi district became aware of modern agricultural technologies which helped them to increase their productivity with lesser production costs and double their income in near future.

Promotion of Backyard Poultry among Resource Poor Farmers for Livelihood Security

Institute has adopted 07 villages (Dhanapur, Baburamkapura, Upadhyaypur, Paniyara, Lashkariya, Shaktiyarpur, and Rajapur) in Arazilines block of Varanasi under the Farmer First project with a mission to provide small and resource poor farmers' different livelihood options or strategies for sustainability. In this direction, promotion of backyard poultry with improved breed is a better option of livelihood

particularly for resource poor farmers and landless laborers. Hence, improved poultry breed CARI-Deventra, CARI-Nirvik and Kadaknath from ICAR-Central Avine Research Institute, Bareilly were introduced among selected 127 farmers from Dhanpur, Paniyara and Laskariya villages after proper training on backyard poultry, their management and marketing. Under the guidance of the Director, ICAR-IIVR and Farmers FIRST team 50 chicks (01 day old) along with 15 days starter feed, poultry feeder & water utensils and important medicines were provided to selected farmers in three phase ie., 01 July 2018, 14 July 2018 and 05

November 2018. All these poultry bred are of dual purpose ie., both eggs as well as meat and survive at no extra cost on rearing with better result in terms of number of eggs, growth for meat and market rate in comparison to local breed. The director of the institute encouraged these farmers to follow backyard poultry and told that in the future, this technique will be a milestone in the Prime Minister's ambitious plan to double the income of the farmers.

Kisan Kalyan Diwas Celebrated

Under the Village Swaraj Campaign, call of Hon'ble Prime Minister the institute had celebrated Kisan Kalyan Diwas on 2 May 2019 in which apart from the scientists of ICAR-IIVR & BHU, Varanasi, 50 farmers from 5 FPOs of Varanasi, Ghazipur and Chandauli districts had participated. On this occasion the scientists discussed the consolidated farming system along with the vegetables, so that the income of the farmers could be doubled by 2022. In his inaugural address on this occasion, Chief Guest Dr. Punjab Singh, President of National Academy of Agricultural Sciences, said that scientists need to develop more and more entrepreneurial technologies in agriculture and encouraged more and more farmers to adopt it like a business. On this occasion, Dr. Singh informed that FAARD Foundation had helped in the formation of 12 Farm Producers Company in Eastern Uttar Pradesh, out of which 5 are in Varanasi, 2 in Chandauli, 2 in Gazipur and 3 in Azamgarh. These companies are working in dairy farming, milk processing, vegetable cultivation and their marketing.

On this occasion, Dr. A.K. Srivastava, Member, ASRB appreciated the efforts made by the institute for farmers' welfare and suggested to identify the problems of farmers of this region and continue to do various programs from time to time to solve it for enhancing their income. He told the farmers about the symptoms of animal diseases and asked not to vaccinate oxytocin to milking animals. On this occasion, Dr. R.B. Singh, Former Chairman, NAAS, said that malnutrition and poverty are the biggest problem of India and this problem is the highest in Eastern India. On this occasion Dr. Kirti Singh, Former Chairman, Agriculture Scientific Recruitment Board, New Delhi informed that there is a greater need of sustainable farming, thereby reducing cost and increasing productivity and income of the farmers. On this occasion Dr. Kalloo Gautam, Former DDG (Hort. Science), ICAR, New Delhi informed that seeds and micro-organism will be needed for cultivation in the coming years, which will help in increasing farm productivity.

Inauguration of Mechanized Agro Waste Converter Unit by Additional Secretary, Ministry of Agriculture & Farmers Welfare, Government of India

Research work on organic farming in vegetables was carried out by the institute for many years. Under this, various vegetable crops residues were used for preparing organic compost through Nadep Compost technique, Vermi Compost technique, etc., which is a time taking process. In this continuation, Ms. A. Neerja,

Additional Secretary, Department of Agril. Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India inaugurated Mechanized Agro Waste Converter Unit at the ICAR-IIVR on 22 September 2018, where crop residue is converted mechanically into high quality organic compost in a very short period of time, While discussing with scientists on this occasion, Ms. Neerja said that this is a commendable step taken by the institute and this kind of machines have the ability to contribute to waste management and Clean India campaign given by Hon'ble Prime Minister.

1st Vegetable Science Congress on "Emerging Challenges in Vegetable Research and Education" (VEGCON-2019)

Indian Society of Vegetable Science in association with ICAR-Indian Institute of Vegetable Research, Varanasi, Agriculture University, Jodhpur, Rajasthan, Indian Council of Agricultural Research, New Delhi, and Society for Integrated Development of Agriculture, Jodhpur organized 1st Vegetable Science Congress on "Emerging Challenges in Vegetable Research and Education" (VEGCON-2019), Agriculture University, Jodhpur, Rajasthan during 1-3 February 2019. This 1st Vegetable Science Congress was inaugurated by the Chief Guest Dr. Kirti Singh, Former Chairman ASRB in presence of Dr. Premnath, PNASF, Banagalore and a galaxy of dignitaries from across the country. More than 350 Scientists from various ICAR Institutes, State Agricultural Universities, Students from AU, Jodhpur and representatives from various Pvt. Seed Companies had participated in this congress. On this Occasion, a number of publications including Souvenir, Abstract book and 04 technical bulletins were released by the chief guest. Dr. Balraj Singh, VC, AU, Jodhpur, welcomed the delegates and urged upon the scientists to

bring out concrete recommendations for vegetable research & education, policy issues, as well as technology related issues.

Addressing the participants, Chief guest Dr. Kirti Singh, Former Chairman, ASRB, New Delhi stressed upon the importance of vegetable crops as hope of farmers to get the continuous flow of cash which makes these crops an integral part of the agriculture for livelihood and nutritional security. He also emphasized on the ability of vegetables to tackle the malnutrition because of their high content of beneficial compounds to human health. So it is time to focus more on vegetable crops and the future strategies through vegetable research and education. On this occasion, Dr. G. Kalloo, Former Vice Chancellor, JNKVV, Jabalpur emphasized on the importance of vegetables for enhancing the income of small and marginal farmers and are treated as best source of effective cropping system for employment and economic security. Guest of Honour Dr. Prem Nath, PNASF, Banagalore addressed the gathering on enormous diversity of vegetables, ways to enhance and sustain vegetable productivities and their potential to meet the nutritional security of increasing

population in the country by reorienting our research and development efforts towards sustainable growth and development. Special invitee Dr. Nazeer Ahmed, VC, SKUA&T, Kashmir suggested the inclusion of protected cultivation, hi-tech horticulture, precision farming in vegetable research for increasing farmer's income and livelihood security. In his presidential address Dr. D.P. Ray, President-ISVS & Former VC, OUAT, Bhubaneswar discussed about enormous growth in terms of area, production, productivity and consumption of vegetables achieved during last decade. During the inaugural session, prestigious awards of Indian Society of Vegetable Science, including Dr. Kirti Singh Life Time Achievement Award, Dr. Bishwajit Choudhary Memorial Award, Dwarika Nath Memorial Award, Dr. Harbhajan Singh Memorial Award and Vegetable Science Fellow Award were presented to the scientists by the chief guest.

On this occasion, 07 different technical sessions were organized on Genetic Enhancement in Vegetable Crops; Novel Insights & Innovations in Biotechnology; Vegetable Production Systems; Pest Management-Recent Advances; Secondary Agriculture: Value Chain Management and Post-Harvest; Quality seed, IPRs and Technology dissemination, PPP and Agribusiness. Around 393 abstracts were received for all the seven technical sessions which have been published in Abstract Book. A Souvenir Book has also been published with 16 Messages of dignitaries along with 38 informative articles. In total, 3 Memorial Lectures, 05 lead lectures, 10 Invited lectures and 27 Oral presentations by scientists/researchers were presented and deliberated upon. Besides this more than 333 abstracts were submitted for the poster session from scientists and students of ICAR institutes and SAU's. The posters were judged by eminent scientists and the best 03 posters in each technical session were awarded. A separate panel discussion on Vegetable Science: Educational Strides was also held where, 06 Vice-Chancellors including two present Vice-Chancellors from Jodhpur and Srinagar expressed their views for further improvement in Vegetable Education and Research to generate trained/skilled human resources in this stream. During the deliberations, session wise suggestions and recommendations were emerged which has been discussed.

Inauguration of Scientific Societies Complex

Regional Office of National Academy of Agricultural Sciences- Varanasi Chapter was inaugurated by Dr. Punjab Singh, President, NAAS, and Dr. A.K. Shrivastav, Vice President, NAAS on 02 May, 2018 at ICAR-Indian Institute of Vegetable Research, Varanasi. On this occasion, Dr. Bijendra Singh, Coordinator, NAAS-Varanasi Chapter& Director, ICAR-IIVR, said that the main purpose of this Varanasi chapter is to prepare brain storming session for the smooth diagnosis of agricultural problems of this region, mentoring program for students, scientists and peasant, discussions and preparation of data base of scientists from the areas covered under this chapter. This National Agricultural Sciences Academy- Varanasi chapter has the working area of eastern and western Uttar Pradesh as well as the Bundelkhand region. Apart from this, the new office of Indian Society of Vegetable Science (ISVS) was inaugurated by Former Presidents, ISVS Dr. Kirti Singh and Dr. Gautam Kalloo. On this occasion, the office of the Association of Prohibitions of Innovation in Vegetables (APIV), a society of institutes staff was inaugurated by Dr. R.B. Singh, Former Chairman, National Academy of Agriculture Sciences.

Official Language Workshop

ICAR.-Indian Vegetable Research Institute, Varanasi organized the official language workshop on the functioning of Hindi on March 11, 2019. Dr. Jagdish Singh, Director of the Institute, directed to do 100% administrative work in Hindi and to promote progressive use of the language. Dr. Singh told the importance of Hindi in administration, research and extension work at the institute. In this workshop, participants were given necessary training to increase the use of Hindi in the office. In order to make the official language accessible to the work, the official language terminologies have been explained in detail.

