




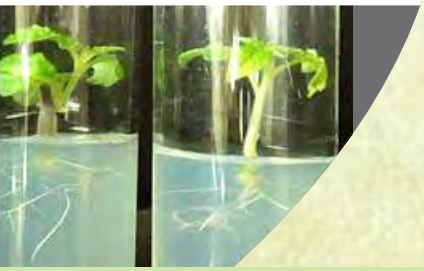

Annual Report

2015-16




भाकृअनुप
ICAR

ICAR-Indian Institute of Vegetable Research

(An ISO 9001: 2008 Certified Institute)

(Indian Council of Agricultural Research)

Varanasi -221 305

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Dr. Bijendra Singh
Director

Compilation and Editing
Core committee:
A.B. Rai, P.M. Singh, R.N. Prasad and Sunil Gupta

Sub committee:
Vegetable Improvement: Rajesh Kumar, Sudhakar Pandey, S.K. Tiwari and J.K. Ranjan
Vegetable Production: Neeraj Singh, Anant Bahadur and P.B. Chaukhande
Vegetable Protection: Jaydeep Halder, K.K. Pandey and A.N. Tripathi
AICRP (VC): Major Singh and T. Chaubey
Krishi Vigyan Kendras: A.K. Dubey, Rajendra Prasad and A.R. Kumari
Administration: S.K. Jindal and D.K. Agnihotri

ICAR-Indian Institute of Vegetable Research
Post Bag No. 1, P.O.- Jakhini (Shanshahpur)
Varanasi -221305, Uttar Pradesh, India
Phone: +91-5422635236; 37; 47
Fax:+91-5443-229007
Email: directoriivr@gmail.com

Printed at: Army Printing Press, 33 Nehru Road, Sadar Cantt., Lucknow Ph.: 0522-2481164, 6565333

PREFACE

Vegetables plays a crucial role in Indian agriculture as it is essential, not only to meet the food and nutritional security to the people and provide livelihood and income in the rural areas, but also to meet the export demand and requirement of raw material/inputs for the processing industries in the domestic front. The diversified climatic and soil characteristics have helped the country in producing various types of vegetable crops based on their suitability to the specific environment which gives the country an opportunity to produce a wide range of varieties of a particular vegetable crop with specific characteristics and taste. India is the second largest producer of vegetables in the world and the concerted efforts of vegetable research and emergence of corporate sector in vegetable seeds have contributed immensely in enhancing productivity and production of vegetables in our country but still there exists a gap of 10.1% in national productivity in comparison to global scenario. Further, 62.1% (18 out of 29 states) states in the country are having lower productivity in comparison to national productivity of vegetable (17.8 t/ha).

To bridge this gap, the concerted efforts have been made by the institute in the field of basic, strategic and applied research. The research and development activities of the institute are being carried out under its 6 mega programmes on Gene Management, Seed Enhancement, Productivity Enhancement through Better Resource Management, Plant Health Management, Post Harvest Management and Value Addition, Prioritization of R&D Needs and Impact Analysis of Technologies. These R&D programmes are strengthened by 27 externally funded projects running in the institute. The institute activities have also been strengthened in vegetable seed production and transfer of technologies with the efforts made by its Regional Station at Kushinagar and 3 KVKs at Bhadohi, Deoria and Kushinagar. Extension activities in 14 tribal villages of Sonbhadra under TSP, 7 Sansad Aadarsh Gaon, and 26 villages of Eastern Uttar Pradesh under the flagship programme of the Prime Minister of India, "Mera Gaon Mera Gaurav" will certainly help in joining the weaker section of society to the national stream for livelihood and nutritional security.

It's a great pleasure for me to bring out the Annual Report 2015-16 highlighting the significant achievements and activities made under research and extension front by the institute, AICRP (VC), Regional Station and KVKs.

I express my deep sense of gratitude and reverence to the Secretary, DARE & Director General, ICAR and DDG (Hort. Sci.), ICAR for their rigorous support, constant encouragement and guidance to meet the research and physical targets of the institute during 2015-16.

All the scientists, technicals administrative and other staffs of vegetable family are duly acknowledged for their untiring cooperation, coordination, compilation of information and finally bringing out this document.

Varanasi
June 24, 2016

(Bijendra Singh)
Director

Contents

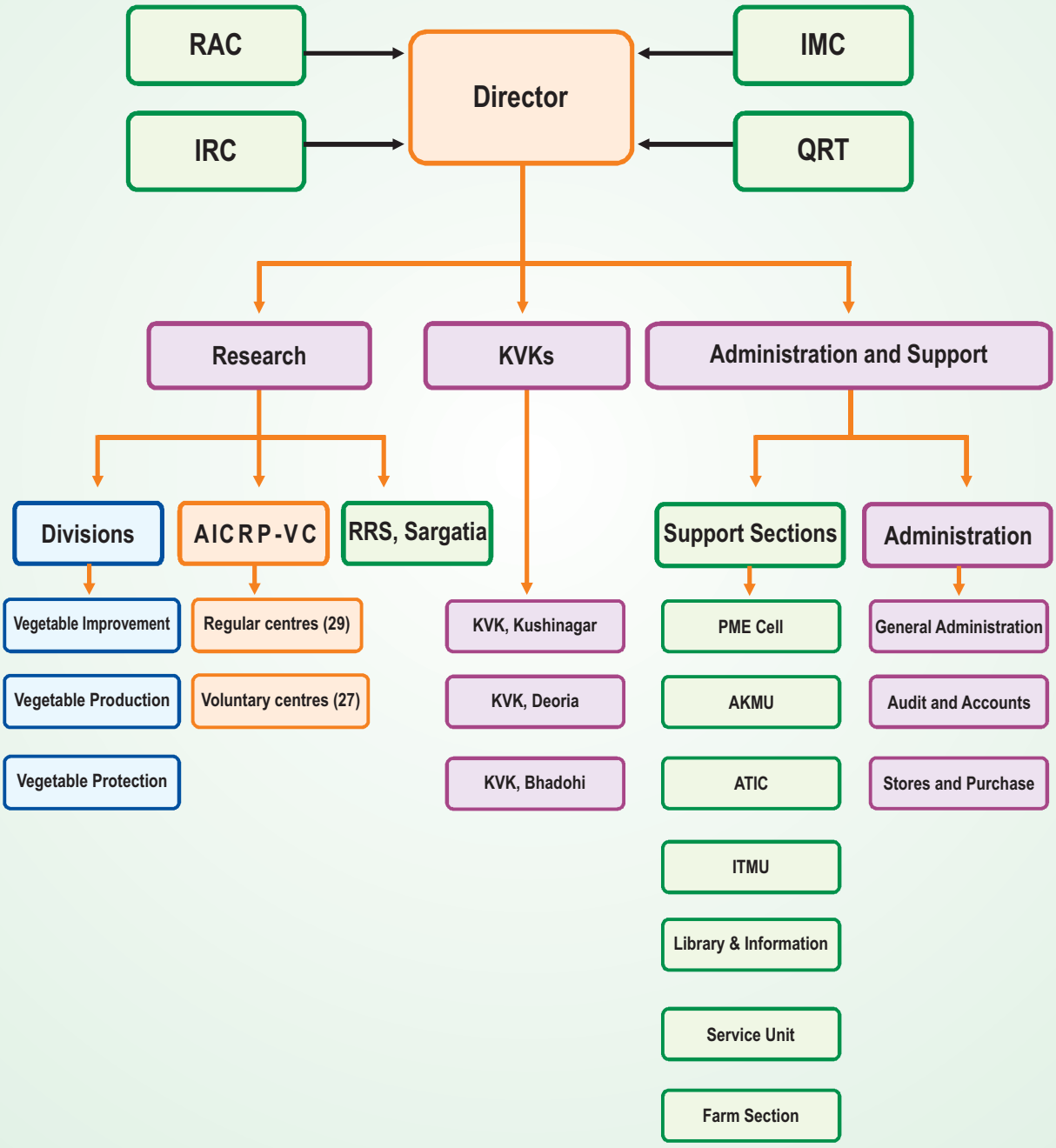
ABBREVIATIONS

a.i.	Active Ingredient
AAP	Access Acquisition Period
ABSP-II	Agricultural Biotechnology Support Project-II
ADOC	Additional Days Over Control
AICRP(VC)	All India Coordinated Research Project (Vegetable Crop)
AIR	All India Radio
ASR	Accumulated Survival Rate
ATIC	Agricultural Technology Information Centre
ATMA	Agricultural Technology Management Agency
AU	Astronomical unit
BCR	Breakpoint Cluster Region protein
BHI Broth	Brain Heart Infusion Broth
CD	Critical Difference
CFU	Colony forming unit
CH	Casein Hydrolysate
CISH	Central Institute for Subtropical Horticulture
CMS	Cytoplasmic Male Sterility
CRIDA	Central Research Institute for Dryland Agriculture
CTAB	Cetyl Trimethyl Ammonium Bromide
CUPRAC	Cupric Ion Reducing Antioxidant Capacity
CV	Coefficient of Variation
DAC ELISA	Direct Antigen Coating Enzyme Linked Immuno Sorbent Assay
DAI	Days After Inoculation
DAS	Days After Sowing
DAT	Days After Transplanting
DBM	Diamond Back Moth
DDG	Deputy Director General
DNA	Deoxyribonucleic acid
DPPH	Diphenyl Picryl Hydrazine
DS	Drought Stress
DSI	Drought Sensitivity Index
DUS	Distinctness Uniformity Stability
DW	Dry Weight
DYMV	Dolichos Yellow Mosaic Virus
EC	Emulsifiable Concentrate
ESFB	Early Shoot and Fruit Borer
FLD	Front Line Demonstration
FRAP	Ferric Reducing Antioxidant Property
FSB	Fruit and Shoot Borer
FW	Fresh Weight
GAE	Gallic Acid Equivalent

GDD	Growing Degree Days
GDP	Gross Domestic Product
GMS	Genetic Male Sterility
GMV	Golden Mosaic Virus
HCN	Hydrogen Cyanide
IAA	Indole Acetic Acid
IAP	Inoculation Access Period
IASRI	Indian Agricultural Statistic Research Institute
IC Numbers	Indigenous Collection Numbers
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
IISR	Indian Institute of Spices Research
IIVR	Indian Institute of Vegetable Research
IRM	Insecticide Resistance Management
ISSR	Inter Simple Sequence Repeat
ITS	Internal Transcribed Spacer
IVGRIS	IIVR Vegetable genetic Resource Information System
KVK	Krishi Vigyan Kendra
LC50	Lethal Concentration 50
MRS Broth	deMan, Rogosa and Sharpe Broth
MS	Murashige and Skoog
MTA	Material Transfer Agreement
NAIP	National Agricultural Innovation Project
NB	Nutrient Broth
NBPGR	National Bureau of Plant Genetic Resources
NGOs	Non-Governmental Organizations
NH	National Highway
NPTC	Network Project on Transgenic Crop
NUE	Nutrient Use Efficiency
OD	Optical Density
OFT	On Farm Trials
PCR	Polymerase Chain Reaction
PDI	Per cent Disease Index
PEG	Polyethylene Glycol
PLW	Physiological Loss in Weight
PPM	Parts Per Million
PPOC	Per cent Protection Over Control
PPP	Public Private Partenership
PSB	Phosphate Solubilizing Bacteria
QTL	Quantitative Trait Loci
R&D	Research and Development
RAPD	Random Amplified Polymorphic DNA
RBD	Randomized Block Design
RFLP	Restriction Fragment Length Polymorphism

RH	Relative Humidity
RILs	Recombinant Inbred Lines
RNA	Ribonucleic acid
ROS	Reactive Oxygen Species
SA	Sodium Alginate
SAARC	South Asian Association for Regional Cooperation
SC	Soluble Concentrate
SCAR	Sequence Characterized Amplified Region
SCoT Primers	Start Codon Targeted Primer
SDI	Sub-surface Drip Irrigation
SDS	Sodium Dodecyl Sulphate
SEM	Standard Error Mean
SNPs	Single Nucleotide Polymorphism
SPS	Single Plant Selection
SR	Survival Rate
SSDI	Sub Surface Drip Irrigation
SSR	Simple Sequence Repeat
TbCSV	Tobacco Curly Shoot Virus
TGT	Temperature Gradient Tunnel
TI	Tolerance Index
ToLCB	Tomato Leaf Curl Associated Beta satellite
ToLCuB	Tomato Leaf Curl Beta satellite
ToLCV	Tomato Leaf Curl Virus
TSS	Total Soluble Solids
USDA	United States Department of Agriculture
WG	Water Dispersible Granules
WUE	Water Use Efficiency
YVMV	Yellow Vein Mosaic Virus

ORGANOGRAM


RAC
IRC
Director
IMC
QRT
Research
KVKs
Administration and Support
Divisions
AICRP-VC
RRS, Sargatia
Support Sections
Administration
Vegetable Improvement
Vegetable Production
Vegetable Protection
Regular centres (29)
Voluntary centres (27)
KVK, Kushinagar
KVK, Deoria
KVK, Bhadohi
PME Cell
AKMU
ATIC
ITMU
Library & Information
Service Unit
Farm Section
General Administration
Audit and Accounts
Stores and Purchase

EXECUTIVE SUMMARY

The research, extension and development activities of ICAR-Indian Institute of Vegetable Research, Varanasi are being carried out under six Mega-programmes, namely (i) Integrated Gene Management (ii) Seed Enhancement in Vegetables (iii) Productivity Enhancement Through Better Resource Management (iv) Post Harvest Management and Value Addition (v) Prioritization of R&D Needs and Impact Analysis of Technologies Developed by IIVR (vi) Integrated Plant Health Management and 27 externally funded projects. In each Mega-programme numbers of sub projects have been formulated with specific objectives.

Under Management of Vegetable Genetic Resources Including Under-Utilized Crops, a total of 5027 accessions of 32 different major and minor vegetable crops were maintained and 395 new germplasm accessions in 16 vegetable crops were augmented. The institute has also maintained 215 accessions of 46 wild/related species in nine vegetable crops. Besides, 1718 accessions of germplasm from 18 vegetable crops and fungus cultures were supplied to 49 organizations for use in research and evaluations after signing of the Material Transfer Agreement (MTA). The ICAR-IIVR also became the first institute to have Low-Energy Seed Gene Bank facility in the country.