International Women's Day

ICAR-IIVR organized the International Women's Day on 08 March, 2019. The program was inaugurated by Dr. Jagdish Singh, Director of the Institute, with lamp lighting and welcome speech. On this occasion, apart

from institute's employees, about 200 farm women of adjoining villages were present. On this occasion, the annotation given by Prime Minister Shri Narendra Modi on World Women's Day was broadcast in the auditorium. The Director of the institute, recalling the role of women in the nation building, told the importance of their interest, inspiration and successful participation in agriculture. Considering women empowerment he suggested that through self-help group and farmer producer organization, women can get the opportunity to create new jobs. Under agricultural diversification, women are advised to adopt the hybrid seed production of vegetables, mushroom production, bee keeping, fisheries, post harvesting technology and value addition, thereby increasing the employment and income. The Director of the institute honored the women workers Shrimati Phulmani Devi with flowers and shawls for her excellent work in the field of vegetable production.

NASS, Varanasi Chapter : Lecture on nutritional security - a bigger challenge

National Academy of Agricultural Sciences - Varanasi Chapter organized a special lecture on "Feeding 1.37 billion with Nutritional Security: Bigger Challenge" delivered by Dr. A.K. Srivastava, Chairman, ASRB, New Delhi & Vice President, NAAS on 29 January, 2019, at ICAR-Indian Institute of Vegetable Research, Varanasi. During his deliberation, Dr. Srivastava emphasized on nutritional, food and economic security of farmers. He also advised the

scientists to develop the climate resilient technologies, which may be helpful to sustain the production to feed the increasing populations. He categorically mentioned for adoption of new technologies like genome editing to keep pace with advance researches being done elsewhere in the world. He stressed for more focused attention towards developing hybrids in vegetables by public sector and making them available to the farmers at affordable prices. Dr. Gautam Kalloo, Former Vice Chancellor, JNKVV, Jabalpur and DDG (HS) gave his remarks. On this occasion Fellows, NAAS-Varanasi chapter, Scientists, Technical, Research Associates, SRFs etc. were present.

While visiting technology Park, experimental fields and laboratories of the institute, Dr. Srivastva appreciated the team ICAR-IIVR for excellent works being done at the institute. He was highly impressed with live demonstration of latest vegetable technologies in Technology Park for the benefit of farmers and other stakeholders. Dr. Bijendra Singh, Director, ICAR-IIVR & Convener, NAAS-Varanasi Chapter, briefed the ongoing activities of the chapter as well as achievements of the institute and its impact on farmers.

Visit of Second Sub-Committee of Parliamentary Official Language Committee

Second sub-committee of Parliamentary Official Language Committee reviewed the work and activities of the institute for the promotion of official language during 23-25 February 2019. On this occasion, Dr. Bijender Singh, Director, ICAR-IIVR, Varanasi welcome the said Parliamentary Committee Chairman Hon'ble Dr. Prasain Kumar Patasani, Member of Parliament (Lok Sabha) and Hon'able Shri Pradeep Tamta, Members of Parliament (Rajya Sabha) along with all the other officers of the committee and introduced the officers of the institute and headquarters present in the review meeting. Subsequently, the review was done by the convener of the commencement committee. He gave

the examples of other developed/developing nations to promote their official language by doing research and other activities in their own language. In addition, he appreciated the use of official language for research and dissemination work in the institute. Regarding the progress report of Hindi in the administrative functions of the institute, the committee expressed satisfaction over the day to day work done and appreciated over the expenditure incurred in Hindi on advertising and promotion during the last one year. Hon'ble Chairman of the Committee Dr. Prasanna Kumar Patasani also appreciated the Unicode software tools installed on all computers and advised to take action to fill Hindi officials and translator posts in the institute. On this occasion, the committee released the new issue of official language magazine "Sabzi Kiran" Vol. 12 (1 & 2) published from the Institute.

Institute Celebrated Hindi Chetana Maas

ICAR-Indian Institute of Vegetable Research, Varanasi celebrated Hindi Chetana Maas during 14 September to 12 October, 2018. Chief Guest Prof Ramkali Sarraf, Head, Hindi Department, Art Faculty, BHU, Varanasi inaugurated the Hindi Chetana Maas on September 14, 2018. In the opening remarks, he said that Hindi is not only a language of knowledge but also a symbol of nationality and Indian culture and its roots are within the public. During Hindi Chetana Maas number of competitions in hindi were organized and the names of the winners of various hindi competitions were announced and prizes were given to the winning team on the closing ceremony. Closing ceremony of this function was presided over by Dr. Jagdish Singh, Head, Crop Production of the Institute on 12th October 2018. The chief guest of this program was Dr. Anurag Kumar, Head of Hindi Department, Mahatma Gandhi Kashi Vidyapeeth, Varanasi. In his opening remarks, Dr. Kumar appreciated the work being done by the institute in Hindi. Describing Hindi as the beneficiary of science, he requested the scientists and other staff for commitment towards working in Hindi. On this occasion, Dr. Jagdish Singh, reviewed the works being done in hindi and advised that in order to discharge constitutional functions in the institution there is a need to do more work in Hindi.

Institute Biosafety Committee Meeting

The institute biosafety committee meeting was conducted on 04 May 2018 to review ongoing projects related to transgenic work. The meeting was initiated

with the introductory remarks by Chairman, IBSC, Dr. B Singh, Director of the institute. Dr Achuit Singh, Member secretary, IBSC briefed the ongoing/proposed rDNA related research work. DBT nominee Prof. R K Asthana, Dept. of Botany, BHU, external expert Prof J P Shahi, Institute of Agricultural Sciences, BHU and the internal committee members of the IBSC.

International Yoga Day

International Yoga Day, 2018 was observed on 21 June, 2018 from 7:00 – 8.00 A.M. in the IIVR – Guest House, Sunderbagia, Varanasi, with great enthusiasm and vehement participation by the employees of the Institute, including the Guest House Visitors. Various Yogasans including Pranayam, Kapal - Bharati, Surya - Namaskar, Bhujangasan, etc. were practiced by the employees under the able guidance of 2 Yoga experts. It was emphasized that regular practice of Yogasans would be helpful in cure and prevention of

several diseases *viz.* diabetes, blood pressure, heart & lung related diseases and other common ailments, pains, aches, etc. At the conclusion of the session, all participants resolved to practice yoga daily and also pledged to widespread the benefits and practice of Yoga amongst their living environment.

AWARDS, HONOURS, RECOGNITIONS AND PATENTS

1. Anant Bahadur conferred Fellow of Indian Society of Vegetable Science (ISVS)-2017 during 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) at Agriculture University, Jodhpur on February 1, 2019.
2. A. K. Chaturvedi conferred Excellence in Extension award in national conference on Doubling Farmer Income for Sustainable and Harmonious Agriculture (DISHA-2018) organized by Science & Technology Society Integrated Rural Improvement, Thorrur, Mahabubabad, Telangana on 11-12 August 2018 at IINRG, Ranchi.
3. B. Rajasekhar Reddy, K. Nagendran, Achuit K. Singh, Maneesh Pandey, B. Singh and P.M. Singh received Best Poster Award in Ist Vegetable Science Congress on Emerging Challenges in Vegetable Research & Education (VEGCON-2019), February 1-3, 2019 for the poster presented on "Screening for cowpea golden mosaic disease resistance in cowpea by grafting under field conditions".
4. G. K. Choudhary conferred Excellence in Extension award in 2nd international conference on Food and Agriculture -2018 (Sustainable Agriculture for Food Safety) organized by *Endling conference* on 29-31 March 2018 at Dhanbad.
5. G. K. Choudhary conferred Excellence in Extension award in national conference on Doubling Farmer Income for Sustainable and Harmonious Agriculture (DISHA-2018) organized by Science & Technology Society Integrated Rural Improvement, Thorrur, Mahabubabad, Telangana on 11-12 August 2018 at IINRG, Ranchi.
6. Manjunatha T Gowda conferred best oral presentation award in1st International Conference on Biological control Approaches and Applications on the paper Compatibility and efficacy of entomo-pathogenic nematode-insecticide combinations against *Holotrichia consanguinea* Blanch. (Coleoptera: Scarabaeidae) at Bengaluru during 27-29 September, 2018.
7. Jaydeep Halder received best poster presentation award in 1stVegetable science congress on "Emerging challenges in vegetable research & Education (VEGCON-2019) for the research paper "Synthesis & validation of eco-friendly IPM technology for bottle gourd (*Lagenaria siceraria*) in a farmers' driven approach & its economics", Agriculture University, Jodhpur during 1-3 February, 2019.
8. Jaydeep Halder conferred "SPPS Young Scientist Award-2018" for significant contribution in the field of Entomology by the Society of Plant Protection Sciences (SPPS), ICAR-NCIPM, New Delhi during December, 2018.
9. K.K. Gautam received best oral presentation award in National Symposium on Innovation in Agriculture, Environment, and technology for Inclusive Development from March 17-18, 2019 at Prayagraj by SBSRD Society.
10. K.K. Gautam received Young Fellow Award in 2nd International Conference on Advances in Agricultural, Biological and Applied Sciences for Sustainable future (ABAS-2018) from 20-22 October 2018 at Meerut by ATDS Society.
11. N. Rai received Kirti Singh Life Time achievement Award for outstanding contribution and leadership in the area of vegetable science by Indian Society of Vegetable Science.
12. Nagendran, K. awarded with *"Outstanding Scientist in Plant Virology"* by *RULA AWARDS* for International Innovation & Betterment Excellence in Technical Research at Trichy, Tamil Nadu on 12 November, 2018.
13. Nakul Gupta, Manimurugan C., PM Singh, Rajesh Kumar, Anant Bahadur, BR Meena, Vidyasagar and B Singh received best poster award for their paper "Nano particles in mitigating lead (Pb) toxicity in Indian Spinach (*Basella* spp.). In: 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) during February 01-03, 2019 at Agriculture University, Jodhpur.
14. P. Karmakar received third best poster award in 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) , 1-3 February, 2019 for the poster presented on "Sexual reproduction in dioecious pointed gourd: Sex inheritance, diversification and molecular marker aided sex identification in seedling population".
15. R. P. Chaudhary received best KVK scientist award by Indian Society of Extension Education in National Seminar on Integrated farming System for enhancing income and nutritional Security at WBUAFS, Kolkata on 5-7 December 2018.
16. R. P. Chaudhary received Excellence in Communication award in national conference on Doubling Farmer Income for Sustainable and

Harmonious Agriculture (DISHA-2018) organized by Science & Technology Society Integrated Rural Improvement, Thorrur, Mahabubabad, Telangana on 11-12 August 2018 at IINRG, Ranchi.