In solanaceous vegetables, 36 advance lines of tomato were evaluated for presence of *Ty2, Ty3* and RKN genes through PCR analysis using gene specific primers. Nine tomato F_1s containing *Mi 1.2* gene in heterozygous condition were also screened against *Meloidogyne incognita* at 2 J_2/ g of soil inoculum level. In an effort to combine resistance for ToLCV, RKN and late blight diseases, hybridity of the F_1s of last year was confirmed with the help of molecular markers and further crossing was done among the F_1s. In brinjal, eighty eight F_1 hybrids were evaluated for earliness, yield and quality traits. Hybrids (IVBHR-20, IVBHL-20) and advanced lines (IVBR-20, IVBL-24) of brinjal in long and round segment, respectively were found promising. Under distant hybridization programme in brinjal, back-crossing was done in 5 F_1s obtained using wild related species (*S. incanum, S. aethiopicum* and *S. undatum*). In chilli and capsicum, nine sets (A1 to A9) of cytoplasmic male sterile lines and two genetic male sterile lines (GMS-3 and MS-12) were maintained. Two distinct accessions in chilli, IIVRC-469 and EC-587152 were identified for their unique performance. In sweet pepper (capsicum), genotype VRCAP-1 was found to have deep purple fruit colour. A total of 150 F_1 hybrids were developed in chilli. Eight chilli hybrids along with four popular hybrids belonging to private companies were evaluated. The maximum yield was exhibited by the hybrid CCH-12 (195.6 q/ha) followed by CCH-2 (188.84 q/ha). Four hundred and eleven F_2 individual plants of the cross of Kashi Anmol × Japani Longi were screened for mite's tolerance.

Among leguminous vegetables, fourteen dwarf and bush type advance lines along with one national check (Kashi Kanchan) were evaluated during *kharif* 2015 and highest pod yield per plant was obtained from line 112-4 (352.6 g) followed by 96-4 (313.0 g). In pea, Among the early maturity group, three lines *viz.* VRPE-16 x VRPE-22, Arkel x Ageta and VRP-6 x VRPE-25 and among mid maturity group two lines *viz.* PC-531 x VRP-270 and PC-531 x DARL-404 were found promising. In French bean, a genotype VRFBB-91 was found promising with respect to earliness, short duration (75-80 days), pod quality and yield. In Indian bean, two advanced breeding materials VRBSEM-3 and VRBSEM-9 were evaluated along with four checks. The maximum number of pods/ plant and yield/ plant was recorded in line VRBSEM-3. On the basis of biochemical evaluation also the advanced line VRBSEM-3 was found better as it has high protein and phenol content coupled with high catalase activity and may show better adaptability under adverse condition (abiotic stress).

Among gourds, 10 bitter gourd hybrids were evaluated for various horticultural traits using Pusa Hybrid-2 as a check. Among them cross combinations VRBTG-3 x VRBTG-5 and VRBTG-21 x VRBTG-4-1 were found superior with 21% heterosis. In bottle gourd, seven cross combinations were developed. In long fruited segment, combination VRBG-5 x VRBG-1 expressed 23% heterosis. In round type combination, VRBG-7 x VRBG-20 expressed 25% heterosis. In sponge gourd, one open pollinated genotype namely, VRSG-195 and one hybrid VRSGH-3 were found promising. From the 48 developed F_1 hybrids of sponge gourd VRSG-57 × VRSG-195, VRSG-2-12 × VRSG-195, VRSG-

9 × VRSG-195, VRSG-91 × VRSG-214 and Phule Prajakta × VRSG-195 were found promising for various horticultural traits

Under Genetic Improvement of Melons, Pumpkins and Cucumber, an early and high yielding variety of long melon (VRSLM-16) developed through selection from local material at IIVR – Regional Research Station (RRS), Sargatia, Kushinagar has been identified by AICRP for release for Zone IV (Bihar, UP, Jharkhand and Punjab). The fruits of this variety are crispy, light green coloured and with smooth prominent ridges. It has yield potential of 400-450 q/ha. Among the advanced lines of cucumber, the best performing line was VRCU-Sel.-13-01. From five advanced breeding lines of pumpkin, the maximum yield per plant was observed in VRPK-230 (13.85 kg) followed by VRPK-01 (12.5 kg).

In okra, among 22 hybrids, VRO-6 x VRO-107 was earliest and took 41 days for 50% flowering. The line VRO-111 and VRO-112 were found promising with respect to resistance to YVMV and ELCV. While screening 1225 okra accessions for various agro-morphological traits, an accession, IC-117090 with unique trait of fruit with 9 ridges was identified.

In cauliflower, fifty-four genotypes, including 10 advanced lines, were evaluated to screen out the promising lines for September, October, November and mid-December maturity group. Among them, the genotypes VRCF-86 and VRCF-201 were the potential yielder in October maturity (22-32 °C); VRCF-50, VRCF-75, VRCF-37 and VRCF-102 in mid-November maturity (16-28 °C); and VRCF-2, VRCF-202, VRSCF-77 and VRCF-104 were found to be better in late-November to mid-December maturity group (11-22 °C).

Under Transgenic and Regeneration Protocols, for *Agrobacterium* mediated genetic transformation protocol for bitter gourd (*Momordica charantia*) were optimized. The factors which influenced genetic transformation and the overall gene transfer efficiency such as effect of explant age, different regimes of plant growth regulators, initial selection pressure, pre-culture period, *Agrobacterium* cell density in the inoculum and co-cultivation period were optimized. In order to determine the appropriate concentration of selection agent for effectively screening transformed shoots, leaf explants were cultured on CIM supplemented with different concentrations of kanamycin (25-100 mg/l). 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 technique for establishment of aseptic culture from nodal explants of seedless pointed gourd was refined and culture establishment has been achieved successfully.

Under Biotechnological Interventions for Improvement of Selected Vegetable Crops, marker assisted selection was employed to select *Ty-3* lines from different intraspecific crosses. Combination of marker assisted selection and pedigree selection was used to select 22 F_2 plants and F_3 families derived from each of the selected F_2 plants were grown. A total of 30 hybrids were also developed based on combination of *Ty-2* and *Ty-3* lines and these will be evaluated during both early and main tomato growing seasons. The parental lines used in the generation of these hybrids included previously developed *Ty-2* and *Ty-3* carrying lines. Embryo rescue for isolating *S. lycopersicum* X *S. arcanum* interspecific hybrid has been achieved. WRKY transcription factors specifically involved in plant growth regulation and stress response were also studied in tomato to identify their expression patterns during drought stress. Similarly, proline rich proteins involved in almost all plant processes showed their impact on plants under drought stress. SlPRP, a gene from tomato is being studied for its drought responsive properties. At the same time, keeping pace with world biotech research, the work on genome editing using most efficient CRISPR/Cas9 technology has been initiated recently for functional studies. The embryo rescued plants were tested for hybridity using morphological features and marker assay. DNA isolation protocol in okra genotypes have also been standardized.

Under Genetic Improvement of Underutilized Vegetables Including Vegetable Soybean, Leafy and Root Vegetables, seventeen advanced lines and fifty-one germplasm of tropical carrot for various root colour (red, orange, black, yellow and rainbow) were evaluated. The genotypes VRCAR-185, VRCAR-186, VRCAR-109, VRCAR-112, VRCAR-201 and VRCAR-117 (red coloured root); VRCAR-91-2 and VRCAR-91-1 (orange coloured root); VRCAR-107-2, VRCAR-171-1 and VRCAR-107-1 (rainbow-type: purple-red coloured root); VRCAR-124, VRCAR-126 and VRCAR-89-1 (black coloured root); and VRCAR-178, VRCAR-153 and VRCAR-127 (yellow coloured root) were found to be potential root yielder along with better quality

traits. In radish, eight genotypes were found to be good yielder (>120 g root weight) along with better quality traits (uniform root shape, smooth root and fewer secondary roots) such as VRRAD-150 (white exterior); VRRAD-143, VRRAD-131-2 and VRRAD-160 (red exterior); VRRAD-130 (red exterior and red xylem); VRRAD-131, VRRAD-130-2 and VRRAD-135 (purple exterior); and VRRAD-151 (purple exterior and purple xylem) which have been advanced for next generation. With respect to genetic emasculation in radish, populations have been advanced to BC_3F_1 and BC_2F_1 stages in various backgrounds (leaf morphology, root shape and colour) through back-cross for transferring male sterility CMS system in radish. Two genotypes of bathua, namely VRCHE-2 (green leaves and stem) and VRCHE-4 (purplish-green leaves and stem) have been found promising and harvested leaf yield potential was 350 q/ha and 400 q/ha, respectively in six pickings. Biochemical traits were estimated in 38 genotypes of basella. Wide range of variation was observed for total carotenoids (0.41-1.55 mg/g fresh wt), total phenol (77.33-285.67 GAE/100g) and antioxidant activity measured through CUPRAC (4.97-24.74µmol TE/g). Two basella genotypes VRB-17 and VRB-11 were found promising in terms of yield and nutritional quality. In addition, two unique genotypes were also identified viz., late flowering basella: IC561377 and basella with snowwhite flower (EC769321-1). DNA isolation has been completed in 40 basella genotypes for PCR amplification. For molecular diversity analysis, 30 arbitrary ISSR primers were screened which produced 86 fragments with an overall average polymorphism of 59.55 %. A genotype of tropical kale (VRKALE-1) has been identified at ICAR-IIVR, Varanasi which induces bolting and flowering, sets seeds in the North Indian plain and does not require any vernalization for bolting.

Under Seed Enhancement in Vegetables, the overall seed production programme (Breeder+TL) was undertaken in 29 varieties of 17 vegetable crops. The breeder seed production was undertaken for 21 varieties in 10 different vegetable crops viz tomato, brinjal, chilli, cowpea, peas, pumpkin, bottle gourd, ash gourd, okra and radish. A total of 835 kg breeder seeds were produced against the targeted National indents of 773.50 kg from Deputy Commissioner (Seeds). In addition to National indent, 1739 kg breeder seeds of different varieties of IIVR were also produced. Under pollen storability studies, the better pollen viability was maintained at -20 °C in all the three crops up to 6 months. Diurnal activity of different insect fauna was also observed during the summer months to know about activity of different pollinators, the dominant pollinator and the time of maximum activity of the pollinators in sponge gourd. The observations indicate that the maximum pollinators activity was recorded during 6-10 AM. Pollinators included honey bees, bumble bees, carpenter bees, solitary bees, hoverflies, beetles, butterflies and moths. The dominant honey bee species was *Apis florea*. The preliminary results on increasing pollination efficiency showed that maximum seed yield per plant was obtained form 10% Jaggery (134.77 g seed/plant) followed by 10% sugar solution (89.92 g seed/plant) in bottle gourd. The okra seeds primed with osmotica for 24h showed better germination, seedling length and vigour index. For polymer coating, four concentrations each of four chemicals viz. PEG (Poly Ethylene Glycol), PVCR (Poly Vinyl Chloride Resin), PVA (Poly Vinyl Acetate) and PVP K-30 (Poly Vinyl Pyrodidone) along with a control were tried on brinjal seeds.

In Vegetable Production Trials, among 46 different combinatuion of potting medium, a mixture comprised of coco peat and rice husk was found most suitable for raising of tomato seedling under low tunnel poly house. In an experiment on the growing of vegetables under protected condition, maximum yield was observed in the indeterminate hybrid tomato 'Tolstoi' under poly house condition. Similarly among four different cultivars of capsicum, hybrid Swarna was found to be better cultivar for higher yield under low cost protected structure. In precision farming trial, the performance of cowpea and okra were observed for the effect of sowing date on yield. It has observed that cowpea sown on 25thMarch, okra sown on 24th July have produced maximum biomass and yield. In another experiment effect on nitrogen doses were evaluated on tomato cultivar Kashi Aman, and it was observed that application of nitrogen at the rate of 160 kg N/ha resulted maximum fruit yield (641.8 q/ha).

In organic farming trial, use of three organic manures *viz*. FYM, Vermicompost and NADEP compost have significantly enhanced the brinjal yield. In case of pea, the combined use of FYM and NADEP compost recorded 25.37 to 37.51% higher pod yield over inorganic control. However in cabbage, the head yield did not varied significantly with application of organic manures. In all cases, application of organic

manures also influenced the nutritional quality, soil organic carbons and soil microbial activities significantly. In conservation tillage, the zero tillage with residue retention technology has been found very profitable in cowpea and pea production as for as input conservation, yield and energy savings was concerned. In another study, it was reported that conventional tillage increased the yield of cabbage, while it was *at par* to conservation tillage in chilli and cowpea. The highest productivity in terms of rice equivalent yield (REY) was observed in cowpea-cabbage-cowpea cropping sequence.

In an experiment on enhancing water and nutrient use efficiency, several trials related to fertigation, mulching, integrated nutrient management, *etc* were conducted. Drip irrigation in tomato with K-fertigation at 80 kg K_2O/ha resulted the maximum fruit yields (58.17 tones/ha) with 70% higher yield over conventional fertilization, however the maximum nutrient use efficiency (98.5 kg yield/ kg K_2O) was reported with fertigation of K @ 60 kg/ha. In hybrid chilli, the maximum fruit yield of 110.6 and 105.63 q/ha, respectively were reported through 100% NPK fertigation with water soluble fertilizers (WSF) or 75% fertigation with WSF and rest 25% as soil application. In okra, drip irrigation daily at 100% PE coupled with black-silver polyethylene mulching registered maximum fruit yields (87.55 q/ha). INM study in bottle gourd revealed that maximum fruit production was achieved with soil application of FYM 12.5 t/ha + ½ recommended N from inorganic fertilizers. In broccoli, although different micronutrients sprays significantly enhanced the growth and yields, three foliar sprays of boron at 50 ppm registered 67.8% higher yield over recommended doses of NPK. In a study on performance of tomato and cucumber under subsurface drip irrigation with varying level of water application from 50% ET to 100% ET responded positively. Cucumber yield obtained under 100% ET was 1.38 times higher than that of conventional furrow irrigation method. The yield declined faster with decreasing amount of water from 100% ET to 50% ET. Cucumber yield obtained at 50% ET (9.85 t/ha) was one third of that with 100% ET (27.5 t/ha).

In Shelf Life Enhancement Project, shellac based edible coating was standardized and used for coating of capsicum to enhance its shelf life and retain quality. Coating was found to be effective for retention of green color, firm texture and ascorbic acid during storage under both ambient and refrigerated condition. In another project, nutraceutical composition were evaluated in bitter gourd genotype and microgreens from leafy vegetables and legumes. Some of the promising lines of bitter gourd having high antioxidant potential were IC-588072, IC-68238, IC-8565-1B, IC-4459 VRBTG-3 and VRBTG-15. Legume microgreens were found to be higher sources for phenolics antioxidants compare to their seed and geminated seed. In project 'A total value chain on commercialization of value added convenience vegetable products' two new processed products were formulated *viz.* instant protein rich corn soup mix and protein rich moringa soup mix. In network project on phytochemicals/ high value compounds, black carrot anthocyanins were purified using polymeric resin. Purified anthocyanins were characterized using high resolution mass spectrophotometry. In addition to this, *in vitro* antioxidants and antidiabetic potentiality of black carrot were evaluated.

In a survey among the farmers about the pesticide use, paired mean differences were calculated to identify the gap between knowledge and actual practice in chemical usage. Maximum differences were found in case of usage of proper nozzles in spray for self-protection measures. Constraints faced by the growers in vegetable production were studied among 1179 farm respondents through focus group discussions and results were classified under 4 broad heads *viz.*, social, technological, economic and organizational constraints. Under TSP project, more than 100 demonstrations of pea cv. Kashi Udai, 1000 demonstrations of wheat cv HUW 234 and 450 demonstrations of each urd cv. T-9, pigeon pea cv. Malviya Chamatkar and sesamum cv. Shekhar were conducted in the area of 250 ha in tribal region at Chopan block of Sonbhadra district. It has been observed that a significant increase in yield over traditional cultivars. Under Mera Gaon Mera Gaurav Programme, Institute has adopted 25 villages in Varanasi, Mirzapur, Chandauli, Jaunpur, Gazipur and Mau Districts where various programme like farmers' interaction programme, demonstrations of improved vegetable varieties coupled with production technologies were conducted at 2400 farmers' field in more than 200 ha area. Institute also conducted training/kisan gosthi and demonstrations of developed vegetable technologies in adopted Sansad Aadarsh Gaon in Varanasi, Mirzapur, Chandauli,

Jaunpur, Gazipur and Mau districts of Uttar Pradesh and East Champaran in Bihar including Prime Minister Aadarsh Gaon, Jayapur in Varanasi and Union Minister of Agriculture & Farmers' Welfare Aadarsh Gaon Kharimal in East Champaran (Bihar). Considering the importance of nutritional security, 5000 kitchen garden packets containing seeds of tomato, brinjal, chilli, cowpea, dolicous bean, sponge gourd, okra and bottle gourd were provided to 5000 farm households in 46 adopted villages of U.P. and Bihar including 1000 tribal households in Sonbhadra.

Under Integrated Plant Health Management, integrated module comprising spray of azadiractin, rynaxpyr, novaluron, emamectin benzoate at 10-15 days interval, was most effective with 88.43% reduction in diamondback moth with 69.64 % increase in yield and B:C ratio (1:8.68) in cabbage.

Under toxicological investigation, rotational strategy-I with spray of flupyridifuron followed by flonicamid and cyantarniliprole and rotational strategy-II comprising flonicamid followed by cyantarniliprole and flupyridifuron were effective in reducing leafhopper and whitefly. Native PAGE analysis of leafhoppers showed less expression of esterase enzymes in flupyridifurone, flonicamid and rotational strategy-I, indicating their effectiveness. Insecticide *viz*., cyzapyre, flonicamid and spiromesifen were harmless (< 30% mortality) to predatory rove beetle. In okra, among different doses, flonicamid 50WG at 0.4g/l was most effective against leafhoppers and whitefly population and its residues dissipated to below the MRL of 0.01 mg kg^{-1} on the same day. Flupyridifurone, cyantraniliprole, sulfoxaflor, flonicamid and spirotetramat were highly effective against whitefly 78.89, 87.92, 96.30 and 100% mortality, respectively compared to neonicotinoid and conventional insecticides. Based on the LC50 values, the descending order of insecticide toxicity against okra leafhopper was imidacloprid 17.8 SL > imidacloprid 30.5 SC > imidacloprid 70 WG > thiamethoxam > dimethoate > acetamiprid > chorpyriphos > quinolphos. The relative resistance for okra leafhopper development of 1.85, 8.63 and 1.0 fold resistance to imidacloprid, thiamethoxam and dimethoate, respectively

Under biological control, promising natural enemies like *Aenasius arizonensis* from invasive mealy bug, *Phenacoccus solenopsis* infesting brinjal, tomato, okra, pointed gourd, chillies, *Dinarmus basalis* as solitary, larval-pupal ecto-parasitoid of *Callosobruchus chinensis* infesting pea were recorded. Another larval endoparasitoid *Microplitis tuberculifer* was recovered from *Spodoptera litura* infesting cauliflower during Oct-Nov. Among different EPF tested alone and in 1:1 ratio with neem oil against *Bagrada hilaris*, *Lecanicillium lecanii* @5 g/l, had lowest median lethal time (LT_{50}) of 103.72 hour. *L. lecanii* + Neem oil (1:1) took still lower time (50.37 hr) showing compatibility and synergistic action. Strong host-mediated variation was recorded towards the effects of *L. lecanii* alone and in 1:1 combination with neemoil against *P. solenopsis*. Lowest LT_{50} value was noted for *L. lecanii* when *P. solenopsis* fed on okra and ascending order of median lethal time was Okra > Pointed gourd > Tomato > Chilli > Cotton > Eggplant > Cucumber > Parthenium. Among imidacloprid, thaimethoxam in combination with EPF at half of their recommended doses against *L. erysimi* indicated Imidacloprid + *L. lecanii* to be effective with lowest LT_{50} value of 24.31 hr and highest co-toxicity coefficient value (1.39). Among EPF combined seperately with neem oil at 1:1 ratio, *L. lecanii* + neem oil showed compatibility and synergistic action against melon weevil as evidenced by the lowest median lethal time 63.78 h. The conidial suspension of *Isaria farinosa* (1×10^8 conidia/ml) was highly effective against mealybug with 81.14% mortality after 96h and equally effective as imidacloprid and chlorpyriphos. It (1×10^8 conidia ml^{-1}) also caused 49.31% mortality of binjal shoot and fruit borer after 48h which was 84.95 and 23.78% higher than cypermethrin and chlorpyriphos, respectively.

Among 55 brinjal varieties/lines and 17 wild *Solanum* spp. screened against little leaf (Phytoplasma), the variety 'Uttara' including 17 wild lines were found completely immune. The Varanasi eggplant phytoplasma shared maximum sequence identity with 16SrRNA sequence of the eggplant little leaf (EF186820, AF228052, X83431) belong to the 16SrVI clover proliferation group.

Incidence of gummy stem blight disease on bottle gourd was recorded 55%. Among 38 varieties/ germplasms lines screened against late blight of tomato, two line VRT-265 and VRT-808 were moderately resistant under challenge inoculation condition. PCR analysis (based on polygalacturonase gene) of twenty isolates of FOL collected from tomato across the country indicated the prevalence of race-I.

In silico analysis of potential *Trichoderma* strain revealed 100% similarity to *Trichoderma asperellum* (Accession No. KT824429). *In vitro* study, it showed inhibition values of 43.57, 38.16, 42.56 and 54.87% for *Pythium aphanidermatum*, *P. debaryanum*, *Sclerotium rolfsii* Sr1 and *S. rolfsii* Sr3, respectively. It also showed 100% compatibility with mancozeb, azoxystrobin, cymoxanil+mancozeb, metalxyl+mancozeb at 100, 200 and 300 ppm, while 98.15, 74.82 and 50.38% compatible with carbendazim. *Trichoderma* isolate (Phyto-6) showed 88% reduction of *Fusarium* wilt as against 33.1% in control. Among talc based formulations of promising bacterial isolates, CRB-7 proved effective against *S. rolfsii* (80.95% reduction). The isolates TRB-4 and CRB-18 utilized maximum of 15 substrates were promising in terms of adaptability.

Incidence of tospovirus was recorded to 46% on brinjal and 21% on tomato. Out of 20 samples of bitter gourd, sponge gourd, *Parthenium* and wild cucumber tested, most of the samples were infected with bipartite begomovirus, three samples associated with both α- and β-satellite; three samples associate α-satellite and only one sample associated with β-satellite.

The root knot nematode (RKN) population was maximum during October (2.8 J_2/g of soil) followed by April and November (2.6) and minimum population in July and January (1.0 J_2/g of soil). The minimum population was on cowpea at 198 nematodes/200 g of soil and maximum population was in pointed gourd at 496 nematodes/200g of soil. It was present at above ETL in all the crops except cowpea. *In-vitro* efficacy of rhizobacteria revealed that CRB7 recorded highest mortality (83.3%). Among different bio-control agents tested at 0.5% and 1% under pot condition in tomato, there was reduction in the number of galls, soil population and reproductive factor compared to inoculated control. An application of carbofuran @ 1 kg a.i/ha+ carbendazim @ 0.25%+ TRB4 @1% + CRB2 @ 1% significantly reduced soil population (28%), gall (64.5%) and collar rot disease and increased yield by 77.5% in tomato.

Under dynamics of pests, a large fluctuation of *Leucinodes orbonalis* in brinjal was observed with highest peak during October 1st week. Weekly recording of fruit fly incidence of cucurbits revealed its peak during November 1st week of followed by October 3rd week. Its activity was less during rainy months and winter season. Trap catches of *Spodoptera* was higher during 15-17, 21 and 42 standard weeks indicating its major activity during April-May and October. In the case of *Helicoverpa,* it reached two peaks, one during 15 and second in 39 standard week with maximum trap catch of 29 and 35/trap, respectively.

Research Achievements

Division of Vegetable Improvement

MEGA PROGRAMME 1: INTEGRATED GENE MANAGEMENT

Programme Leader: Major Singh/P.M. Singh

Project 1.1: Management of Vegetable Genetic Resources Including Under-Utilized Crops

Status of vegetable germplasm: A total of 5027 accessions of 32 different major and minor vegetable crops were maintained at ICAR-IIVR, Varanasi during 2015-16. These include brinjal (370), tomato (1014), chilli (335), capsicum (16), french bean (214), cowpea (362), pea (506), Indian bean (129), okra (498), cauliflower (85), pointed gourd (131), muskmelon (150), fenugreek (21), sponge gourd (79), basella (52), amaranth (150), chenopod (5), quinoa (1), pumpkin (90), ash gourd (60), cucumber (110), bitter gourd (68), bottle gourd (55), radish (105), carrot (96), watermelon (59), round melon (20), long melon (33), vegetable soybean (17), snake gourd (7), ridge gourd (102) and broad bean (30). Beside this one each in tropical kale and tropical cabbage are also being maintained.

Three hundred ninety five new germplasm accessions in 16 vegetable crops which include 64 in brinjal, 102 in tomato, 11 each in chilli and pointed gourd , 3 each in cowpea and radish, 8 in pea, 12 in okra, 2 each in cauliflower and carrot, 4 in sponge gourd, 48 in basella, 110 in amaranths, 1 in quinoa, 10 in bitter gourd and 4 in bottle gourd were also augmented. The institute has also maintained 215 accessions of 46 wild/related species in nine vegetable crops (Table 1).

Table 1: Wild accessions maintained at institute

Crop	Wild/related species
Brinjal	24 [(*S. undatum* (1), *S. ferox* (1), *S. sisymbrifolium* (1), *S. æthiopicum* (4), *S. macrocarpum* (1), *S. lasiocarpum* (1), *S. anguivi* (1), *S. villosum* (1), *S. viarum* (1), *S. xanthocarpum* (1), *S. nigrum* (2), *S. gilo* (3), *S. khasianum* (2) *Solanum torvum* (1), *S. incanum* (3)]
Tomato	10 [*Solanum neorockii* (2), *S. arcanum* (1), *S. pimpinellifolium (EC-520078)* (1), *S. habrochaites* (EC-520061) (1), WIR 3928 and WIR *3957*, *S. peruvianum* (1), *S. hirsutum* (1), *S. gladossum* (1)]
Chilli	9 [(*C. praetermissum* (1), *C. baccatum* (4), *C. chacoense* (3), *C. chinense* (2), *C. eximinum* (2), *C. tovarii* (1), *C. frutescens* (8), *C. galapagoense* (1), Natural interspecific derivatives (4)]
French bean	12 [*P. lunatus* (9), *P. coccineus* (2), *P. acutifolius* (1)]
Okra	107 [*A. mannihot* (63), *A. moschatus* (24), *A. tuberculatus* (13), *A. angulosus* (01), *A. tetraphyllus* (02), *Hibiscus cannabinus* (03), *A. calli* (01)]
Cucumber	48 accessions of *Cucumis hardwickii*
Bitter gourd	1
Bottle gourd	1 (bitter in nature)
Radish	1 [*Raphanus sativus* var. *caudatus*]

Characterization and screening of germplasm

Chilli and Capsicum: Three hundred thirty seven accessions of chillies which included 307 cultivated lines and 30 wild accessions/interspecific derivatives, nine sets of cytoplasmic genetic male sterile lines, two genetic male sterile lines (GMS-3 and MS-12) were maintained during 2015-16 through selfing under nylon bags/cages/muslin cloth bag with rings. The cytoplasmic male sterile lines were maintained by crossing them with respective maintainer lines. The seeds of released varieties, parental lines of the hybrids and some elite lines were enhanced through self pollination. Nine accessions of chillies were collected (Figure 1) and genotype BS-2015-1 was found to be tolerant to LCV. Sixteen accessions of capsicum (Figure 2) were maintained and utilized in breeding programme.

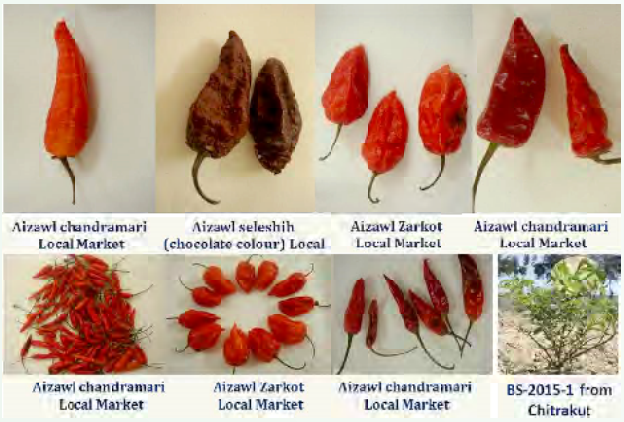


Fig. 1: Germplasm augmented in chilli 2015-16

Fig. 2: Capsicum germplasm maintained at IIVR

Pea: A total of 380 accessions of pea were grown and maintained during the year 2015-16. Eight accessions *viz*. IC395309, IC0218988, IC296677, IC208366, IC279125, IC397028, IC208378 and IC296678 were augmented from NBPGR, New Delhi. These were evaluated for different morphological traits (Table 2).

Table 2 : Performance of augmented pea germplasm lines for yield and related traits

Genotypes	50% flowe-ring (days)	Pod length (cm)	Pod width (cm)	Pods/ plant	Seeds/ pod	Yield/ plant (g)
IC 395309	71	6.26	1.28	10.29	6.6	62.0
IC 218988	59	6.98	1.25	24.50	6.67	105.0
IC 296677	76	7.15	1.21	19.20	4.83	70.0
IC 208366	53	7.30	1.32	27.0	6.0	178.0
IC 279125	53	7.75	1.62	25.0	4.0	90.0
IC 397028	62	6.22	1.08	22.67	5.4	56.0
IC 208378	70	6.24	1.1	26.67	4.6	73.0
IC 296678	76	7.5	1.1	15.0	4.8	60

Identification of a five podded pea genotype: A unique five podded plant (Figure 3a) was indentified from a segregating population in F_4 generation. The plants had 12 pods with average pod length of 7.20 cm and width of 0.95 cm. The triple and tetra-podded plants (Figure 3b) were also recovered from the same segregating population.