17. Rajesh Kumar conferred upon Fellowship of ISVS 2017 presented during the 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) , Feb. 1-3, 2019 at Agriculture University, Jodhpur.
18. Rakesh Kumar Dubey awarded with "Distinguished Service Award for outstanding contribution in field of Vegetable Science" on the occasion of National Symposium on Innovations in Agriculture, Environment and Technology for Inclusive Development on March 17-18, 2019 by Society of Biological Sciences and Rural Development, Prayagraj.
19. Rakesh Kumar Dubey received "Excellence in Research Scientist Award-2018 for outstanding contribution in field of Horticulture (Vegetable Science)" on the occasion of 2nd International Conference on Advances in Agricultural, Biological and Applied Sciences for Sustainable Future (ABAS-2018) on October 20-22, 2018 by Agricultural Technology Development Society, Ghaziabad.
20. Rakesh Kumar Dubey received ISNS Fellowship - 2019 for significant contribution in Agricultural Research & Development during the Interactive Workshop at University of Madras, Guindy Campus, Chennai on 23 - 24 March, 2019.
21. Sudhir Singh granted patent No. 306128, January 19, 2019 for Process for shelf stable low-fat tomato whey soup.
22. Sujan Majumder received Best Ph.D. Thesis Award, 2018 from Society of Pesticide Science (SPS) India in 30th foundation day of SPS India held on November 16, 2018 at ICAR-IARI, New Delhi.
23. Swati Sharma received Second Best poster award in 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019) , 1-3 February, 2019 for poster presented on "Post-harvest quality dynamics of chitosan coated eggplant cultivars in cold storage condition".
24. Vikas Singh awarded with Emerging Scientist Award-2018 in the field of Vegetable Breeding and Seed Production during October 20-22, 2018 by Agricultural Technology Development Society (ATDS), Ghaziabad.
25. Vikas Singh awarded with ISNS Fellowship award for the year 2019 at University of Madras, Guindy Campus, Chennai on 23 March, 2019 by International Society for Noni Science, Chennai, India

HUMAN RESOURCE DEVELOPMENT

Training and Capacity Building

Training of ICAR-IIVR Scientists/KVK SMS

Name of IIVR Scientists/KVKs SMS	Title of training	Duration	Held at
A. K. Chaturvedi	Orchard Management Practices in fruit Crops	27-29 August, 2018	ICAR- IIHR, Bengaluru
B.K. Singh	Short Course on Genomic assisted pre-breeding in vegetable crops	25 June - 05 July, 2018	Division of Vegetable Science, ICAR-IARI, New Delhi
Indivar Prasad	Workshop on International (OECD) Seed Certification	11-12 September, 2018	Uttarakhand State Seed and Organic production Certification Agency, Dehradun
K.K. Gautam	Recent approaches in horticultural development for enhancing farm income in environmentally constrained ecosystem	27 November -17 December, 2018	ICAR-CAZRI, Jodhpur
	Hindi Karyashala	24 August, 2018	ICAR-IIVR, Varanasi
Raghwendra Singh	Developing Winning Research Proposals	23-28 August, 2018	NAARM, Hyderabad
Rekha Singh	Food Safety and Quality Management of food products with reference to HACCP, Value addition and Quality Standards	04-24 September, 2018	I.Ag.Sci., BHU, Varanasi
Shweta Kumari	CAFT training on Modern concepts in Plant Disease Management for enhancing quality and productivity	8-28 February, 2019	GBPUA&T, Pantnagar
Sujan Majumder	One month orientation training	16 October - 15 November, 2018	ICAR-IIVR, Varanasi
	Three months professional attachment training	19 November, 2018 - 18 February, 2019	ICAR-NRCG, Pune
Vijaya Rani	One month orientation training	16 October - 15 November, 2018	ICAR-IIVR, Varanasi
	Three months professional attachment training	19 November, 2018 - 18 February, 2019	ICAR-NBAIM, Mau

Training and Skill Development of Farmers and Field Functionaries conducted

Sl. No.	Name of training programme	Date	Sponsored by	Nature of participants	No. of participants
1.	Improved vegetable Production and Animal Health Management at Sonbhadra	23 May, 2018	TSP, IIVR	Tribal Farmers	55
2.	Improved vegetable Production and Animal Health Management at Sonbhadra	24 May, 2018	TSP, IIVR	Tribal Farmers	72
3.	Integrated Pest Management in Vegetable Crops	26-28 June, 2018	Bayer Crop Science Ltd, Varanasi	Field Officers	20
4.	Production technology in vegetables and other cereal crops	18-19 July, 2018	TSP, IIVR	Tribal farmers	250
5.	Integrated production and management of vegetable	18-22 August, 2018	DD Agri., Chandauli	Farmers	54
6.	Integrated Crop Management in Vegetables	28-30 August, 2018	Tirunelveli, Tamil Nadu	Farmers	20

7.	Organic farming and value addition in vegetables	11-15 September, 2018	ATMA Samastipur	Farmers	20
8.	Organic Production Technologies in Vegetables	27-29 September, 2018	Hort Dept, Hyderabad	Officials/farmers	15
9.	Organic Production Technologies in Vegetables	23-27 October, 2018	ATMA, Patna	Farmers	25
10.	Integrated Production Technology in Vegetables	13-17 November, 2018	ATMA, Kangra, Palampur, H.P.	Farmers and officials	35
11.	Integrated Production Technology in Vegetables	20-22 December, 2018	NABARD, Balia	Farmers	50
12.	Integrated Production Technology in Vegetables	7-11 January, 2019	ATMA, Madhubani	Farmers	21
13.	Integrated Production Technology in Vegetables	21-25 January, 2019	ATMA, Darbhanga	Farmers	20
14.	Integrated Production Technology in Vegetables	19-23 February, 2019	ATMA, Sitamarhi	Farmers	25
15.	Production Technology in Vegetables	20-21 February, 2019	NABARD, Meerut	Farmers	20
16.	Integrated Production Technology in Vegetables	25-27 February, 2019	ATMA, Vaishali	Farmers	20
17.	Integrated Production Technology in Vegetables	25-27 February, 2019	Development Foundation, Jharkhand, New Delhi	Farmers	20
18.	Production Technology in Vegetables	6-7 March, 2019	NABARD, Bharatpur	Farmers	20
19.	Production Technology in Vegetables	7-8 March, 2019	ATMA, Samastipur	Farmer	40
20.	Integrated Production Technology in Vegetables	11-13 March, 2019	Arya Sambhu Krushak Club, Odisha	Farmers	20
21.	Integrated Production Technology in Vegetables	12-16 March, 2019	ATMA Muzaffarpur	Farmers	22

Training and Skill Development of ICAR/SAUs/State/KVKs Officials conducted

Name of the programme	Date	Sponsored by	Number & nature of participants
Market-led extension for production, post-harvest, processing and marketing of vegetables	27-31 August, 2018	VANAMATI, Nagpur	30 Agricultural officials
Advanced Vegetable Production Technologies for Enhancing Productivity and Nutritional Security	1-15 October, 2018	MANAGE, Hyderabad	11 officials for Module II Training
Advanced Vegetable Production Technologies for Enhancing Productivity and Nutritional Security	27 November – 11 December, 2018	MANAGE, Hyderabad	18 officials for Module II Training
Exposure visit and training of horticulture officers under MIDH	19-24 December, 2018	ADH, Hort. Dept., Patnagarh, Bolangir, Odisha	10 officials
Exposure visit of progressive farmers and extension officers from Assam	28 December, 2018	Assam Agribusiness and Rural Transformation Project (APART), World Bank	36 Farmers / officials

Seminar/symposium/conference/workshop attended

Name of Scientist	Title of seminar/ symposium/ conference/ workshop	Duration	Held at
A. T. Rani	First Vegetable Science Congress on Emerging Challenges in Vegetables research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
A.K. Chaturvedi	First Vegetable Science Congress on Emerging Challenges in Vegetables research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
A.N. Tripathi	Recent challenges and opportunities in sustainable plant health management (RCOSPHM-2019)	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Achuit K Singh	First Vegetable Science Congress on Emerging Challenges in Vegetables research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	National Symposium on "Recent Challenges and Opportunities in Sustainable Plant Health Management (RCOSPHM-IPS2019)	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi
Anant Bahadur	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Anurag Chaurasia	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
B. Rajasekhar	XXXVI Group Meeting of AICRP (VC)	18-21 May, 2018	RARI, Durgapura, Jaipur
Reddy	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	Seminar on Recent challenges and opportunities in sustainable plant health	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi
BK Singh	XXXVI Group Meeting of AICRP (VC)	18-21 May, 2018	RARI, Durgapura, Jaipur
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
D.R. Bhardwaj	International Seminar on "Global Partnership in Agricultural Education and Research	21-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 219	Agriculture University, Jodhpur
DK Singh	53rd Annual Convention of Indian Society of Agricultural Engineers (ISAE) and International Symposium on "Engineering Technologies for Precision and Climate Smart Agriculture".	28-30 January, 2019	I.Ag. Sc., B.H.U., Varanasi
G.K. Choudhary	Mid-term Review workshop for finalizing the action plan for 2019-2020 and progress report	29-31 November, 2018	NDUAT, Kumarganj, Ayodhya
Hare Krishna	National Conference on Doubling Farmers' Income: Technological and Management Interventions	18-19 May, 2018	Doon Business School, Dehradun
	International Seminar on Global Partnership	22-24 December,	I.Ag. Sc., B.H.U., Varanasi

	in Agricultural Education and Research	2018	
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Indivar Prasad	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	BHU, Varanasi
J. Singh	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
K.K. Gautam	2nd International Conference (ABAS-2018)	20-22 October, 2018	Meerut
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	National Symposium on Innovation in Agriculture, Environment, and technology for Inclusive Development	17-18 March, 2019	Prayagraj
Manjunatha T. Gowda	1st International Conference on Biological control Approaches and applications	27-29 September, 2018	ICAR-NBAIR, Bengaluru
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	National symposium on Recent challenges and opportunities in sustainable plant health management	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi
N. Rai	Indo- US Bilateral Workshop on Water food Energy Climate Nexus: A perspective Towards a sustainable Future (WFEC-2018)	16-21 November, 2018	Institute of Environmental & Sustainable Development
	International Seminar on Global Partnership in Agriculture Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	01-03 Feburary, 2019	Agriculture University, Jodhpur
N. Singh	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Nagendran K	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	Recent Challenges and Opportunities in Sustainable Plant Health Management	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi
R.B. Yadava	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
R.N. Prasad	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
R.P. Chaudhary	ISEE National Seminar on "Integrated Farming System for enhancing Farmers' Income and Nutritional Security"	05-07 December, 2018	West Bengal University of Animal and Fishery Sciences, Belgachia, Kolkata
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 219	Agriculture University, Jodhpur
Raghwendra Singh	ISWS Golden Jubilee International Conference on "Weeds and society: Challenges and	21-24 November, 2018	Jabalpur

	Opportunities"		
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agricultural University, Jodhpur
Rajesh Kumar	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	XXXVI Group Meeting of AICRP (VC)	18-21 May, 2018	RARI, Durgapura, Jaipur
	Meeting of the DNA Finger Printing Crop Group (Tomato, Brinjal, Chilli, Mango and Banana)	11 September, 2018	ICAR-IIHR, Bengaluru
Rakesh K. Dubey	2nd International Conference on "Advances in Agricultural, Biological and applied Sciences for sustainable Future (ABAS-2018)	20-22 October, 2018	Sardar Patel Auditorium, Swami Vivekanand Subharati University, Meerut(UP)
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	National symposium on Innovations in Agriculture, Environment and Technology for Inclusive Development	17-18 March, 2019	Vigyan Parishad Auditorium, Prayagraj (UP)
S. Gupta	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 219	Agriculture University, Jodhpur
S.N.S. Chaurasia	International Seminar on Global Partnership in Agricultural Education and Research	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agricultural University, Jodhpur
Shubhadeep Roy	ISEE National Seminar-2018 on Integrated farming system for enhancing farmers' income and nutritional security	5-7 December, 2018	WBUAFS, Kolkata
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	XIV Agricultural Science Congress on Innovations for Agricultural Transformations	20-23 February, 2019	NASC, New Delhi
	Zonal level review workshop of Farmer FIRST project	18-19 January, 2019	ICAR-ATARI, Kanpur
	Rajbhasa Hindi ke Pragami Prayog ko Badhaba (Hindi workshop)	04.08.2018	ICAR-IIVR, Varanasi
Shweta Kumari	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
SK Singh	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
SK Tiwari	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Sudhakar Pandey	12 Review Meeting of DUS Test Centres"	15-17 January	ICAR-IISR, Lucknow
	The Fourth International conference on creativity and innovation at/for/from/with grassroots (ICCIG 4)	28-30 January, 2019	IIM, Ahmedabad

	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Sudhir Singh	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agricultural University, Jodhpur
Swati Sharma	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
	International Seminar on Global Partnership in Agricultural Education and Research.	22-24 December, 2018	I.Ag. Sc., B.H.U., Varanasi
	Rajbhasha Hindi ke pragami prayog ko badhava	24 August, 2018	ICAR-IIVR, Varanasi
Tribhuvan Chaubey	9th National Seed Congress-2018 "Quality Seed: A Key Component For Doubling The Farmer's Income"	19-21 February, 2019	NSRTC, Varanasi & Dept. of Genetics and Plant Breeding, I.Ag. Sc., B.H.U., Varanasi
Vikas Singh	XXXVI Group Meeting of AICRP (VC)	18-21 May, 2018	RARI, Durgapura, Jaipur
	2nd International conference on "Advances in Agricultural, Biological and Applied Sciences for Sustainable Future (ABAS-2018)"	20-22 October, 2018	Swami Vivekanand Subharti University, Meerut (UP)
	First Vegetable Science Congress on Emerging Challenges in Vegetables Research and Education (VEGCON-2019)	1-3 February, 2019	Agriculture University, Jodhpur
Yerasu Suresh Reddy	National conference on Recent challenges and opportunities in sustainable plant health management	26-28 February, 2019	I.Ag. Sc., B.H.U., Varanasi

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infecting watermelon in India. *European Journal of Plant Pathology*, 153(3): 759-770.

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1. Bhardwaj DR, Gautam KK, Saha S, Nagendran K, Pandey KK, Singh AK, Singh PM and Singh B. 2018. Mining the sources of resistance for downy mildew and gummy stem blight in bottle gourd (*Lagenaria siceraria* L.). *Indian Journal of Agricultural Sciences*, 88(5): 746-750.
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35. Kumari AR, Meena K, Pandey MK and Prasad RN. 2018. Study on Knowledge Level of Potato Growers in Deoria District. *In: National farmers' Science Congress on "Grassroots Innovations in Farm Production, Value Chain Integration and Market Linkage",* pp. 10.
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42. Kumari AR, Srivastava R, Pandey MK, Meena K and Prasad RN. 2018. A Study on Role of Farm Women in Decision Making towards Agricultural Operations. *In: ISEE National Seminar on "Integrated farming System for enhancing Farmer's Income and Nutritional Security",* pp. 55.

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57. Rai TN, Rai KN and Rai AK. 2018. Weed Management in Rabi Maize. *In: Golden Jubilee & Water and Soil Management Approaches for Climate Smart Agriculture, (WASMACS, 2018),* pp. 202.
58. Rai TN, Rai KN and Sahu A. 2018. Effect of Zero-tillage and mulching with rice straw on wheat yield and soil health. *In: Golden Jubilee & Water and Soil Management Approaches for Climate Smart Agriculture, (WASMACS, 2018)*, pp. 200.
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61. Rai TN, Rai, KN and Rai AK. 2018. Mild Scented Rice A New Profited Venture. *In: Golden Jubilee & Water and Soil Management Approaches for Climate Smart Agriculture, (WASMACS, 2018)*, pp. 135.
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65. Reddy Y S, Krishnan N, Prasanna HC, Kasyap S, Yadav R and Singh B. 2019. Pyramiding of late blight and ToLCV resistance genes in tomato for multiple disease resistance. *In: National conference on recent challenges and opportunities in sustainable plant health management,* pp. 147.
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67. Roy S, Singh N, Vanitha SM, Singh J and Singh B. 2019.Perception analysis on priorities of vegetable protection in India. *In Abstract: 1st Vegetable Science Congress on "Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp. 212.
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69. Sahu A, Awasthi N, Duey AK and Singh S. 2019. Impact of Maize Sheller on Drudgery reduction and Skill upgradation of farm Women in District Kushinagar. *In: Souvenir and Abstracts of National Conclave on Empowering Rural Womwn through Agripreneurship and Innovative Farm Technologies (Utthan Agripren 2019)*, pp.111-112.

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72. Sharma S, Singh S and Singh J. 2018. Modulation of postharvest quality of fresh horticultural produce by exogenous polyamines treatment. *In: International Seminar on Global Partnership in Agricultural Education and Research,* pp. 86.

73. Sharma S, Singh S and Singh J. 2019. Post-harvest quality dynamics of chitosan coated eggplant cultivars in cold storage condition. *In Abstract: 1st Vegetable Science Congress on "Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp. 225-226.

74. Singh A K , Kaladhar V C and B. Singh. The functional characterization of a C4 gene from Tomato leaf curl virus in Tomato transient expressed plants. *In Abstract: 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp. 88.

75. Singh R, Singh SK, Singh J and Singh B. 2018. Effect of pre-and post-emergence herbicide on weed control and pod yield of vegetable cowpea. *In: ISWS Golden Jubilee International Conference on Weeds and society: challenges and opportunities,* pp. 38.

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80. Singh DK, Bahadur A, Chaurasia SNS, Singh S and Singh. 2019. Study on response of plant geometry configuration and drip fertigation in sweet pepper. *In Abstract: 1st Vegetable Science Congress on "Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp.164.

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83. Singh Vikas, Dubey RK, Bhardwaj DR, Karmakar P, Gautam KK, Kushwaha ML and Singh B. 2018. Genetic studied on variability for yield and its contributing traits in spine gourd (*Momordica dioica* Roxb.). *In: Souvenir & Conference Book: 2nd International conference on "Advances in Agricultural, Biological and Applied Sciences for Sustainable Future (ABAS-2018),* (2): 175-176.

84. Tiwari A, Srivastava R, Pandey, MK, Kumari AR, Meena K, and Singh B. 2018. Performance of Okra (*Abelmoschus esculentus L.* Moench.) Cultivars to Picking Intervals for Maximum Marketable Yield. *In: National Conference on Intensification and Diversification in Agriculture for Livelihood and Rural Development,* pp. 34-35.

85. Tripathi AN, Manjunath M T, Chaurasia A., Pandey KK, Singh B and Gupta S. 2019. Evaluation of microbial bioagents against plant diseases and management of plant health in bottle gourd under

field condition. *In Abstract: 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp. 208-209.

86. Tripathi AN, Meena BR, Chaurasia A, Pandey KK, Rai AB and Singh B. (2019). Diversity analysis of isolates of *Ralstonia solanacearum* causing bacterial wilt on solanaceous vegetables. *In Abstracts: National Symposium on Recent challenges and opportunities in sustainable plant health management (RCOSPHM-2019),* pp. 93.
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88. Yadava RB, Lama TD, Prasad RN, Singh DK, Singh J and Singh B. 2018. Effect of organic management systems on vegetable productivity and soil health. *In Abstracts: National Conference on Intensification and Diversification in Agriculture for Livelihood and Rural Development,* pp. 110.
89. Yadava RB, Singh J and Prasad RN. 2019. Response of foliar application of micronutrients on growth and yield of bitter gourd (*Momordica charantia* L.). *In Abstract: 1st Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019),* pp. 161-162.

Extension Folder:

1. Choudhary GK, Chaudhary RP, Singh R and Chaturvedi AK. 2018. *Pashu Dhan Bima Yojna*. Extension Folder No. 02/2018, KVK, Bhadohi.