Fig. 3a: Plant bearing five pods

Fig. 3b: Plant bearing triple and four pods

Cowpea: Three new cowpea genotypes were collected and evaluated during *kharif* 2015 (Table 3). Genotype LC-07-15 took minimum days to 50% flower (43.7 DAS). Genotypes LC-07-15 and Ujjain AC exhibited pole type growth habit while Almora LC was bushy. The maximum number of branches per plant was recorded in genotype Almora AC (4.6) followed by Ujjain AC (4.1). The longest peduncle was found in genotype Ujjain AC (36.8 cm). However, the maximum number of peduncles (15.5) and pods (23.2) per plant was obtained from Ujjain AC followed by Almora LC. Similarly, longest and heaviest pod was obtained from genotype LC-07-15 (46.6 cm and 13.8 g) followed by Ujjain AC (37.7 cm and 9.8 g). The maximum number of seeds per pod was recorded in genotype Ujjain AC (16.3) followed by LC-07-15 (11.2). The highest pod yield per plant was obtained from genotype LC-07-15 (246.8 g) followed by Ujjain AC (231.9 g). The pod quality with regard to colour, pulpiness and parchment free pod was better in genotype LC-07-15. The seed-coat colour of genotypes LC-07-15 and Ujjain AC was red while Almora LC was cream. Genotype Almora LC showed resistance to cowpea golden mosaic virus under field condition.

Table 3 : Performance of cowpea genotypes during *kharif* 2015

Characters	LC-07-15	Almora LC	Ujjain AC
Days to 50% flower (DAS)	43.7	48.5	55.3
Plant height (cm)	198.2	57.8	248.5
Branches plant^{-1} (No)	3.8	4.6	4.1
Peduncle length (cm)	22.2	21.1	36.8
Peduncles plant^{-1} (No)	11.3	13.8	15.5
Pods plant^{-1} (No)	17.6	21.2	23.2
Pod length (cm)	46.6	9.2	37.7
Pod weight (g)	13.8	3.6	9.8
Seeds pod^{-1} (No)	11.2	9.5	16.3
Pod yield (g plant^{-1})	246.8	79.6	231.9
Pod colour	Dark green	Dark green	Green
Seed colour	Red	Cream	Red
Pulpiness	High	Less	Medium
Parchment	Absent	Present	Absent
Reaction to CGMV	HS	R	HS
Reaction to *Cercospora*	HS	MS	HS

French bean: The genotypes of *Phaseolus vulgaris* are categorized in to various groups on the basis of plant growth habit (bush type and pole type), colour of standard (white, pinkish-white, pink and violet), pod shape (round, semi-round and flat) and uses (vegetable type and dry seed type). Among bush type, the genotypes belonging to vegetable types found to be promising were VRFBB-2, VRFBB-91, VRFBB-95, FMGC6V-1129, FMGC6V-1176, Giolli, Paulista and Riveragro.

Seven advanced lines and 32 germplasm of bushy growth habit were evaluated under field conditions. Among them, eleven genotypes (VRFBB-2, VRFBB-67, VRFBB-91, VRFBB-95, VRFBB-98, FMGC6V-1129, FMGC6V-1176, FORC6V-1136, Giolli, Paulista and Riveragro) belong to vegetable types were found to be potential yielder along with good quality pod traits (cylindrical pods, slow seed development, tender and bright colour).

Dolichos bean: A total of 45 pole type germplasm were maintained, documented and evaluated for early, high yield and good pod quality (Table 4).

Table 4. Promising genotypes of Dolichus bean

Traits	Promising accessions
Early and high yield	VRSEM-201, VRSEM-117, VRSEM-51, VRSEM-953
Green with purple line	VRSEM-45, VRSEM-223, VRSEM-201
White	VRSEM-601, VRSEM-808, VRSEM-100 VRSEM-934
Green	VRSEM-755, VRSEM-37, VRSEM-948, VRSEM-757

Okra: A total of 1225 germplasm as received from NBPGR, New Delhi were evaluated for disease resistance. Genotypes IC-117088, IC-117245 and IC-117333 had 7 ridges while IC-117090 had 9 ridges. Eight genotypes *viz*. IC024904-A, IC117027, IC117247, IC117321, IC117336, EC169408, EC169419, and IC 033206 were found free from YVMV and OELCV under field conditions.

Cauliflower: Fifty-four genotypes on cauliflower were evaluated to screen out the promising lines in different maturity group. The genotypes are categorized in to various groups based on maturity group (September, October, November and December), plant growth habit (spreading, semi-spreading and erect leaf), stalk length (short, medium and long), frame size (small, medium and large), curd shape (flat, round and pointed), curd colour (yellow, cream, white and snow-white), curd compactness (loose, medium compact and compact), and presence/absence of curd disorders *i.e.* riceyness and leafiness. Among them, the genotypes VRCF-86 and VRCF-201 were the potential yielder in October maturity (22-32 °C); VRCF-50, VRCF-37 and VRCF-102 in mid-November maturity (16-28 °C); and VRCF-2, VRCF-202 and VRSCF-77 were found to be better in late-November to mid-December maturity group (11-22 °C). Additionally, one genotype each of tropical kale (VRKALE-1) and tropical cabbage (VRCAB-101) was evaluated for various traits of economic importance.

Cucumber: A total of 52 germplasm of cucumber were evaluated for flowering, yield and related traits. The results indicated that the number of days required for anthesis of first female flower ranged from 37 (VRCU-3) to 53 (VRCU-26) and number of days required for anthesis of 50% female flower ranged from 36 (VRCU-5) to 55 (CH-122). The average fruit weight for 52 genotypes ranged from 75 (VRCU-12-18) to 215 g (VRCU-14-3). Yield per plant ranged from 610.20 (VRCU-3) to 1137.28 (VRCU-14-3) with a general mean value of 627.42 g.

Evaluation of wild cucumber (*Cucumis hardwickkii*): Eight accessions of wild cucumber were evaluated for flowering and fruit traits during rainy season 2015 (Table 5). In accession IC-248263, first female flower appears on 8th node. The average fruit weight was ranged from 30g (IC-248263) to 145g (IC-248339). Fruit shape of evaluated accession was round oval to oval.

Table 5: Horticultural parameters of wild cucumber

Accession No.	Node on first female flower	Inter nodal (cm)	Vine length (cm)	Polar circum. (cm)	Equat-orial circum. (cm)	Fruit weight (g)	Fruit shape
IC-248151	24	6.15	192.5	11.75	9.75	20.0	Round oval
IC-248339	15	7.68	347.5	30.00	19.00	145.0	Oval
IC-256248	16	6.57	170.6	14.50	6.59	40.0	Oval
IC-469591	23	4.08	160.0	15.00	7.58	40.0	Oval
IC-248263	8	14.03	160.0	14.15	6.25	30.0	Round oval
IC-248275	16	8.80	400.0	15.15	13.55	42.5	Round oval
VRCHW-13-04	24	9.66	300.0	16.25	8.57	35.0	Oval
VRCHW-13-06	20	12.00	320.0	19.00	15.00	57.5	Round oval

Pumpkin: Eighty germplasm were evaluated for yield and quality attributes. A total of 107 lines including identified/released varieties were maintained as active collections. Variability for different characteristics was observed in evaluated lines. The evaluated lines were grouped based on the rind colour and shape of the fruits. Fruit yield ranged from 2.14 kg per plant (VRPK-15-07) to 11.39 kg/plant (VRPK-15.03. Number of fruits per plant varied from 2.5 (VRPK-80) to 3.25 (VRPK-15-04). Individual fruit weight ranged from 1.45 kg (VRPK-101) to 8.56 kg (VRPK-220-4) at mature stage. All the lines have been maintained through selfing / sibbing for their further utilization. The seeds of above germplasm were increased through selfing and sibing.

Bitter gourd: Among 10 new collections (five green and five light creamy fruit bearing types) made during the year (Table 6 & 7), VRBTG-12 (green type) and VRBTG-42 (light creamy white type) were selected for yield and earliness. One hundred and fifty lines were received from NBPGR, New Delhi but only seven germinated, characterized and seed multiplied.

Table 6: Evaluation of green fruited collections of bitter gourd

Types of fruit	Genotypes	Fruit length (cm)	Yield/ plant (g)	Number of fruits	Vine length (cm)
Small	VRBTG-3	10.0	765	17	229
Medium	VRBTG-4	12.50	585	13	319
Long	VRBTG-6	14.25	750	15	300
	VRBTG-8	28.50	1170	15	486
	VRBTG-12	35.0	2500	15	486

Table 7: Evaluation of light cream coloured bitter gourd genotypes

Types	Genotypes	Fruit length (cm)	Yield/ plant (g)	Number of fruits	Vine length (cm)
Small	VRBTG-21	9.0	857	23	219
Medium	VRBTG-84	11.50	659	15	321
Long	VRBTG-96	17.25	1000	18	302
	VRBTG-57	21.50	1285	12	429
	VRBTG-42	25.0	2500	13	399

Bottle gourd: Total 33 genotypes including 10 new collections were evaluated (Table 8) and VRBG-61 was selected considering earliness, better fruit size and high yield.

Table 8: Evaluation of new collections of bottle gourd

Genotypes	Source	Fruit shape	Fruit length (cm)	Fruit circum. (cm)	Fruit weight (g)	Yield/ pl (kg)
VRBG-15-1	Rajasthan	Long	36.5	27.0	925	4.12
VRBG-15-2	Rajasthan	Round	20.3	39.0	800	3.69
VRBG-4-1	Mirzapur	Round	15.0	36.0	875	4.00
VRBG-9-1	Mirzapur	Round	20.4	43.0	1050	5.68
VRBG-61-3	Varanasi	Oblong	15.0	38.0	725	5.24
VRBG-11-1	Sonbhadra	Round	23.6	37.0	875	3.56
VRBG-47-2	Jaunpur	Oblong	30.0	35.0	975	3.99
VRBG-71	Mirzapur	Round	19.5	29.0	650	2.87
VRBG-19	Chandauli	Round	20.7	41.0	800	3.41
VRBG-61	Varanasi	Mediu m long	27.1	28.0	900	5.54
Kashi Ganga (C)	IIVR	Long	33.0	18.1	625.5	6.25
Pusa Santusthi (C)	IARI	Long	37.2	26.0	950.0	5.69

Pointed gourd: During the year, triple fruit bearing pointed gourd unique line 'VRPG-15-11' collected and being multiplied. On the basis of yield performance VRPG-103 and VRPG-21 were selected for further validation.

Sponge gourd: Out of 79 germplasm, 10 lines viz VRSG-3-13, VRSG-185, VRSG-19, VRSG-73, VRSG-2-14, VRSG-6-13, VRSG-40, VRSG-108, VRSG-63 and VRSG-136 (Table 9) were found promising for horticultural traits and were free from viral disease symptoms under field conditions.

Watermelon: Forty five accessions including identified/released varieties were maintained as active collections and multiplied. Eight germplasm of watermelon were collected from Uttar Pradesh, Rajasthan and Karnataka and are being multiplied for evaluation and further use in breeding programme.

A unique mutant germplasm VRW-50 was found with non-lobed leaves, which can be potentially used as morphological marker in advanced breeding programme. The fruits are oblong, small, dark green colour with yellow to orange flesh (Figure 4)

Fig. 4: VRW-50: A watermelon mutant line

Carrot: Sixty-eight genotypes of tropical carrot were evaluated to screen out the promising lines for various root colour (red, orange, black, yellow and rainbow). The evaluated genotypes varied considerably for shoot weight (24.6-94.9 g), shoulder diameter (2.6-4.9 cm), root length (14.5-25.6 cm), root weight (33.1-129.2 g) and harvest index (41.5-69.7 %). The following genotypes were found to be promising such as VRCAR-185, VRCAR-186, VRCAR-109 and VRCAR-201 (red coloured root); VRCAR-178 and VRCAR-153 (yellow coloured root); VRCAR-107-2 and VRCAR-171-1 (rainbow-type: purple-red coloured root); VRCAR-91-

Table 9: Characterization of promising germplasm of sponge gourd

Geno-types	Days to 1st female flowering	Days to 1st harvest	Fruit colour	Fruit length (cm)	Fruit circum. (cm)	Fruits/ plant	Avg. fruit wt.(g)	Yield/ plant (kg)
VRSG-3-13	38	50	Dark Green	27.26	13.8	9.5	149	1.42
VRSG-185	36	48	Green	26.10	14.62	9	151	1.52
VRSG-19	40	52	Green	23.02	13.5	10.5	145	1.53
VRSG-73	39	48	Light green	201.6	11.08	11	140	1.54
VRSG-2-14	38	49	Dark green	26.8	12.00	10.5	144	1.52
VRSG-6-13	38	51	Light green	31.46	10.52	10.00	142	1.42
VRSG-40	38	48	Green	34.12	11.84	8.00	147	1.18
VRSG-108	38	49	Light green	30.02	11.78	8.5	149	1.27
VRSG-63	36	49	Green	25.84	12.3	9.5	140	1.33
VRSG-136	39	48	Green	27.3	10.53	11.5	139	1.59

2 and VRCAR-91-1 (orange coloured root); and VRCAR-124 and VRCAR-126 (black coloured root) (Figure 5)

Fig. 5: Variation in carrot root colour

Radish: Fifty-five genotypes of tropical nature, in radish were assessed to screen out the promising lines for various root colour (white/pink/purple), leaf incision (lyrate/sinuate) and petiole colour (green/pink/purple). The evaluated genotypes varied considerably for anthocyanin content (negligible to 170 µg/g), gross plant weight (63.6-325.5 g), shoot weight (31.6-194.8 g), number of leaves (8.3-14.6), leaf length (29.3-45.4 cm), shoulder diameter (1.4-3.4 cm), root length (10.7-26.9 cm), root weight (45.1-155.8 g) and harvest index (36.3-68.6%). There were lot of variation in synthesis and accumulation of anthocyanins responsible for pink/purple pigmentation of the roots (Figure 6).

Fig. 6: Variation in radish root colour

Basella: Fifty two genotypes of basella (Indian spinach) were augmented, characterized and evaluated for agro-morphological traits using 20 descriptors. Wide range of variation was observed for green yield (20-45 t/ha), number of branch/plant (3.4-20.12), shoot weight (10.57-100.68), number of leaves/shoot (8.22-20.4), leaf length (4-11.3 cm) and stem girth (0.36-1.24 cm). Leaf shape varied from ovate, elliptical to cordate while colour showed a range of green, red to purple tinge (Fig. 7). Stem colour varied from light green, dark green, red to purple.

Fig. 7: Variation in leaf shape and colour in basella

Germplasm supplied: Promising germplasm and released varieties/hybrids being maintained at the institute were supplied to various organizations for research, evaluation and demonstration purpose after signing of the Material Transfer Agreement (MTA). During 2015-16, 1718 accessions of germplasm from 18 vegetable crops and fungus cultures were supplied to 49 organizations for use in research and evaluations. Details of the germplasm supplied along with the recipient organizations are given in Table 10.