Radio Talks: 27

TV Talks: 15

APPOINTMENTS, TRANSFERS, PROMOTIONS AND SUPERANNUATION

Appointments:

- Sh. Mukesh Onkar joined the post of Technical Assistant on 29.07.2018 at ICAR-IIVR.
- Ms. Poornima joined the post of Technical Assistant on 30.07.2018 at ICAR-IIVR.
- Sh. Sudhir Kumar joined the post of Technical Assistant on 25.08.2018 at ICAR-IIVR.
- Sh. Prakash Modanwal joined the post of Technical Assistant on 27.08.2018 at ICAR-IIVR.
- Dr. Sujan Majumdar joined the post of Scientist (Agriculture Chemicals) on 09.10.2018 at ICAR-IIVR.
- Ms. Vijaya Rani joined the post of Scientist (Agricultural Microbiology) on 10.10.2018 at ICAR-IIVR.
- Sh. Vinod Kumar Verma joined the post of Technical Assistant on 08.01.2019 at ICAR-IIVR.
- Sh. Sudeep Singh joined the post of Lower Division Clerk on 23.01.2019 at ICAR-IIVR.

Transfers:

- Dr. H.C. Prasanna, Principal Scientist transferred from ICAR-IIVR, Varanasi to ICAR-IIHR, Bengaluru on 29.06.2018.
- Dr. Swati Sharma, Scientist transferred from ICAR-NRCL, Muzaffarpur (Bihar) and joined ICAR-IIVR on 02.07.2018.
- Dr. Y. Bijen Kumar, Scientist transferred from ICAR-IIVR, Varanasi to ICAR-Resesarch Complex for NEH Region, Mizoram Centre, Kolasib on 13.07.2018.
- Dr. Hare Krishna, Principal Scientist transferred from ICAR-CIAH, Bikaner (Rajasthan) and joined ICAR-IIVR on 14.07.2018
- Dr. Indivar Prasad, Scientist transferred from ICAR-CSSRI, Bharuch (Gujarat) and joined ICAR-IIVR on 19.07.2018
- Sh. Ajay Uniyal, Persnal Assistant transferred from ICAR-DFR, Pune to ICAR-IIVR, Varanasi on 13.08.2018.
- Sh. Rahul Roshan, Assistant transferred from ICAR-IIVR, Varanasi to ICAR Headquarter, New Delhi on 28.02.2019.
- Ms. Poornima, Technical Assistant resigned from ICAR-IIVR, Varanasi on 30.07.2018.
- Dr. Bijendra Singh, Director, ICAR-IIVR joined as Director General (UPCAR), Lucknow, U.P. on 05.03.2019.

Promotions:

- Dr. Raghvendra Singh, Principal Scientist promoted from Rs. 37,000-67,000 + RGP 9000 to 37600-67000+RGP 10000 w.e.f. 24.02.2017.
- Sh. S.K. Singh, Chief Technical Officer promoted from Rs.15600-39100 + RGP 6600 to 15600-39100 + RGP 7600 w.e.f. 08.11.2016.
- Dr. Sunil Gupta, Chief Technical Officer promoted from Rs.15600-39100 + RGP 6600 to 15600-39100 + RGP 7600 w.e.f. 01.04.2017.

Supperannuation:

- Dr. A.B. Rai, Head, Crop Protection Division, ICAR-IIVR superannuated from services on 31.08.2018.
- Dr. Rajendra Prasad, Programme Coordinator, KVK, Bhadohi, ICAR-IIVR superannuated from services on 30.09.2018.

CLASSIFIED ABSTRACTS OF EXPENDITURE

(2018-2019)

ICAR-Indian Institute of Vegetable Research (Plan)

(In Lakhs)

Sub-head	Plan	
	Provision made in RE	Expenditure
Establishment Charges	1316.00	1315.93
Wages	-	-
O.T.A.	-	-
T.A.	17.45	17.45
Other Charges (Contingency)	643.40	643.29
H.R.D.	1.0	1.0
Works	88.00	87.98
Equipment	22.00	21.99
Library	6.50	6.50
Vehicle	-	-
Annual Repairs /Maintenance	-	-
Information	17.75	17.70
Technology TSP NEH	18.48	18.47
Total	**2130.58**	**2130.31**

Revenue generation

(In Lakhs)

Particulars	Target	Revenue generation
IIVR	56.04	154.32

Krishi Vigyan Kendra (Plan)

(In Lakhs)

KVKs	RE	Expenditure
KVK, Kushinagar	130.50	127.28
KVK, Deoria	110.50	116.89
KVK, Bhadohi	121.00	113.20
Total	**362.00**	**357.37**

Externally Funded Projects

Name of project	Funding agency	Duration of projects	Allocation & Expenditure 2018-19	
			Allocation	Expenditure
Crop Improvement				
Genome-wide mining and characterization of microsatellite markers for anthracnose resistance in chilli (*Capsicum* species)	DST, SERB	April, 2018 – March, 2020	9.60	8.55
Network Project on Transgenic Crops (NPTC)	ICAR	2017-2020	6.10	5.84
Introgression of Begomovirus Resistance Genes in Tomato (*Solanum lycopersicum* L.) through MAS and Genomic Approaches	DBT	2015- Dec., 2019	8.50	8.50
National Innovations in Climate Resilient Agriculture (NICRA)	ICAR	2011-2020	74.50	75.07
CRP on Hybrid Technology Project	ICAR	2015-2020	16.00	14.61
Cowpea golden mosaic disease (CPGMD) resistance: Agroinfectious clone development, Screening, Genetics of inheritance, Molecular Tagging and Mapping for CPGMD resistance gene(s) in cowpea by using linked markers	DST, SERB	2017-2020	20.90	15.37
CRP on Agrobiodiversity	ICAR	2015-2020	5.85	5.85
Central Sector Scheme for Protection of Plant Varieties and Farmer's Rights Authority (DUS testing of tomato, brinjal, okra, cauliflower, cabbage, vegetable pea, French bean, bottle gourd, bitter gourd, pumpkin and cucumber).	PPV & FRA	2009-2020	23.00	23.34
Agri Business Incubator (ABI)	ICAR	2016-2020	22.75	22.71
Zonal Technology Management Unit (ZTMU)	ICAR	2015-2020	15.50	15.68
Using genome editing to unravel *Fusarium* wilt resistance in tomato	DBT	Jan., 2018 – Oct., 2018	14.7	14.85
Crop Production				
Efficient Water Management in Horticultural Crops (under Agri-CRP on Water Project)	ICAR	2015-16 to 2019-20	9.7	9.50
Development of shelf stable intermediate moisture leafy vegetables using radiation processing	BARC, Mumbai	2017- 2020	6.05	-
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- 2020	22.45	21.69

Scheduled Tribes Component (Earlier Tribal Sub Plan) for Tribal of Sonbhadra district in Uttar Pradesh (National Assignment by Department of Agricultural Research & Education, Ministry of Agriculture and Farmers Welfare, Govt. of India)	ICAR	2013 - continue till date	16.48	16.48
Crop Protection				
Establishment of Integrated Beekeeping Development Centre (IBDC)/Centre of Excellence (CoE) on Beekeeping	NBB, DAC&FW, Govt. of India, New Delhi	2017-20	99.75	64.72
Agro infectious clones development for probing resistance to chilli leaf curl diseases caused by begomoviruss and devising integrated management strategies	DST	2016 - Sept., 2019	9.04	7.88
AICRP on Biocontrol	ICAR-NBAIR	2018 - 2021	4.5	1.98

Staff Strength (as on 31.03.2019)

Sl. No.	Category	Sanctioned Strength	Staff in Position	Vacant
SCIENTIFIC				
1.	Scientist	45	41	04
2.	Senior Scientist	12	08	04
3.	Principal Scientist	06	02	04
	TOTAL	**63**	**51**	**12**
TECHNICAL				
1.	Technician	11	10	01
2.	Senior Technician	-	-	-
3.	Technical Assistant	13	08	05
4.	Senior Technical Assistant	02	02	-
5.	Technical Officer	-	-	-
6.	Senior Technical Officer	-	-	-
7.	Assistant Chief Technical Officer	-	-	-
	TOTAL	**26**	**20**	**06**
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	04	01
6.	Private Secretary	01	01	-
7.	Personal Assistant	02	-	02
8.	Stenographer Gr. III	02	-	02
9.	UDC	02	02	-
10.	LDC	04	-	04
	TOTAL	**20**	**10**	**10**
SKILLED SUPPORTING STAFF				
1.	S.S.S	16	16	-
	TOTAL	**16**	**16**	**-**
	Grand Total	**125**	**97**	**28**

Staff strength of Krishi Vigyan Kendras (as on 31.03.2019)

KVK Sargatia, Kushinagar

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Subject Matter Specialist	06	06	-
2.	Farm Manager	01	01	-
3.	Programme Assistant	01	01	-
4.	Programme Assistant (Computer)	01	-	01
5.	T-1 (Driver)	02	02	-
	Total	**11**	**10**	**01**

KVK, Deoria

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Subject Matter Specialist	06	05	01
2.	Farm Manager	01	01	-
3.	Programme Assistant	01	01	-
4.	Programme Assistant (Computer)	01	-	01
5.	T-1 (Driver)	02	02	-
	Total	**11**	**09**	**02**

KVK, Bhadohi

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Subject Matter Specialist	06	06	-
2.	Farm Manager	01	01	-
3.	Programme Assistant	01	01	-
4.	Programme Assistant (Computer)	01	01	-
5.	T-1 (Driver)	02	02	-
	Total	**11**	**11**	**-**

Staff in position
(as on 31.03.2019)

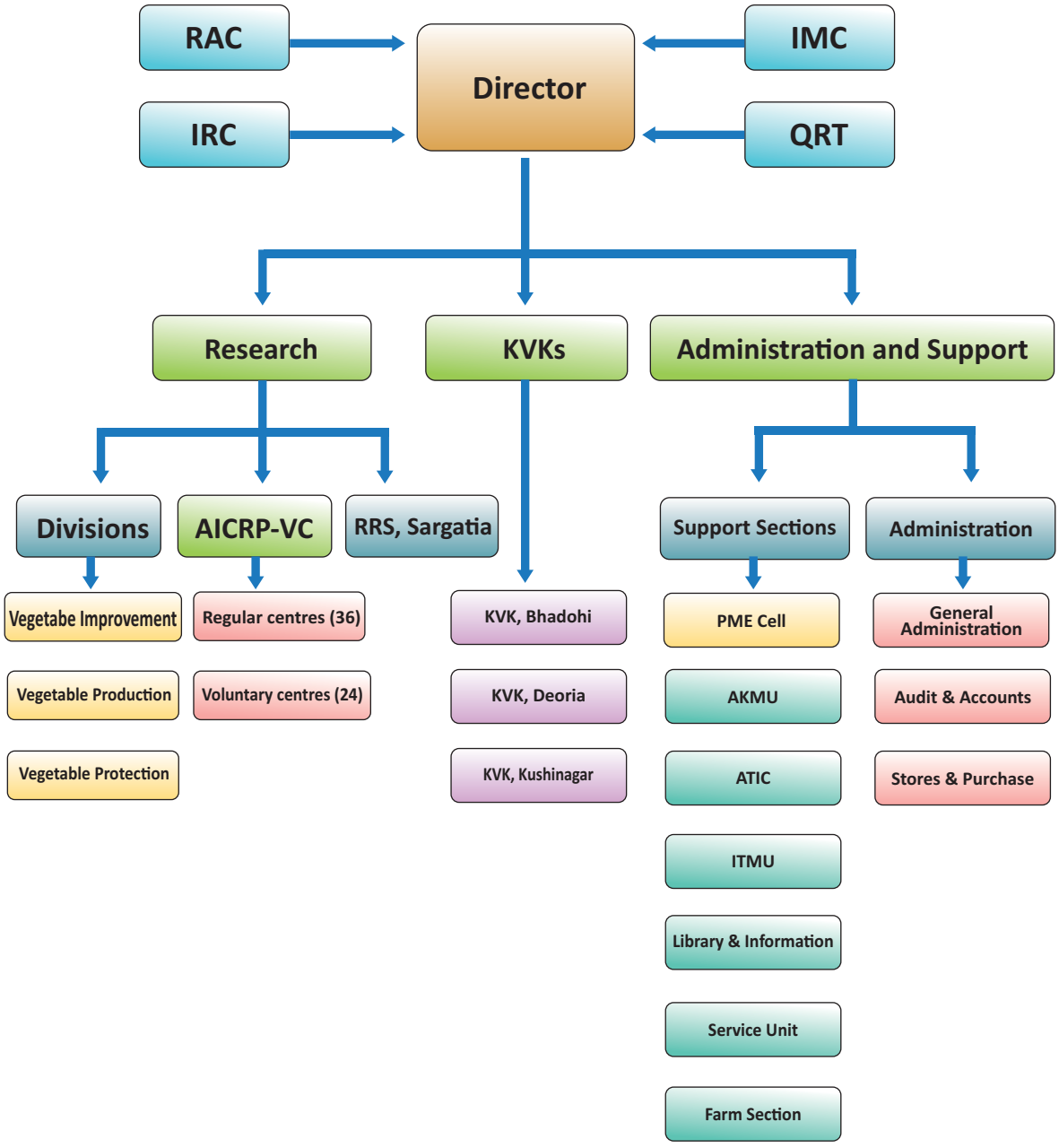
Sl. No.	Name	Designation	Email
1.	Dr. Jagdish Singh	Director (Acting)	directoriivr@gmail.com
Director's Cell			
2.	Sh. Ajayan P.	Private Secretary	ajaynair27@gmail.com
3.	Sh. Ajay Uniyal	Personal Assistant	ajay.uniyal1@gmail.com
Project Coordinator Cell			
4.	Dr. S.K. Verma	Principal Scientist	skverma10@yahoo.com
5.	Dr. Ram chandra	Principal Scientist	rchandraiivr2016@gmail.com
6.	Dr. T. Chaubey	Principal Scientist	tchaubay@gmail.com
7.	Dr. B. Rajasekhar Reddy	Scientist	rajasekharhortico@gmail.com
8.	Dr. A.P. Singh	Senior Technical Officer	apsinghento@gmail.com
Division of Vegetable Improvement			
9.	Dr. P.M. Singh	Principal Scientist & I/C Head	pmsiivr@gmail.com
10.	Dr. Nagendra Rai	Principal Scientist	nrai1964@gmail.com
11.	Dr. D.R. Bhardwaj	Principal Scientist	dram_iivr@yahoo.com
12.	Dr. Rajesh Kumar	Principal Scientist	rajes74@gmail.com
13.	Dr. Sudhakar Pandey	Principal Scientist	sudhakariivr@gmail.com
14.	Dr. Achuit Kumar Singh	Senior Scientist	achuit@gmail.com
15.	Dr. Rakesh Kumar Dubey	Senior Scientist	rksdubey@gmail.com
16.	Dr. Shailesh Kumar Tiwari	Scientist	tiwarishailu@gmail.com
17.	Dr. Binod Kumar Singh	Scientist	bksinghkushinagar@yahoo.co.in
18.	Dr. Pradip Karmakar	Scientist	pradip9433@gmail.com
19.	Dr. Yerasu Suresh Reddy	Scientist	yerasusureshreddy@yahoo.co.in
20.	Dr. Indivar Prasad	Scientist	indivar234@gmail.com
21.	Dr. Jyoti Devi	Scientist	jyoti17iivr@gmail.com
22.	Sh. K.K. Gautam	Scientist	kkgautam008@gmail.coms
23.	Sh. S.G. Karkute	Scientist	suhaskarkute@gmail.com
24.	Sh. Nakul Gupta	Scientist	nakulgupta1988@gmail.com
25.	Dr. Vidya Sagar	Scientist	vidya.sagarkaushal@gmail.com
26.	Sh. A.K. Singh	Assistant Chief Technical Officer	ashoksinghiivr@gmail.com
27.	Dr. Rameshwar Singh	Assistant Chief Technical Officer	bisen.singh@gmail.com
28.	Sh. Vishwanath	Assistant Chief Technical Officer	vishwanathbhargava@gmail.com
29.	Sh. Ashutosh Goswami	Assistant Chief Technical Officer	ashutosh12031972@gmail.com
30.	Sh. Chandra Bushan	Technical Officer	cb.dubey2011@gmail.com
31.	Sh. Subhash Chandra	Senior Technical Assistant	subhash301269@gmail.com
32.	Sh. Sudhir Kumar	Technical Assistant	sudhir2203@gmail.com
Division of Vegetable Production			
33.	Dr. R.N. Prasad	Principal Scientist & I/C Head	rnprasad_zcu@rediffmail.com
34.	Dr. Sudhir Singh	Principal Scientist	sudhiriivr@gmail.com
35.	Dr. S.N.S. Chaurasia	Principal Scientist	chaurasiaiivr@gmail.com
36.	Dr. R.B. Yadav	Principal Scientist	raj_yadava@rediffmail.com
37.	Dr. Neeraj Singh	Principal Scientist	neerajatic@gmail.com

38.	Dr. D.K. Singh	Principal Scientist	dharmendraksingh@rediffmail.com
39.	Dr. S.K. Singh	Principal Scientist	skscprs@gmail.com
40.	Dr. Anant Bahadur	Principal Scientist	singhab98@ gmail.com
41.	Dr. Hare Krishna	Principal Scientist	kishun@rediffmail.com
42.	Dr. Raghwendra Singh	Principal Scientist	singhraghu75@gmail.com
43.	Dr. Shubhadeep Roy	Scientist	shubhadeepiari@gmail.com
44.	Dr. S.M. Vanitha	Scientist	vanita.gkvk@gmail.com
45.	Dr. Swati Sharma	Scientist	swtsharma92@gmail.com
46.	Sh. Y.P. Singh	Senior Technical Officer	ybsinghiivr@gmail.com
47.	Sh. P.C. Tripathi	Technical Officer	tripa732003yahoo.co.in
48.	Sh. Pankaj Kumar Singh	Technical Officer	pksingh@gmail.com
49.	Sh. Mukesh Onkar	Technical Assistant	onkar.mukesh1@gmail.com
Division of Vegetable Protection			
50.	Dr. K.K. Pandey	Principal Scientist & I/C Head	kkpiivr@gmail.com
51.	Sh. Anurag Chaurasia	Scientist	anurag_vns1@yahoo.co.in
52.	Dr. Jaydeep Halder	Scientist	jaydeep.halder@gmail.com
53.	Dr. A.N. Tripathi	Scientist	antripathi_patho@rediffmail.com
54.	Dr. Nagendran Krishnan	Scientist	krishnagendra@gmail.com
55.	Sh. Manjunatha GowdaT.	Scientist	goudru9@gmail.com
56.	Sh. Bharat Raj Meena	Scientist	brrm1406@gmail.com
57.	Dr. Rani A.T	Scientist	raniatgowda@gmail.com
58.	Ms. Shweta Kumari	Scientist	sweta.aau@gmail.com
59.	Dr. Sujan majumdar	Scientist	sujaniari@gmail.com
60.	Ms. Vijaya Rani	Scientist	ranivijaya78@gmail.com
61.	Sh. Raghubansh Mani Rai	Assistant Chief Technical Officer	raghubanshmaniiivr@gmail.com
Administration			
62.	Sh. Sumit Kumar Jindal	Senior Administrative Officer	saoiivr@gmail.com
63.	Sh. U.K Saxena	Finance & Account Officer	iivrfao@gmail.com
64.	Sh. U.N. Tiwari	Assistant Administrative Officer	udainarayantiwari@gmail.com
65.	Sh. Gopi Nath	Assistant	gopiiivr@gmail.com
66.	Sh. Prakash Modanwal	Technical Assistant	prakash.iivr@gmail.com
67.	Sh. R.K. Mehrotra	Upper Division Clerk	ritesh.iivr@gmail.com
68.	Sh. A.K. Mishra	Upper Division Clerk	arunmishraiivr@gmail.com
69.	Sh. S.K. Gupta	Upper Division Clerk	sushilskg@yahoo.co.in
70.	Sh. Sudeep Singh	Lower Division Clerk	Singhabc16@gmail.com
Farm Section			
71.	Dr. T. Chaubey	Chairman	tchaubay@gmail.com
72.	Sh. Vishwanath	Farm Manager	vishwanathbhargava@gmail.com
73.	Sh. Pankaj Kumar Singh	Technical Officer	pksinghiivr@gmail.com
74.	Sh. K.K. Upadhyay	Technical Officer	upadhyay@gmail.com
PME Cell			
75.	Dr. P.M. Singh	Chairman	pmecell.iivr@gmail.com
76.	Dr. Sunil Gupta	Chief Technical Officer	gupta.sunil191@gmail.com
Library			
77.	Sh. S.K. Singh	Chief Technical Officer	sksinghiivr@gmail.com