Table 10: Cropwise details of the germplasm supplied to other organizations

Crop	Recipient organization
Tomato (639)	NIPGR, New Delhi (2); IIHR, Bengaluru (244); TNAU, Coimbatore (57); IAS, BHU, Varanasi (1); AKS, University, Satna (31); ICAR-IARI, New Delhi (7); ICAR-CSSRI, Karnal (130); ICAR-NCIPM, New Delhi (1); SHIATS, Allahabad (66); LPU, Phagwara (30); TERI, New Delhi (1); GKVK, Bengaluru (13); RAU, Samastipur (2); MGCGVV, Chitrakut (31); BBAU, Lucknow (16); CAU, Barapani, Meghalaya (7); ICGEB, New Delhi (1)
Brinjal (374)	IAS, BHU, Varanasi (63); RVSKVV, Gwalior (30); ICAR-IARI (15); AKS University, Satna (20); ICAR-CIAH, Bikaner (200); Bharat Crop Sciences India Pvt. Ltd, Jodhpur (1); GBPUA&T, Pantnagar (4); Navsari Agricultural University (20); CSKHPKV, Palampur (12); Central Costal Agricultural Research Institute, Odisha (5); CAU, Barapani, Meghalaya (4)
Okra (283)	IAS, BHU, Varanasi (79); RVSKVV, Gwalior (60); ICAR-IARI (1); Navsari Agricultural University (18); TNAU, Coimbatore (2); ICAR-NBPGR Regional Station, Thrissur (6); Junagadh Agricultural University (30); SHIATS, Allahabad (25); CAU, Barapani, Meghalaya (25); SVPUA&T, Meerut (37)
Cowpea (99)	IAS, BHU, Varanasi (200); SHIATS, Allahabad (50); Bharat Crop Sciences India Pvt. Ltd, Jodhpur (1); College of Horticulture, Mandsaur, RVSKVV, Gwalior (5); CAU, Barapani, Meghalaya (23)
Dolichos bean (84)	University of Allahabad (44); CAU, Barapani, Meghalaya (40)
Chilli (81)	RVSKVV, Gwalior (14); University of Rajasthan, Jaipur (34); University of Horticultural Science, Bagalkot (15); Y S Parmar University for Horticulture and Forestry, Solan (1); ICAR-IARI, New Delhi (2); TNAU, Coimbatore (13); ICGEB, New Delhi (1); SHIATS, Allahabad (1)

Crop	Recipient organization
French bean (48)	College of Horticulture, Mandsaur, RVSKVV, Gwalior (23); OUA&T, Bhubneshwar (15); SHIATS, Allahabad (10)
Pea (32)	CSKHPKV, Palampur (3); IAS, BHU, Varanasi (1); Rajasthan Agri. Res. Institute, Durgapur (3); CAU, Barapani, Meghalaya (25)
Cauliflower (20)	Y S Parmar University for Horticulture and Forestry, Solan (10); Lovely Professional University, Phagwara (10)
Carrot (12)	MPUAT, Udaipur (12)
Pumpkin (11)	CSIR-CFTRI, Mysore (1)
Ridge gourd (11)	MPUAT Udaipur (11)
Cucumber (9)	IAS, BHU, Varanasi (9),
Sponge gourd (7)	JNKVV, Jabalpur (7)
Snake Gourd (3)	Kakatiya University, Warangal (3)
Bottle gourd (1)	Bioseeds Research India (1)
Bitter gourd (1)	Bioseeds Research India (1)
Pointed gourd (1)	KVK,GBPUA&T, Pantnagar (100 cuttings)
Alternaria solani (2)	PI Industry Ltd, Gurgaon (1); TERI, New Delhi (1)
Total	**1716 accessions and 2 cultures of fungi**

Project: 1.2: Genetic Improvement of Solanaceous Vegetables

Tomato

Confirmation of *Ty2*, *Ty3* and *RKN* gene in advanced lines: Gene confirmation was done on 36 advanced lines of tomato developed at IIVR, Varanasi through specific primers. The lines *viz.*, F10-30-SPS-2, F10-12-SPS-2, F9-01-SPS-1, F9-01-SPS-2, KT-19, KT-13, TLCV-32, TLCV-11 (SPS-2), TLCV-28, F10-15-SPS-3, and F6-23-SPS-2 expressed the presence of *Ty-3* genes while KT-1 showed the presence of root knot nematode (*RKN*) gene. None of the lines showed the presence of *Ty-2* gene.

Screening of tomato F_1s against root knot nematode (RKN) (*Meloidogyne incognita*): Nine tomato F_1s containing *Mi 1.2* gene in heterozygous condition were screened against *Meloidogyne incognita* at 2 J_2/ g of soil inoculum level along with highly susceptible and highly resistance genotypes. All the nine F_1s have showed resistance reaction with gall number ranging from 2 to 9 (Figure 8).

Gene pyramiding: In an effort to combine resistance for ToLCV, RKN and late blight diseases, hybridity of the F-$_1$s of last year was confirmed with the help of molecular markers and further crossing was done among the F_1s.

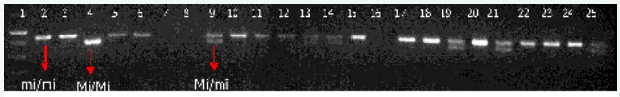


Fig. 9: Lanes 1 - 100 bp ladder; 4 – positive control; 2, 3 4 and 5 negative control; 9, 13, 14, 19, 21 and 25 are hybrids for *Mi 1.2* gene

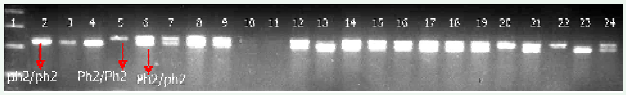


Fig.10: Lanes 1- 100 bp ladder; 5 – positive control; 2, 3 and 4 negative control; 6 - 12, 14 - 19, 21 and 24 are hybrids for *Ph-2* gene

Genetic studies of collar rot resistance caused by *Alternaria solani:* In total, 288 F_2 seedlings of cross between collar rot resistant yellow fruited wild species (WIR 3928) and susceptible cultivated tomato, Hawaii 3998 along with parents were challenged with *A. solani* and were scored for collar rot symptoms (Figure 11). Results indicated that the resistance may be controlled by a single recessive gene. It has to be further confirmed in other segregating generations. For this, F-$_1$ was crossed with susceptible parent to develop back cross generations.

Fig. 8: Symptoms of susceptible (*mi/mi*) and resistance reaction of F_1 (*Mi/mi*) hybrids of tomato

Fig. 11: Tomato seedlings of resistant (WIR 3928) and susceptible (Hawaii 3998) parents after 10 days of inoculation

Generation advancement: F_{10}: thirteen segregates were advanced and selected 12 segregants on the basis ToLCV resistant / tolerant with high yield. F_9: Fourteen segregates were advanced and selected six segregants on the basis ToLCV resistant/ tolerant with high yield. F_8: Five segregates were advanced and selected 01 segregant on the basis high yield, ToLCV tolerant and good fruit quality. F_7: Three segregants were advanced and selected 02 segregants on the basis high yield, ToLCV tolerant and good fruit quality. F_6: Six segregants were advanced and 02 segregants were selected on the basis high yield, ToLCV tolerant and good fruit quality. For high beta carotene, fifteen segregating populations (F_6) were advanced and selected ten sergeants. Similarly, for Cherry tomato, sixteen segregates were advanced to (F_4). For pot culture tomato, four segregates were advanced (F_6 to F_7) and selected only two segregates for further advancement. For high TSS, lycopene and ascorbic acid, eight cross combinations were advanced from F_2 to F_3 generation and harvested seeds in bulk.

Testing of advanced lines and maintenance: Four advanced lines of F_{10} generation were evaluated with national check Kashi Vishesh for traits like yield, quality and ToLCV incidence. The performance of these advance lines are given in Table 11. Forty five parental lines of tomato were maintained.

Table 11: Performance of advanced lines of tomato

Entries	Growth habit	Number of fruits/plant	Avg. Fruit weight (g)	Fruit shape	% ToLCV disease under field condition	TSS (%)
VRT-19	Det.	51	90-95	Flattish round	15	4.1
VRT-32	Det.	45	70-80	Large oval round	11	3.16
VRT-14	Det.	46	110-120	Flatty round	7	4.28
VRT-1	Det.	57	70-80	Oblong	14	4.16

Maintenance of parental lines: Maintained and harvested fresh seeds of 45 parental lines of tomato.

Brinjal

Evaluation of hybrids: Eighty eight F_1 hybrids were evaluated for earliness, yield and quality traits. Yield parameters of some promising hybrid in different segments are given below (Table 12).

Table 12: Performance of brinjal hybrids

Hybrids	Shape and colour	Earliness (Days to 50% flowering)	Av. fruit wt (g)	Fruits/ plant	Yield/ plant (kg)
IVBHR-20	Round Deep Purple	49	195	31.33	6.12
IVBHR-21	Round Light Purple	51	225	22	4.95
IVBHR-22	Round Light Purple	52	235	18	4.23
IVBHR-23	Round Dark Purple	53	230	20	4.6
IVBHR-24	Round Light Purple	51	265	19	5.04
IVBHL-21	Long Light Purple	52	125	28	3.5
IVBHL-22	Long Purple	51	120	24	2.9
Punjab Sadabahar (C)	Long Purple	54	115	14	1.61
Swarnamani (C)	Round Purple	58	225	16	3.6
Kashi Sandesh (C)	Round Purple	52	225	19.2	4.32

Hybridization and generation advancement: Under distant hybridization programme, back-crossing in 5 F_1s obtained using wild related species (*S. incanum, S. aethiopicum* and *S. undatum*) was done. Other wild species are being evaluated for resistance to nematode. In cultivated brinjal, 34 cross-combinations in round shape and 27 cross-combinations in long shape have been attempted utilizing promising parental lines.

Two promising advanced lines IVBL-24 in long fruited and IVBR-20 in round fruited were selected for high yield and better fruit quality (Fig. 12). The selected lines shall be used for yield trial at station before multi-location testing in AICRP (VC). Four hundred and seven segregating populations (88: F_1 to F_2; 46: F_2 to F_3; 31: F_3 to F_4; 36: F_4 to F_5; 14: F_5 to F_6; 51: F_6 to F_7; 46: F_7 to F_8; 60: F_8 to F_9; 35 F_9 to F_{10}) were advanced to subsequent generation.

Table 13: Performance of selected entries of brinjal

Entries	Fruit shape and colour	Days to 50% flowering	Av. fruit wt (g)	Fruits/ plant	Yield/ plant(kg)
IVBHL-20 (F_1)	Long Purple	47	65-70	66.66	4.45
IVBR-20 (OP)	Round Light Purple	52	230-240	26.45	6.00
IVHL-24 (F_1)	Long Light Purple	48	120-130	33.35	4.20
Punjab Sadabahar (C)	Long Purple	54	115	14	1.61
Swarnamani (C)	Round Purple	58	225	16	3.60

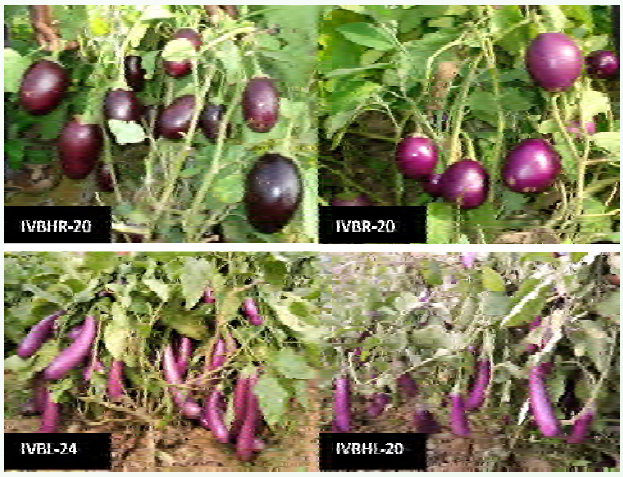


Fig. 12: Promising hybrids (IVBHR-20, IVBHL-20) and advanced (IVBR-20, IVBL-24) lines of brinjal in long and round segment

Maintenance breeding: Seeds of Kashi Sandesh (800g), Kashi Taru (350g), Kashi Komal (300g), Kashi Prakash (150g) and Kashi Uttam (550g) was multiplied for distribution to farmer and multi-location demonstration /evaluation by public and private organizations. Parental line of hybrids *viz*- PR-5 (IVBR-15) (400g), CHBR-2 (270), Pant Rituraj (160g), Uttara (160g) Punjab Barsati (250g), ADM-190 (350g) and IVBL-22 (250g), IVBR-16 (250g), IVBL-23 (250g), IVBL-24 (250g), IVBR-17 (200 g), IVBHR-16 (170g), IVBHL-20 (250g) were also multiplied.

Chilli and Capsicum

Maintenance and utilization of elite accessions: Nine sets (A1 to A9) of cytoplasmic male sterile (CMS, Figure 13) lines and two genetic male sterile (GMS) lines (GMS-3 and MS-12) were maintained by crossing them with respective maintainer lines and utilized in developing hybrids. Under maintenance breeding, selfing of selected populations, varieties and parental lines of hybrids was done and seeds collected separately. An amount of 600 g of Kashi Anmol, 250 g each of Kashi Gaurav and Kashi Sinduri and parental lines of Kashi Surkh, Kashi Tej and Kashi Early were produced.

Identification of distinctive genetic stock: Two distinct accessions in chilli, IIVRC-469 and EC-587152 (Figure 14) were identified for their unique performance and

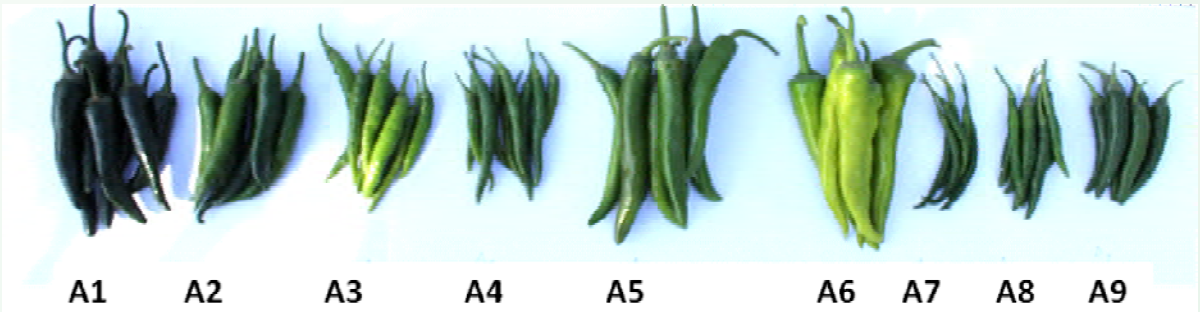


Fig 13: Variability in fruit morphology of CMS chilli plants after maintenance

Fig.14: Distinct accessions of chilli and sweet pepper

maintained for further detail characterization. The genotype IIVRC-469 exhibited deep purple, cordate-shaped ornamental fruits, length 2.0–2.5 cm and width 1.4–1.6 cm, resembling fruits of Jamun tree. Genotype EC-587152 gave approximately 100 fruits per plant with average fruit length of 11.06 cm, fruit width 1.16 cm, fruit weight 7.66 g and yield 750g per plant. In sweet pepper (capsicum), genotype VRCAP-1 was found to be of deep purple fruit colour, plants of medium height (45-50cm) and with 8-10 fruits per plant and average fruit weight of 40-50g, fruit length 5-6 cm and width 3-4 cm.

Development and Evaluation of F_1 hybrids of chilli

Development of hybrids: New combinations were developed on CMS lines and few elite accessions of chillies utilizing the elite pollen parents in order to find the better cross combinations of chilli with respect to quality, resistance, fruit morphology and yield parameters. A total of 150 F_1 hybrids were developed during 2015-16, seeds of all the combinations were harvested and saved for evaluation during 2016-17.

Evaluation of F_1 hybrids: Eight chilli hybrids along with four popular hybrids belonging to private companies were evaluated during 2015-16. IIVR Chilli hybrids CCH-7, CCH-12, Kashi Surkh, CCH-4, Kashi Early, CCH-10 and CCH-11 were evaluated against VNR-305, Soldier, Divya Jyoti and Super-16. The performance data of these hybrids are presented (Table 14). The maximum yield was exhibited by the hybrid CCH-12 (195.6 q/ha) followed by CCH-2 (188.84 q/ha). VNR-305 performed better among the private seed company's hybrids followed by Divya Jyoti.

Table 14. Performance of F_1 chilli hybrids

Hybrids	Plant Ht. (cm)	Fruits/ plant	Fruit length (cm)	Fruit width (cm)	Fruit colour	Fruit yield Q/ha (Est.)
CCH-7	48.87	96.33	8.13	1.20	Green	167.00
CCH-12	51.33	120.00	9.78	1.28	Green	195.60
CCH-2	61.90	112.75	10.56	1.63	Light green	188.84
CCH-4	57.09	106.22	13.21	1.37	Light green	186.84
CCH-3	78.81	124.87	5.99	1.23	Green	135.00
CCH-10	46.07	117.55	7.36	1.14	Green	145.86
CCH-11	57.39	180.00	10.50	0.98	Green	187.86
VNR-305	42.55	94.35	7.10	1.22	Green	180.87
Soldier	54.83	91.76	9.18	1.44	Green	130.88
Divya Jyoti	57.02	77.70	8.25	1.22	Dark Green	138.88
Super-16	58.86	107.65	6.77	1.27	Green	109.89
SEM ±	2.94	6.14	0.43	0.06	-	8.12
CD 0.05	8.66	18.11	1.27	0.19	-	23.96
CV %	9.10	9.52	8.46	8.64	-	8.76

Screening for mites tolerance in chilli: Four hundred and eleven F_2 individual plants of the cross of Kashi Anmol × Japani Longi were screened for mites tolerance. The two parental lines differed with respect to fruit orientation, reaction to mites and thrips and leaf curl disease. Japani Longi expresses tolerance towards mites, thrips and leaf curl disease along with bearing upright fruits in clusters. Mites infestation and total phenols contents (mg GAE/g) in leaves were recorded (Table 15 &16). Correlation between phenol content, percent damage in F_2 population and mites population were also studied and it was found that the plants having high phenol content showed less damage.

Table 15: Descriptive statistics of phenol content, percent damage by mites in chilli

Statistics	Phenol content (mg GAE/g)	% damage by mites	Mites' population
Mean	6.63	48.79	4.91
Standard Error	0.18	1.06	0.08
Median	5.81	40.00	4.67
Mode	6.93	30.00	3.33
Standard Dev.	3.67	21.64	1.68
Sample Variance	13.52	468.70	2.84
Kurtosis	2.55	-0.43	1.36
Skewness	1.41	0.54	0.65
Range	23.36	90.00	11.00
Minimum	0.64	10.00	1.33
Maximum	24.00	100.00	12.33
Sum	2727.63	20040.00	2016.33
Count	411.00	411.00	411.00

Table 16: Correlation between phenol content, percent damage and mites population

	Phenols	Damage	Mites population
Phenols	1.00	0.23	-0.20
Damage		1.00	-0.93*
Mites population			1.00

Line development: Under the line development activity, selected individual/crosses were advanced to subsequent generation. From the segregating lines, *i.e.* 130 combinations in F_2 generation, 113 families in F_3, 312 in F_4, 249 families in F_5, 27 families in F_6 and seven families in F_7 were advanced. The promising combination in F_3 for leaf curl, thrips and mites with high pungency were PBC-904 x NG-3, PBC-904 x NG-4, PBC-904 x NG-7, PBC-904 x C0-309 and PBC-904 x NBC-1. Three populations of advanced lines, Kashi Sinduri x AKC-89/38 (Figure 15) for morphological character and anthracnose, PT-12-3 x Bhut Jolokia for morphological, capsaicin and leaf curl disease and

Kashi Sinduri x BS-35 for leaf curl disease, anthracnose and capsaicin were advanced to subsequent generation in F_7 for further characterization.

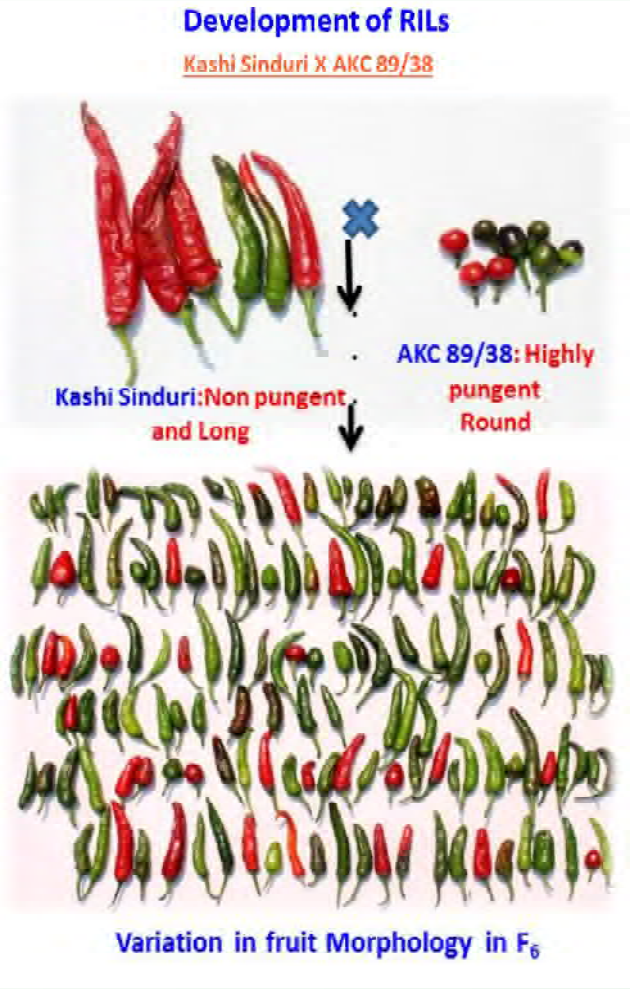


Fig. 15: Variation in fruit morphology in RILs of cross Kashi Sinduri x AKC-89/38

Project 1.3: Genetic improvement of legume vegetables

Cowpea

Hybridization: Parents were selected on the basis of their earliness, growth habit, yield-attributing traits, pod quality and resistance to cowpea golden mosaic virus, and 10 F_1s were developed.

Advancement of generation: A total number of 24 BC_1F_1, 21 BC_1F_2, 35 F_3, 34 F_4, 16 F_5, 14 F_6, 15 F_7 and 14 F_8 families were advanced in to next generation and SPS were done for earliness, higher yield, better pod quality and cowpea golden mosaic virus resistance.

Evaluation of advance breeding lines: Fourteen dwarf and bush type advance lines along with one national check (Kashi Kanchan) were evaluated for earliness, yield attributing traits, yield and resistance to cowpea golden mosaic virus during *kharif*, 2015 (Table 17). Line 70-2 flowered earliest and took minimum days to 50% flower (34.7 DAS) followed by line 98-4 (36.0 DAS). The maximum number of pods per plant was obtained from line 112-4 (27.4) followed by line 96-4 (26.7) and 102-1 (25.6). The maximum number of seeds per pod was observed in line 67-1 (14.2) followed by line 112-4 (13.6) and 66-4 (13.0). The highest pod yield per plant was obtained from line 112-4 (352.6 g) followed by 96-4 (313.0 g) and 102-1 (307.4 g). All the advanced material showed resistance to cowpea golden mosaic virus. Lines 65-8, 96-4, 102-1, 112-4 and 134-2 showed resistance to *Pseudocercospora cruenta* under field condition.

Table 17: Performance of advanced breeding lines during *Kharif* 2015

Advanced line	Days to 50% flower (DAS)	Pods/ plant (No)	Pod length (cm)	Pod weight (g)	Seeds/ pod	Pod Yield/ plant (g)
65-8	36.7	24.2	29.8	11.3	12.6	276.4
66-4	39.0	20.3	30.4	11.6	13.0	238.5
67-1	37.0	21.6	29.0	12.8	14.2	279.8
68-2	38.0	23.2	31.4	11.2	10.9	263.6
70-2	34.7	24.8	28.6	12.2	10.5	305.2
71-1	41.0	22.3	30.2	12.5	11.2	282.7
79-4	39.0	24.6	28.3	11.6	11.4	289.4
96-4	36.7	26.7	30.0	11.5	12.2	313.0
97-3	40.0	24.0	30.5	11.4	11.0	276.5
98-4	36.0	25.4	29.2	12.0	11.8	302.8
102-1	39.3	25.6	31.1	11.9	11.2	307.4
112-4	42.3	27.4	32.6	13.1	13.6	352.6
121-3	37.7	22.8	31.8	11.5	10.2	269.6
134-2	37.0	24.5	28.4	11.8	11.3	292.0
Kashi Kanchan (C)	42.0	24.6	30.2	11.7	11.5	296.5
CD (P=0.05)	4.17	2.68	NS	NS	1.13	51.06
CV (%)	6.45	6.62	5.56	6.24	5.69	10.48

Maintenance breeding of cowpea varieties: The maintenance breeding of IIVR developed cowpea varieties viz. Kashi Shyamal, Kashi Gauri, Kashi Unnati, Kashi Kanchan and Kashi Nidhi were done through pure line selection.

Pea

Hybridization: A total number of 62 F_1 were made by utilizing 22 parental lines targeting the traits like earliness, higher yield, powdery mildew and rust resistance.

Advancement of generation: A total of 11 F_3, 24 F_4, 8 F_5, 10 F_6, 8 F_7 and 8 F_8 cross combinations were advanced in to next generation and SPS were done for desirable horticultural traits.

Evaluation of early and mid maturity groups of advanced lines: Among the early maturity group, three

lines *viz*. VRPE-16 x VRPE-22, Arkel x Ageta and VRP-6 x VRPE-25 and among mid maturity group two lines *viz*. PC-531 x VRP-270 and PC-531 x DARL-404 were found promising with respect to days to 50 % flowering, number of pods per plant, average pod weight, pod length and pod yield per plant (Table 18).

Table 18: Promising advanced breeding lines for early and mid group

Traits	Early group			Mid group	
	VRPE-16 × VRPE-22	Arkel × Ageta	VRP-6 × VRPE-25	PC-531 × VRP-270	Pc-531× DARL-404
Days to 50 % flowering	32	34	34	56	58
Pods per plant	9.78	12.1	8.7	17.2	15.5
Pod weight (g)	10.0	7.85	8.8	9.0	9.2
Pod length (cm)	9.12	8.65	8.91	8.6	9.7
Pod yield per plant (g)	97.8	94.99	76.56	154.8	142.6

Estimation of vitamin C content in edible podded pea: Two snow pea (edible podded pea) lines viz. VRPD-2 and VRPD-3 were analyzed for vitamin C content and found to contain 38.4 mg/100g and 40.8 mg/100g of vitamin C, respectively.

Advanced breeding materials in AICRP (VC) trials: Two advance breeding lines (VRPE-100 and VRPE-101) in early group and one line in mid group (VRPM-50) were included in AVT-1 of AICRP (VC) trial. The seeds of above entries were multiplied for their multi-location testing.

Maintenance breeding of pea varieties released from IIVR: Maintenance breeding of IIVR released pea varieties *viz*. Kashi Uday, Kashi Nandini, Kashi Ageti, Kashi Mukti, Kashi Samarath, Kashi Shakti, and Kashi Samridhi were done through pure line selection.

French Bean

Generation advancement for longer duration flowering and earliness: Population was advanced to F_3 stage for cross (VRFBB-2 × VRFBB-9) for longer duration of flowering, and to F_2 stage of another cross (VRFBB-2 × VRFBB-91) for earliness.

Selection of bush type genotype for earliness, short duration, pod quality and yield: A genotype VRFBB-91 has been identified for earliness, short duration (75-80 days), good pod quality and higher yield. The pods of VRFBB-91 are green and bright in colour, fleshy, tender, straight, cylindrical, parchment free, ready for first picking in 48 days after sowing with pod weight 6.5 g, pod length 15.4 cm, pod width 0.79 cm and bears 20-21 pods/plant. Pods are ready to harvest in about 9-12 days after flowering. The yield potential of VRFBB-91 is 109.00 q/ha which is better than released varieties such as Kashi Sampann, Arka Komal, Arka Suvidha, Swarna Priya, Pant Anupma and Arka Anoop (30-58 q/ha).

Entries in AICRP (VC) trial: Two pole-type genotypes (VRFBP-14 and VRFBP-44) were included in IET of AICRP (VC) trial for their multi-location testing.

Indian Bean (Dolichos bean)

Hybridization: Parents were selected on the basis of their earliness, growth habit, yield-attributing traits and pod quality and 16 F_1s were made during *rabi*, 2015-16.

Advancement of generation: A total of 7 F_3, 19 F_4 and 26 F_7 cross combinations were advanced to subsequent generation and SPS were done for bushy growth habit, earliness, higher yield and better pod quality.

Evaluation of advanced breeding lines: Two advanced breeding materials VRBSEM-3 and VRBSEM-9 (Figure 16) were evaluated along with four checks *viz*., Arka Jay, Arka Swarna, Arka Soumya and Pawan during 2015-16 (Table 19). Variety Pawan flowered earliest and took minimum days to 50% flower (37 DAS) followed by Arka Swarna (42 DAS) and Arka Soumya (45 DAS). The maximum number of pods/plant was recorded in line VRBSEM-3 (275) followed by line VRBSEM-9 (175) and Arka Swarna (148). The highest pod yield per plant was recorded in line VRBSEM-3 (875 g) followed by VRBSEM-9 (710 g) and Arka Soumya (600 g).