Institute Service Unit			
78.	Dr. B.K.Singh	I/C E&M	bksinghkushinagar@yahoo.co.in
79.	Sh. Ashutosh Goswami	Estate Officer & ACTO	ashutosh12031972@gmail.com
80.	Sh. M.L. Vishwakarma	Technical Officer	madanlalvishwa@yahoo.in
Vehicle Section			
81.	Dr. Shubhadeep Roy	Scientist & I/C Vehicle	shubhadeepiari@gmail.com
82.	Dr. Sunil Gupta	Vehicle Officer	gupta.sunil191@gmail.com
83.	Sh. Sanjay Singh	Senior Technical Assistant	
84.	Sh. Rajendra Kumar	Senior Technical Assistant	-
85.	Sh. Manoj Kumar	Senior Technical Assistant	
86.	Sh. Ram Ashrey	Senior Technical Assistant	-
Skilled Supporting Staff (SSS)			
87.	Sh. Jagwat Ram	SSS	-
88.	Sh. Shiv Kumar	SSS	-
89.	Sh. Kailash Singh	SSS	-
90.	Sh. S.P. Mishra	SSS	-
91.	Sh. Naraini Singh	SSS	-
92.	Sh. S.K. Pandey	SSS	-
93.	Sh. Arun Kumar	SSS	aruniivr@gmail.com
94.	Sh. Ramraj	SSS	-
95.	Sh. Suresh Kumar Yadav	SSS	-
96.	Sh. Suresh Kumar	SSS	-
97.	Sh. Virendra Prasad Gond	SSS	-
98.	Sh. Kamlesh Kumar Singh	SSS	-
99.	Sh. Anil Kumar Suman	SSS	-
100.	Sh. Ram Kunwar Chaubey	SSS	-
101.	Sh. Jata Shankar Pandey	SSS	-
102.	Sh. Shivajee Mishra	SSS	-
Regional Research Station, Sargatia, Kushinagar			
103.	Dr. Vikas Singh	Senior Scientist & I/C	vikaschf@gmail.com
104.	Dr. C. Manimurugan	Scientist	manimuruganc@gmail.com
105.	Sh. Pratap A. Divekar	Scientist	pratapento@gmail.com
106.	Sh. Motilal Kushwaha	Programme Assistant (Comp.)	motilalakushwaha@yahoo.com
107.	Sh. Vinod Kumar Verma	Technical Assistant	-
Krishi Vigyan Kendra, Sargatia, Kushinagar			
108.	Dr. R. P. Sahu	SMS (Agril. Extension)	ramdrprakash@gmail.com
109.	Sh. Ajay Kumar Rai	SMS (PP)	kvkkushinagar@gmail.com
110.	Sh. Yogesh Kumar Yadav	SMS (AS)	yogeshkyadav001@rediffmail.com
111.	Smt. Anjali Sahu	SMS (HS)	anjalisahu13march@gmail.com
112.	Dr. T.N. Rai	SMS (Soil Science)	tnrai_78@rediffmail.com
113.	Dr. Shamsher Singh	SMS (Horticulture)	shamshersinghkvk@gmail.com
114.	Sh. Arun Pratap Singh	Farm Manager	arunkuwarsingh76@gmail.com
115.	Sh. Prasant Kumar Gupta	Office Superintendent	pkg1981@gmail.com
116.	Sh. Pankaj Kumar Singh	(T-1) Driver	-
117.	Sh. Satish Kumar Singh	(T-1) Driver	sks.kvkkushinagar@gmail.com

Krishi Vigyan Kendra, Deoria			
118.	Sh. Rajneesh Srivastava	SMS (Horticulture) & I/C Head	rajneeeshkvk@gmail.com
119.	Dr. Ashok Rai	SMS (Ag.Extn)	ashokraibhu@gmail.com
120.	Smt. A. R. Kumari	SMS (HS)	anuradha_rau@rediffmail.com
121.	Dr. Abhay Kumar Singh	SMS (Vet. Sci.)	drabhaysingh@rediffmail.com
122.	Sh. Kamalesh Meena	SMS (SS & Agro)	kamalaagronomy@gmail.com
123.	Sh. Ajay Tiwari	Farm Manager	ajitiwariiivr@gmail.com
124.	Sh. Bharat Singh	(T-1) Driver	bharatiivr@gmail.com
125.	Sh. Sharad Chand Rai	(T-1) Driver	scrai76@gmail.com
Krishi Vigyan Kendra, Bhadohi			
126.	Dr. A.K. Chaturvedi	SMS (Hort.) & Lisening Officer	akciivr@gmail.com
127.	Dr. G.K. Choudhary	SMS (AS)	drgovindvet@yahoo.co.in
128.	Dr. R.P. Choudhary	SMS (Ag. Extn)	rudalpd@rediffmail.com
129.	Dr. Rekha Singh	SMS (HS)	rekhaiivr@gmail.com
130.	Dr. Manoj K. Pandey	SMS (PP)	mkp_bxr@yahoo.co.in
131.	Dr. P.C. Singh	Farm Manager	prabhashiivr@gmail.com
132.	Sh. V.V. Diptikar	Programme Assistant (Comp.)	v_v_diptikar@rediffmail.com
133.	Sh. Roshan Lal	Office Superintendent	roshaniivr@gmail.com
134.	Sh. D.P. Singh	Programme Assistant	dpsinghkvk@rediffmail.com
135.	Sh. Sanjay Kumar Yadav	(T-1) Driver	sanjay8765275294@gmail.com
136.	Sh. Pramod Paswan	(T-1) 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. Jankiram ADG (Horticultural Sciences-I) ICAR, New Delhi	Member
Shri Prakash Yadav August Kunda, Lalia Gali, Varanasi	Non Official Member
Smt. Priyanka Patel Jalaalpurmaafi, 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			
Mega-Programme Leader: P.M. Singh			
Code	**Title of the project**	**P.I.**	**Co-PIs & Associates**
1.1	Genetic Improvement of Tomato	HC Prasanna (upto 30.06.2018)/ YS Reddy (w.e.f. 01.07.2018)	YS Reddy and N. Rai **Associates:** AB Rai (upto 31.08.2018), K.K. Pandey (diseases),K. Nagendran (Viruses) and Manjunath Gowda (Nematodes)
1..2	Genetic Improvement of Brinjal	SK Tiwari	S.K. Verma **Associates:** Pratap Dibekar, Shweta Kumari (Phytoplasma) and A.N. Tripathi (Diseases)
1.3	Genetic Improvement of Chilli	Rajesh Kumar	S.G. Karkute (upto 31.08.2018) and Indivar Prasad (w.e.f. 01.08.2018) **Associates:** AB Rai (upto 31.08.2018), K.K. Pandey (diseases), K. Nagendran (Viruses) and Manjunath Gowda(Nematodes)
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. Dibekar (Insects), 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, P. Karmakar and K.K. Gautam **Associates:** J. Haldar (Insects), M. Gowda (nematodes) and B. Meena (Diseases)
1.8	Genetic Improvement of *Luffah*	T. Chaubey	Sudhakar Pandey, RK Dubey **Associates:** J. Haldar (Insects), M. Gowda (nematodes), B. Meena (Diseases)
1.9	Genetic Improvement of Pumpkins and Cucumber	Sudhakar Pandey	D.R. Bhardwaj, T. Chaubey, Vikas Singh and KK Gautam **Associates:** J. Haldar (Insects), M. Gowda (nematodes), A.N. Tripathi (Diseases) and K. Nagendran (Viruses)
1.10	Genetic Improvement of Melons	Pradip Karmakar	Sudhakar Pandey and KK Gautam
1.11	Genetic Improvement of Okra	B Singh	Achuit Singh, Pradip Karmakar and Vidyasagar **Associates:** J Halder (Insects), M. Gowda (Nematodes) and K. Nagendran (Diseases/Viruses)

1.12	Genetic Improvement of Cole crops and Root crops	BK Singh	P. Karmakar **Associates:** A.T. Rani (Insects) and B. Meena (Diseases)
1.13	Biotechnological interventions including Transgenics for managing stresses in vegetables	Achuit Singh	HC Prasanna (upto 30.06.2018), Sudhakar Pandey, SK Tiwari, YS Reddy, SG Karkute (upto 31.08.2018), Jyoti Devi, Vidyasagar and Manimurugan C. **Associate:** K. Nagendran (Diseases)
1.14	Genetic Improvement of under exploited & future vegetables	R.K. Dubey	BK Singh, SG Karkute (upto 31.08.2018), Jyoti Devi, Y.S. Reddy, B. Rajasekhar Reddy, Vidyasagar and Indivar Prasad (w.e.f. 01.08.2018). **Associates:** P. Dibekar (Insects) and B. Meena (Diseases)
1.15	Genetic Improvement of clonally propagated & perennial vegetables	Vikas Singh	D.R. Bhardwaj, P. Karmakar and Vidyasagar **Associates:** J. Haldar (Insects), M. Gowda (Nematodes) and B. Meena (Diseases)
MEGAPROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES			
Mega-Programme leader: P.M. Singh			
2.1	Priming, Coating, ovule conversion and seed enhancement.	P.M. Singh	Rajesh Kumar, T Chaubey, Vikas Singh, Manimurugan, C. and Nakul Gupta **Associate:** J. Halder (Insects) and A.N. Tripathi (Diseases)
2.2	Pollination studies for seed augmentation in vegetables including support of honey bees.	Nakul Gupta	P.M. Singh, Rajesh Kumar, T Chaubey, J. Halder, Pratap A. Divekar and Manimurugan, C. **Associate:** A.N. Tripathi (Diseases)
2.3	Drying and storage studies on vegetable seeds including modified atmosphere storage	Manimurugan, C.	PM Singh, J. Singh Sudhir Singh, Rajesh Kumar, S. Roy and Nakul Gupta
MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT			
Programme Leader: Jagdish Singh			
3.1	Technologies for protected vegetable production	Anant Bahadur	R.N. Prasad and D.K. Singh **Associates:** K.K. Pandey (Diseases) and Manjunath Gowda T (Nematodes).
3.2	Vegetable based cropping systems	R.N. Prasad	S.K. Singh, R.B. Yadava and Vanitha S.M.
3.9	Physiological and biochemical mechanisms of heat stress tolerance in chilli	Jagdish Singh	Rajesh Kumar
3.10	Agronomic bio-fortification studies in vegetable crops	R.B. Yadava	Jagdish Singh and Raghwendra Singh
3.11	Development of organic production technologies for vegetable based cropping systems	S.K. Singh	R.B. Yadava and Sudhir Singh **Associates:** K.K. Pandey (Diseases), Jaydeep Haldar (Insects), Bharat Meena (Diseases) and Manjunath Gowda T (Nematodes).
3.12	Improving water productivity of vegetable crop sequences through drip irrigation system	D.K. Singh	Anant Bahadur **Associate :** Jaydeep Haldar (Insects)