Table 19: Evaluation of two advanced breeding materials along with checks

Advance line	Days to 50% flowering	Pod width (cm)	Pod length (cm)	Number of pods/ plant	Pod Yield (g/plant)
VRBSEM-3	54	1.8	13.5	275	875
VRBSEM-9	46	1.5	10.5	175	710
Arka Jay (C)	51	1.2	9.5	50	265
Arka Swarna (C)	42	1.8	9.6	148	525
Arka Soumya (C)	45	0.9	11.5	140	600
Pawan (C)	37	1.8	8.9	55	225

Fig. 16: Advance breeding lines of Indian bean

Nutritional and anti-nutritional quality of advanced lines: Seven advance lines of were analyzed for nutritional and anti-nutritional traits (Table 20). VRBSEM-3 and VRBSEM-15 showed high level of protein content; phenol content was highest in VRBSEM-10 and VRBSEM-15, chlorophyll was the maximum in VRBSEM-15 whereas VRBSEM-3 had maximum carotenoid content and VRBSEM-15 and VRBSEM-1 showed highest catalase activity. On the basis of biochemical evaluation the advanced lines viz., VRBSEM-3 and VRBSEM-15 were found better as they have high protein and phenol content coupled with high catalase activity and may show better adaptability under adverse condition (abiotic stress).

Table 20: Biochemical analysis of fresh pods of bush type Indian bean advance lines

Advanced Lines	Protein (mg/g FW)	Phenol (mg/g FW)	Chlorophyll (mg/g FW)	Carotenoid (mg/g FW)	Proline (µg/g FW)	H_2O_2 (µM/g FW)	Catalase activity (µM H_2O_2 reduced/min/mg protein)
VRBSEM-1	87.8	1.9	1.11	0.202	3.08	11.71	3.72
VRBSEM-3	93.6	1.08	0.724	0.212	2.99	16.29	1.94
VRBSEM-8	66.5	1.49	1.29	0.125	2.71	18.64	1.83
VRBSEM-9	44.8	1.41	1.17	0.037	2.76	11.29	0.67
VRBSEM-10	35.2	1.81	1.08	0.119	1.33	19.93	0.89
VRBSEM-14	77.6	1.36	0.938	0.161	1.42	24.14	2.83
VRBSEM-15	91.1	1.49	1.34	0.156	2.90	15.21	4.39

Project: 1.4: Genetic improvement of gourds

Bitter Gourd

Hybridization: During 2015-16, 10 hybrids were evaluated for various horticultural traits using Pusa Hybrid-2 as a check. Among them cross combinations VRBTG-3 x VRBTG-5 and VRBTG-21 VRBTG-4-1 were found superior hybrids with 21% heterosis (Table 21)

Table 21: Performance of bittergourd hybrids

Cross combination	Fruit Length (cm)	Fruit circum-ference (cm)	Fruit Wt. (g)	No. fruits/ plant	Plant height (cm)	Yield/ ha (q)
VRBTG-21 x VRBTG-47	15.0	12.0	50.0	6.0	234.0	209.65
VRBTG-12 x VRBTG-8	27.0	10.5	100.0	7.0	219.0	189.95
VRBTG-3 x VRBTG-4	12.0	12.0	50.0	6.0	213.0	177.52
VRBTG-21 x VRBTG-4-1	12.5	12.0	55.0	9.0	231.0	165.24
VRBTG-10 x VRBTG-8	25.0	11.0	100.0	8.0	209.2	172.14
VRBTG-3 x VRBTG-47-2	11.0	12.0	75.0	5.0	178.4	163.25
VRBTG-3 x VRBTG-5	11.0	14.0	100.0	10.0	213.5	201.0
VRBTG-12 x Kalyanpur Baramasi	17.0	11.0	75.0	9.0	229.0	198.5
VRBTG-12 x VRBTG-17	9.0	9.0	50.0	7.0	198.9	168.1
VRBTG-37 x VRBTG-35	14.0	13.0	100.0	8.0	212.0	198.7
Pusa Hybrid -2 ©	19.0	15.0	100.0	7.0	229.0	174.23

Advancement of generation: A total of 13 F_2, and 5 F_3 cross combinations were advanced in to next generation.

Bottle Gourd

Hybridization: During 2015-16, total 7 cross combinations were developed. In long fruited segment, 7.15 kg per plant yield was recorded in combination VRBG-5 x VRBG-120 and expressed 23% heterosis. In round type combination, VRBG-7 x VRBG-27 gave yield of 6.850kg/plant and expressed heterosis 25% (Table 22).

Table 22. Performance of bottle gourd hybrids

Cross combination	Fruit Shape	F. Length (cm)	F. circum-ference (cm)	F. Wt. (g)	No. fruits/ plant	Plant height (cm)	Yield/ plant (kg)
VRBG-5 x VRBG-1	Long	25.35	21.53	600.25	9.0	725.66	5.30
VRBG-7 x VRBG-20	Round	21.25	40.16	950.36	8.0	824.12	7.15
VRBG-8 x VRBG-1	Long	26.33	22.22	500.00	6.0	525.14	2.50
VRBG-6 x VRBG-5	Long	25.42	21.51	700.00	7.0	701.21	4.87
IC594545 x IC594544	Round	17.58	29.64	725.42	7.0	725.00	4.72
VRBG-44 x VRBG-5	Long	40.00	22.15	875.11	6.0	750.00	4.62
VRBG-7 x VRBG-27	Round	22.00	47.12	900.00	8.0	750.00	6.80
NDBGH-4 (C)	Long	19.00	15.00	1000.0	7.0	651.00	6.56

In bottle gourd total 10 new collections were evaluated for different horticultural traits. Apart from this one unique genotype, VRBG-14-08 reach chlorophyll content and tastes like cucumber in early stage of development.

Advancement of generation: A total of 18 F_2, 6 F_3 and and 5 F_4 cross combinations were advanced in to next generation while in winter fruited bottle gourd, 41 segregating lines in F_5 generation were evaluated, selfed and selection were made to advance in subsequent generation.

Ash Gourd

Evaluation of segregating lines of ash gourd: A total of 80 F_3 segregating lines of wax less and waxy ash gourd were evaluated. The 21 waxless segregating lines were selected for further evaluation.

Maintenance breeding: One kg seeds of each Kashi Dhawal, Kashi Surbhi and Kashi Ujjwal were produced and SPS were made for maintenance of the varieties.

Sponge Gourd

Promising genotypes/ hybrids identified for multiplication testing: One open pollinated genotypes namely, VRSG-195 and one hybrid viz. VRSGH-3 (Fig. 17) was found promising for horticultural traits. Genotype VRSG-195 has average fruit length 19.5 cm, fruit diameter 4.06 cm., 13.5 fruits/plant, fruit weight 122 gm, 2.25 kg fruits yield/plant and green colour of fruits and whereas the F_1 hybrid VRSGH-3 has fruit length 21.26 cm, fruit diameter 2.46 cm, 14.5 fruits/plant, fruit weight 142 gm, 2.45 kg fruit yield/plant and fruits colour is green.

Generation advancement: Eleven F_7, 13 F_6, 15 F_5, 4 F_3 and 5 F_2 population of of sponge gourd were advanced to F_8, F_7, F_6, F_5, F_4 and F_3, respectively. Under the RILs development programme, one population of *Luffa cylindrica* syn. *Luffa aegyptiaca x Luffa acutangula* var. Satputia syn. *Luffa hermaphrodita* advanced from F_2 to F_3 (160 plants).

Development and evaluation of F_1 genotypes (2015-16): From the 48 developed F_1 hybrids of sponge gourd VRSG-57 × VRSG-195, VRSG-2-12 × VRSG-195, VRSG-9 × VRSG-195, VRSG-91 × VRSG-214 and Phule Prajakta × VRSG-195 were found promising for various horticultural traits (Table 23) and showed tolerance against downy mildew and free from virus disease symptoms under field conditions.

VRSG-195 VRSGH-3

Fig. 17: Promising genotypes of sponge gourd VRSG-195 and VRSGH-3

Project 1.5: Genetic improvement of melon, pumpkin and cucumber

Cucumber

Development of hybrids

A total of 5 inbred lines were selected and 5 F_1 cross combinations were developed for further evaluation. Due to lesser variability in cucumber, double hybrid combinations selecting diverse parents for yield, quality and disease resistance were evaluated.

Table 23: Performance of Promising F_1(s) of sponge gourd

F1 Genotypes	Days to Ist male flower appeared	Days to Ist female flower appeared	Days to first harvesting	Fruit colour	Fruit Length (cm)	Fruit circumference (cm)	No. of fruits/ plant	Average fruit wt.(g)	Yield/ plant (kg)
VRSG-57 ×VRSG-195	30	37	47	Green	24.6	11.4	10.5	155.5	1.63
VRSG-212 ×VRSG-195	37	36	47	Green	24.46	10.2	11	145	1.59
VRSG-9 × VRSG-195	36	37	48	Green	21.26	11.14	14.5	142	2.45
VRSG-91 × VRSG-214	37	35	47	Green	29.8	12.6	10.0	155	1.55
Phule Prajkta × VRSG-195	36	38	49	Green	25.2	12.00	11.5	125	1.44

Evaluation of advanced lines

Three advanced lines were evaluated with PCUC-09 as check 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.-13-01 followed check VRCU-Sel.-12-02 (Table 24).

Table 24: Yield and its contributing traits of advanced lines in cucumber

Hybrids	Fruit length (cm)	Fruit diameter (cm)	Fruit/ plant	Fruit weight (g)	Yield/ plant (g)
VRCU-Sel-12-02	13.15	3.55	10.25	130.24	1250.00
VRCU-Sel-13-01	11.65	3.45	13.85	105.00	1275.0
VRCU.Sel.12-03	15.25	3.39	9.00	125.50	975.00
PCUC-09 (C)	18.75	4.55	7.12	126.50	785.00

Generation Advancement

A total of 26 segregating lines which includes F_3 (10), F_4 (8), F_5 (4) and F_6 (4), were evaluated, selfed and further selection were made to advance to next generation.

Pumpkin

Isolation of inbred

Inbreds were selected for hybrid development from the advance generations based on the variability and purity. The target of hybrid development is in mottle green and flat round segment. A total of 10 inbred have been selected for hybridization.

Advancement of breeding material

A total of 54 segregating lines which includes F_2 (14), F_3 (9), F_4 (9), F_5 (10), F_7 (2) and F_8 (12) were evaluated; selfed and further selection were made to advance next generation.

Evaluation of advanced lines

Five advanced breeding lines were evaluated for important horticultural traits. Maximum yield per plant was reported in VRPK-230 (13.85 kg) followed by VRPK-01 (12.5 kg). Whereas, maximum individual fruit weight was observed in VRPK Sel-11-01 (7.25 kg) followed by VRPK-09-01 (4.80 kg) at mature stage. On the basis of overall performance VRPK-01, VRPK-230, VRPK-222-2-1 and VRPK-09-01 was found promising.

Maintenance breeding

Five kg seeds of Kashi Harit variety of pumpkin were produced and 40 SPS were selected for maintenance of the variety.

Melons

Response of muskmelon genotype against water deficit based on physiological parameters

Screening of eight muskmelon genotypes was conducted and performance of these genotypes observed for physiological responses. Increase in days of water-deficit (DWD) negatively affected the relative water content (RWC) of both drought tolerant and drought susceptible genotypes. Drought tolerant genotype MJ-7 showed minimum reduction in RWC and respective declination was 6.90%, 20.40% and 22.79% at 7, 14 and 21 DWD. While RWC reduced maximally in drought susceptible genotype IIHR-595 under similar water-deficit (WD) condition and respective RWC reduction of 51.87%, 83.85% and 138.45% recorded (Table 25). Data indicates that drought tolerant genotype had less increase in EL compared to drought susceptible genotype. Maximum 24.46%, 48.03%, 56.79% and minimum 10.69%, 35.58%, 47.39%, EL was recorded at 7, 14 and 21 DWD for IIHR-595 and MJ-7, respectively. Increasing WD adversely affected photosynthetic rate and stomatal conductance in each genotype. Maximum photosynthesis was recorded in MJ-7 (8.86 µmol m^{-2} s^{-1}) while it was minimum for IIHR-595 (0.783 µmol m^{-2} s^{-1}) at the end of 21 DWD (Table 26). Stomatal conductance reduced minimally in MJ-7 at all stages of water-deficit

Table 25: Effect of elevated water-deficit on relative water content and electrolyte leakage of muskmelon genotypes

Genotype	Relative water content (%)					Electrolyte leakage (%)		
	0 Days	7 Days	14 Days	21 Days	0 Days	7 Days	14 Days	21 Days
Arka Jeet	64.7 ± 2.43	56.4 ± 2.32	46.1 ± 1.47	41.2 ± 1.81	23.7 ± 0.60	27.5 ± 1.18	38.9 ± 1.09	38.3 ± 1.28
IIHR-663	76.7 ± 3.10	59.0 ± 3.37	43.2 ± 1.48	36.9 ± 2.44	31.5 ± 0.54	46.8 ± 0.85	46.1 ± 1.64	63.0 ± 1.40
Dharwad Selection	64.5 ± 2.39	54.5 ± 2.40	42.8 ± 2.88	35.3 ± 1.06	22.0 ± 0.44	29.4 ± 0.68	35.3 ± 0.64	38.7 ± 0.85
Hara Madhu	66.2 ± 3.89	57.2 ± 3.85	46.0 ± 2.81	34.8 ± 1.67	29.6 ± 0.60	39.0 ± 0.72	45.2 ± 1.19	50.2 ± 1.37
IIHR-595	74.0 ± 2.42	55.9 ± 1.76	38.5 ± 1.57	32.0 ± 1.48	29.4 ± 0.50	44.7 ± 0.84	54.0 ± 0.60	70.1 ± 1.49
MJ-7	74.1 ± 2.73	69.9 ± 2.81	59.7 ± 2.35	58.0 ± 3.92	22.6 ± 0.51	25.1 ± 1.06	30.7 ± 0.42	33.4 ± 0.76
BS-25	74.8 ± 3.26	66.7 ± 4.07	57.9 ± 1.83	54.6 ± 1.57	21.7 ± 0.73	26.9 ± 0.67	31.4 ± 0.46	35.7 ± 0.70
IIHR-659	72.0 ± 4.29	58.1 ± 2.57	43.3 ± 1.60	36.7 ± 2.61	27.6 ± 0.98	37.3 ± 1.21	46.4 ± 0.74	54.1 ± 1.11

Table 26: Effect of elevated water deficit on photosynthetic activity and stomatal conductance of muskmelon genotypes

Genotype	Photosynthetic rate (µmol m^{-2} s^{-1})				Stomatal conductance (mmol m^{-2} s^{-1})			
	0 Days	7 Days	14 Days	21 Days	0 Days	7 Days	14 Days	21 Days
Arka Jeet	13.2 ± 0.91	10.6 ± 0.40	7.3 ± 0.14	5.1 ± 0.14	1.18 ± 0.032	1.02 ± 0.009	0.81 ± 0.028	0.68 ± 0.015
IIHR-663	7.2 ± 0.24	4.7 ± 0.35	3.3 ± 0.16	2.3 ± 0.10	1.08 ± 0.030	0.82 ± 0.015	0.60 ± 0.019	0.46 ± 0.022
Dharwad Selection	5.0 ± 0.38	3.7 ± 0.07	2.4 ± 0.13	1.7 ± 0.10	1.25 ± 0.023	1.08 ± 0.009	0.73 ± 0.011	0.66 ± 0.018
Hara Madhu	13.3 ± 1.19	9.4 ± 0.21	7.0 ± 0.37	4.8 ± 0.23	1.09 ± 0.017	0.91 ± 0.015	0.61 ± 0.009	0.52 ± 0.026
IIHR-595	3.2 ± 0.10	1.8 ± 0.05	1.2 ± 0.08	0.8 ± 0.04	0.85 ± 0.009	0.60 ± 0.006	0.46 ± 0.009	0.35 ± 0.009
MJ-7	18.4 ± 0.73	14.9 ± 0.80	10.8 ± 0.26	8.86 ± 0.17	1.09 ± 0.015	0.99 ± 0.031	0.76 ± 0.010	0.70 ± 0.015
BS-25	5.0 ± 0.13	4.0 ± 0.18	2.8 ± 0.13	2.2 ± 0.04	1.55 ± 0.015	1.34 ± 0.015	0.98 ± 0.066	0.85 ± 0.025
IIHR-659	4.3 ± 0.22	3.0 ± 0.07	1.9 ± 0.15	1.3 ± 0.08	1.15 ± 0.013	0.87 ± 0.009	0.64 ± 0.018	0.49 ± 0.021

treatment. Compared to well-watered plants reduction in stomatal conductance was 13.56%, 31.36% and 42.40% in MJ-7 at 7, 14 and 21 DWD respectively. While drought susceptible genotype IIHR-595 had maximum declination of 29.42%, 45.58% and 58.82%, respectively, at similar stages of WD.