3.13	Enhancing productivity, quality and tolerance to biotic and abiotic stresses in vegetables by grafting technology	Anant Bahadur	-
3.14	Weed management in vegetable legumes	Raghwendra Singh	Jagdish Singh and S.K. Singh **Associates:** A.N. Tripathi (Diseases) and Y. Bijen Kumar
3.15	Conservation agriculture under vegetable based cropping system	Raghwendra Singh	S.K. Singh and R.B. Yadava
MEGA PROGRAMME-4: POST HARVEST MANAGEMENT AND VALUE ADDITION			
Programme Leader: Sudhir Singh			
4.3	Modified atmosphere storage for retaining the quality assurance of vegetables for longer time	Sudhir Singh	-
MEGA PROGRAMME 5: PRIORITIZATION OF R&D NEEDS AND IMPACT ANALYSIS OF TECHNOLOGIES DEVELOPED BY ICAR-IIVR			
Programme Leader: Neeraj Singh			
5.3	Development and evaluation of training modules for different stakeholders in vegetables	Neeraj Singh	Subhadeep Roy and Vanitha S.M.
5.4	Empowering rural youth for entrepreneurship	Subhadeep Roy	Neeraj Singh and Vanitha S.M.
5.5	Economic impact assessment of IIVR developed technologies	Vanitha S.M.	Neeraj Singh and Subhadeep Roy
MEGA PROGRAMME-6: INTEGRATED PLANT HEALTH MANAGEMENT			
Programme Leader: A.B. Rai / K.K. Pandey			
6.1	Bio-intensive management of important pests of vegetable crops	AB Rai (upto 31.8.2018) and J Halder (*w.e.f.* 01.9.2018)	J Halder (upto 31.8.2018), PA Divekar, K Nagendran and Y Bijen Kumar (upto 13.7.2018) **Associate :** Neeraj Singh
6.2	Toxicological investigations on the novel and botanical insecticides against major insect pests of vegetables.	PA Divekar	AB Rai (upto 31.08.2018), J Halder, AT Rani and Y Bijen Kumar (upto 13.7.2018)
6.3	Biological control of major insect pests of vegetable crops	J Halder	AB Rai (upto 31.08.2018), PA Divekar, AT Rani, M Gowda T and AN Tripathi
6.4	Development of effective integrated management package for important fungal diseases of vegetable crops	KK Pandey	AN Tripathi, BR Meena, M Gowda T and Anurag Chaurasia
6.5	Bio-prospecting of microorganisms associated with vegetables against plant pathogens	AN Tripathi	KK Pandey, Anurag Chaurasia, Shweta Kumari and K Nagendran
6.6	Management of important bacterial diseases of vegetable crops	AN Tripathi	BR Meena and Y Bijen Kumar (upto 13.7.2018)
6.7	Characterization of viruses infecting vegetable crops and their management	K Nagendran	KK Pandey, Shweta Kumari and Manimurugan C **Associate :** Achuit K Singh
6.9	Management of plant parasitic nematodes infecting vegetable crops	M Gowda T	KK Pandey and J Halder **Associate :** Subhadeep Roy
6.10	Pest and diseases dynamics of important vegetable crops in relation to changing weather scenario	AB Rai (upto 31.8.2018), KK Pandey (*w.e.f.* 01.09.2018)	KK Pandey (upto 31.08.2018), J Halder, BR Meena, PA Divekar and AT Rani

B. Externally Funded

Division of Crop Improvement			
S.N.	**Title of the project**	**P.I.**	**Co-PIs & Associates**
1.	Introgression of Begomo virus Resistance Genes in Tomato (*Solanum lycopersicum*L.) through MAS and Genomic Approaches	H. C. Prasanna (June 2018) Achuit K. Singh (July 2018)	Y. Suresh Reddy
2.	National Innovations in Climate Resilient Agriculture (NICRA)	P.M. Singh	N. Rai, Anant Bahadur, Suhas Karkute (up to 31.08.2018), Achuit Kumar Singh (w.e.f. 01.09.2018) and A.B. Rai (up to 31.08.2018)
3.	CRP on Hybrid Technology Project	N. Rai	Y. S. Reddy
4.	Network Project on Transgenic Crops (NPTC)	Achuit K. Singh	Suhas G. Karkute and Nagendra Krishnan
5.	CRP on Agrobiodiversity	S.K. Tiwari	P. Karmakar and Vidyasagar
6.	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)	B.Singh,Director (upto 5.3.2019), Sudhakar Pandey (6.3.2019 onward)	Sudhakar Pandey (upto 5.3.2019) and T. Chaubey
7.	Agri Business Incubator (ABI)	P.M. Singh	SK Tiwari, Shubhdeep Roy, Neeraj Singh and Sudhir Singh
8.	Zonal Technology Management Unit (ZTMU)	P.M. Singh	SK Tiwari, Shubhdeep Roy, Neeraj Singh and Sudhir Singh
9.	DST SERB project: Cowpea golden mosaic disease (CPGMD) resistance: Agroinfectious clone development, Screening, Genetics 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
Division of Crop Production			
10.	Efficient Water Management in Horticultural Crops (under Agri-CRP on Water Project)	DK Singh	Anant Bahadur and SNS Chaurasia
11.	Development of shelf stable intermediate moisture leafy vegetables using radiation processing	Sudhir Singh	
12.	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, J. Singh and B. Singh

13.	Scheduled Tribes Component (Earlier Tribal Sub Plan) for Tribal of Sonbhadra district in Uttar Pradesh (National Assignment by Department of Agricultural Research & Education, Ministry of Agriculture and Farmers Welfare, Govt. of India)	Neeraj Singh	Shubhadeep Roy, SK Singh, DR Bhardwaj, RN Prasad, AK Chaturvedi, RP Chaudhary, Abhay K. Singh, J. Singh and B Singh
Division of Crop Protection			
14.	Establishment of Integrated Beekeeping Development Centre (IBDC)/Centre of Excellence (CoE) on Beekeeping	A.B. Rai (upto 31.08.2018) K.K. Pandey (w.e.f. 01.09.2018)	K.K.Pandey (upto 31.08.2018) Neeraj Singh, A.N. Tripathi, Jaydeep Halder, K. Nagendran, B.R.Meena, M. Gouda T, Pratap Divekar upto 03.12.2018, Y. Bijen Kumar upto 13.07.2018, Sujan Majumadear w.e.f. 13.03.2019
15.	Agro infectious clones development for probing resistance to chilli leaf curl diseases caused by begomoviruss and devising integrated management strategies	K.Nagendran	Rajesh Kumar

Annexure IV

Distinguished Visitors

Dr. Panjab Singh President National Academy of Agriculture Sciences	02.05.2018
Dr. Kirti Singh Former Presidents, ISVS	02.05.2018
Dr. R.B. Singh Former Chairman National Academy of Agriculture Sciences	02.05.2018
Dr. Gautam Kalloo Former Deputy Director General (Hort. Sci.) ICAR, New Delhi	02.05.2018 28.09.2018 29.01.2019
Dr. A.K. Srivastava Member, ASRB, New Delhi	02.05.2018 29.01.2019
Prof. R K Asthana Department of Botany, BHU	04.05.2018
Prof J P Shahi Institute of Agricultural Sciences, BHU	04.05.2018
Dr. K. E. Lawande Former Vice Chancellor Dr. BSKKV, Dapoli	22-23.06.2018
Dr. S.M.S Tomar IARI, Pusa, New Delhi	22-23.06.2018
Dr. Anil Sirohi Professor, IARI, Pusa, New Delhi	22-23.06.2018
Dr. D.P. Wasker Director (Research) Dr. VNMKVK, Parbhani	22-23.06.2018
Dr. T. Janakiram Asstt. Director General (Hort.-II) ICAR, KAB -II, Pusa,New Delhi	22-23.06.2018
Dr. Neelkanth Tiwari Minister of Law, Judiciary Information, Sports and Youth Welfare Government of Uttar Pradesh	01.09.2018
Shri Radha Mohan Singh Hon'ble Union Minister Agriculture and Farmer Welfare	01.09.2018
Prof Ramkali Sarraf Head, Department of Hindi, BHU	14.09.2018
Ms. A. Neerja Additional Secretary Department of Agril. Cooperation & Farmers Welfare	22.09.2018
Dr. Mangla Rai Former Secretary, DARE & Director General ICAR, New Delhi	28.09.2018
Dr. Anurag Kumar Head, Department of Hindi, Mahatma Gandhi Kashi Vidyapeeth	12.10.2018
Dr. Prasain Kumar Patasani Hon'able Member of Parliament (Lok Sabha)	23-25.02.2019
Shri Pradeep Tamta Hon'able Members of Parliament (Rajya Sabha)	23-25.02.2019

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ICAR-Indian Institute of Vegetable Research
Varanasi-221 305

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Post Bag 01, PO Jakhini (Shahanshahpur), Varanasi- 221 305 (Uttar Pradesh) INDIA
Tel : 0542-2635236 / 37 /47; Fax : 05443-229007
Website : www.iivr.org.in