Summer Squash

Maintenance and evaluation of advanced lines of summer squash

Four promising advanced lines along with a check of *Cucurbita pepo* (summer quash) and five segregating lines were evaluated. Among the evaluated lines, VRSS-10-66 and VRSS-06-12-01 was found promising.

Project 1.6: Genetic Improvement of Okra

Evaluation of hybrids: Twenty-two hybrids were evaluated in rainy season for yield and disease reaction along with susceptible check Pusa Sawani. The hybrid VRO-6 x VRO-107 was earliest and took 41 days for 50% flowering. Maximum number of fruits and yield per plant (g) was harvested from VRO-109SPS x VRO-109-1 (19.7, 216g) followed by VRO-109 x SB-2 (19.4, 213g) (Table 27). The percent disease incidence in susceptible check varied from 70-90% for YVMV and 40-55 % for OELCV.

Evaluation of advanced lines: A total of 30 advanced lines were evaluated for yield and disease reaction. Among these the lines VRO-111 and VRO-112 were found promising for all the characters (Table 28).

Table 27: Performance of superior F_1 hybrids in okra

Crosses	Days to 50% flowering	No. of Fruits/ plant	Fruit yield/ plant (g)	YVMV (%)	YVMV (%) (transformed)	OELCV (%)	OELCV (%) (transformed)
VRO-102 x VRO-5	47	16.1	169	13.6	21.64	9.8	18.24
VRO-101 x SB-2	46	16.3	179	16.4	23.89	7.3	15.68
SB-8 x VRO-101	47	17.5	184	3.3	10.47	8.0	16.43
VRO-3 x SB-2	46	15.6	187	15.1	22.87	13.5	21.56
747-3-1 x SB-2	47	15.5	147	15.7	23.34	12.0	20.27
VRO-6 x VRO-107	41	16.9	152	14.2	22.14	15.6	23.26
SB-8 x VRO-102	46	16.3	155	5.1	13.05	8.6	17.05
VRO-109 x SB-2	45	19.4	213	3.2	10.30	2.7	9.46
VRO-109SPS x VRO-109-1	44	19.7	216	2.9	9.80	1.8	7.71
HOK-152 (C)	51	17.8	171	13.6	21.64	7.9	16.32
CD	6.53	4.34	13.21	2.51	2.46	1.52	2.34
CV	8.30	14.87	4.34	14.27	8.00	10.22	8.21

New Long melon Variety identified

An early and high yielding variety of long melon (VRSLM-16) developed through selection from local material at IIVR – Regional Research Station (RRS), Sargatia, Kushinagar have been identified by AICRP for release for Zone IV (Bihar, UP, Jharkhand and Punjab). The average fruit length and fruit weight of this variety is 30 cm and 50-60g, respectively. The fruit is crispy, light green coloured with smooth prominent ridges. It has average yield of 175-200 q/ha.

Table 28: Characteristics of promising advanced lines VRO-111 and VRO-112

Advance line	Days to first flowering	Node to first flower	Fruit colour	Fruit length (cm)	Fruit diameter (cm)	Fruits per plant	Resistance to disease
VRO-111 (AE-70)	40-43	4-5	Dark green	11-12	1.4-1.5	17-19	YVMV & OELCV
VRO-112	38-40	3-4	Green	12-13	1.4-1.5	19-21	YVMV & OELCV

Okra accessions with seven and nine ridges identified

While screening 1225 okra accessions for various agro-morphological characters during *kharif*-2015 at ICAR-IIVR, Varanasi; an accession, IC-117090 having fruit with 9 ridges was identified (Figure 18). Besides, three more accessions, IC-117088, IC-117245 and IC-117333 were also identified having seven ridged fruits. Further, all these accessions were again grown during summer-2016 for validation, evaluation and characterization. As observed earlier, the accession IC-117090 showed stable expression of nine ridges on its fruit, while other three accessions (IC-117088, IC-117245 and IC-117333) showed seven ridges.

The genotype IC-117090 is being used in breeding programme so as to achieve the goal of getting genotypes having nine-ridges along with high yield and viral disease resistance.

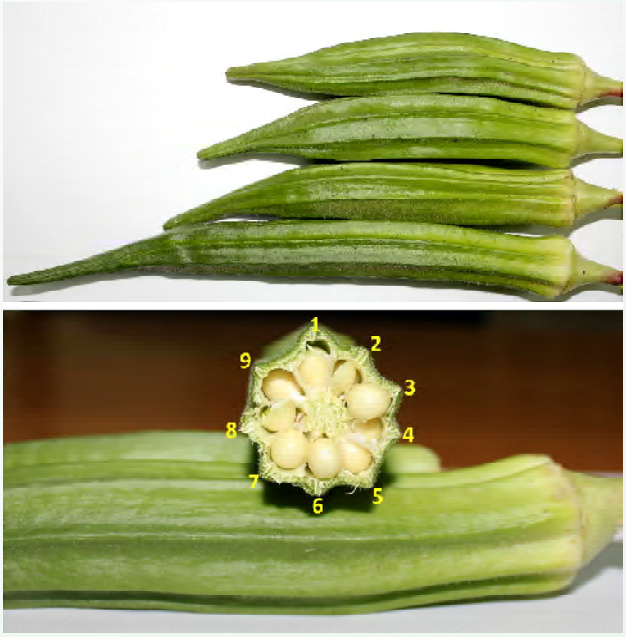


Fig. 18 : Okra accession IC-117090, having nine-ridges on its fruit

Mechanisms of physical and biochemical basis of resistance against leaf-hopper (*Amrasca biguttula biguttula* Ishida): Different biophysical parameters *viz.*, trichomes, leaf length, angle between the mid-ribs, angle between the mid-ribs and vein, mid-rib thickness, leaf angle, number of leaves per plant, plant height and biochemical parameter like total phenol content of leaves were studied in relation to the expression of reaction towards leaf hopper in ten okra genotypes. It was observed that genotype SB-6 had relatively lower number of trichomes on leaf lamina (10.11), mid-rib (7.17) and vein (8.05) showed highly susceptible as compared to tolerant genotype VROB-181 which had

Table 29: Morphological and biochemical parameters of different okra genotypes with jassid incidence

Genotypes	Jassids / Leaf	Trichomes			Leaf length (cm)	Angle between the mid ribs (°)	Angle between the leaf vein and mid rib (°)	Mid rib thickness (mm)	Leaf angle (°)	Total leaf / plant	Plant height (cm)	Phenol (mg / 100 g)
		Mid rib	Lamina	Vein								
SB-6	17.57	7.17	10.11	8.05	22.57	59.7	45.3	1.53	57.86	23.3	84	42.61
SB-8	9.71	8.33	9.95	6.67	20.42	43.2	47.1	1.59	59.71	33.3	101.7	54.43
SB-10	15.57	5.17	8.51	5.13	25.65	43.6	48.8	1.75	57.14	28.4	92.6	48.35
VROB-178	5.71	13.5	15.98	9.83	21.05	41.3	43.1	1.51	60.14	28.1	55.3	59.57
VROB-179	6.57	10.5	13.83	10.83	22.04	46.4	46	1.54	54.00	36.8	62.3	49.74
VROB-181	5.43	9.17	11.85	9.95	22.43	35.7	45.2	1.58	55.57	29.3	67.8	75.04
VROR-157	7.71	12.17	15.39	11.67	23.61	39.6	42.5	1.47	55.29	36.5	55	53.57
VROR-159	5.55	9.6	8.45	9.75	20.1	32.4	38.1	1.55	60.57	37.5	84.7	51.13
VROR-160	8.43	6.33	9.33	7.27	22.15	40.2	46.5	1.57	59.57	23.4	59.2	58.61
VROT-108	10.57	7.85	16.35	12.65	26.28	36.7	38.7	1.68	62.43	36.4	62	63.13
SEM	1.39	0.86	0.91	0.78	0.46	1.16	0.53	0.07	0.35	0.99	1.98	1.22
CD (P=0.05)	3.47	2.15	2.28	1.95	1.15	2.89	1.33	0.19	1.01	2.67	4.95	3.08
F-test	--	S	S	S	S	S	NS	S	NS	S	S	S
Correlation coefficient (r) with jassid	--	-0.678	-0.343	-0.507	0.493	0.723	0.378	0.458	0.056	0.474	0.499	-0.577

11.85, 9.17 and 9.95 trichomes per cm^2, respectively (table 29). Susceptible cultivar SB-10 possessed higher mid-rib thickness (1.75 mm) and leaf length (25.65 cm) as compared to tolerant genotype VROB-181 (1.58 mm and 22.43 cm, respectively). Similarly, higher number of total leaves (31.9) per plant was also recorded from SB-6 as compared to other tolerant lines (VROB-181, VROB-178, and VROR-160). Leaf length, leaf angle, plant height, angle between mid-ribs and total leaves showed a positive correlation (r value = 0.493, 0.056, 0.499, 0.723 and 0.474, respectively) with jassid incidence. Amongst the biochemical parameter, total phenol showed negative correlation (r = - 0.577) with the jassid incidence and the susceptible genotypes *viz*., SB-6 (42.61 mg/100 g) and SB-10 (48.35) had significantly lower total phenol content than the tolerant VROB-181 (75.04).

Generation advancement: Several progeny families in different stages of inbred development were grown, selection was exerted on single plants for desired traits and seeds were collected for further advancement of generation ($F_{2:}$11, $F_{3:}$10, $F_{4:}$23, $F_{5:}$14, F6:10, $F_{7:}$06, $F_{8:}$04, F_9: 03 and $F_{10:}$04). The targets traits were dark green fruit colour, small fruit size and resistance/ tolerance to YVMV/ OELCV.

Maintenance breeding: The maintenance breeding of okra varieties released by IIVR *viz*. Kashi Kranti, Kashi Pragati, Kashi Sathdhai, Kashi Lila, Kashi Vibhuti and Kashi Vardaan were done through true to type single plant selection. The fruits of the selected plants were covered with butter paper bag and seeds were harvested.

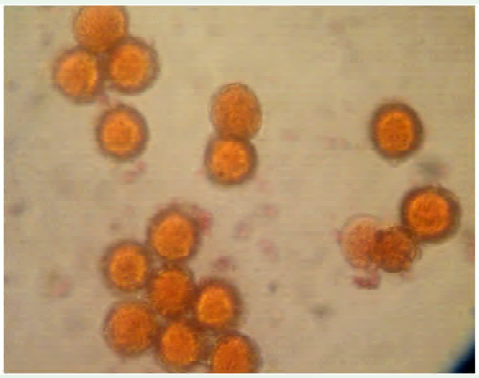
Project 1.7: Genetic Improvement of Cauliflower

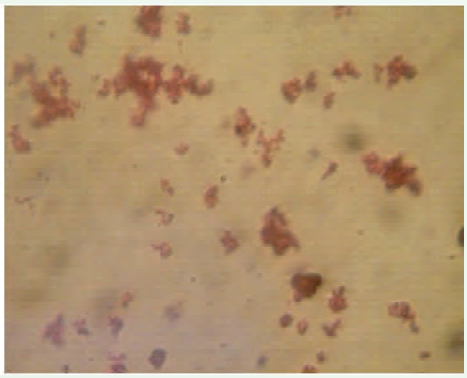
Fifty-four genotypes, including 10 advanced lines, were evaluated to screen out the promising lines for September, October, November and mid-December maturity group. Among them, the genotypes VRCF-86 and VRCF-201 were the potential yielder in October maturity (22-32 °C); VRCF-50, VRCF-75, VRCF-37 and VRCF-102 in mid-November maturity (16-28 °C); and VRCF-2, VRCF-202, VRSCF-77 and VRCF-104 were found to be better in late-November to mid-December maturity group (11-22 °C). The genotype VRCF-86 showed curd yield potential of 130-150 q/ha having small frame size: 30-40 cm, short duration: 55-60 days, net curd weight: 330-350 g, marketable curd weight: 425-500 g, gross plant weight: 850-1050 g, curd size: 6.2-7.0×9.5-11.1 cm, and medium-compact cream-white curds. Moreover, VRCF-50 (Figure 19a) revealed curd yield potential of 210-225 q/ha having net curd weight: 475-525 g, gross plant weight: 1100-1250 g, curd size: 8.2-9.0×13.0-16.1 cm, maturity period of 70-75 days along with compact and white curds; and VRCF-2 had curd yield potential: 250-280 q/ha, net curd weight: 540-625 g, gross plant weight: 1150-1500 g, curd size: 9.5-11.0×14.0-17.5 cm, maturity period of 75-85 days, self-blanched curd along with compact and snow-white curds. Under efforts for transferring male sterility in cauliflower, generations have been advanced to BC_2F_1 and BC_1F_1 stages in different curd maturity groups (Early, Mid and Mid-late maturity) through back-crossing to transfer male sterility CMS system (Fig. 19b).

Project 1.8: Transgenic and Regeneration Protocols

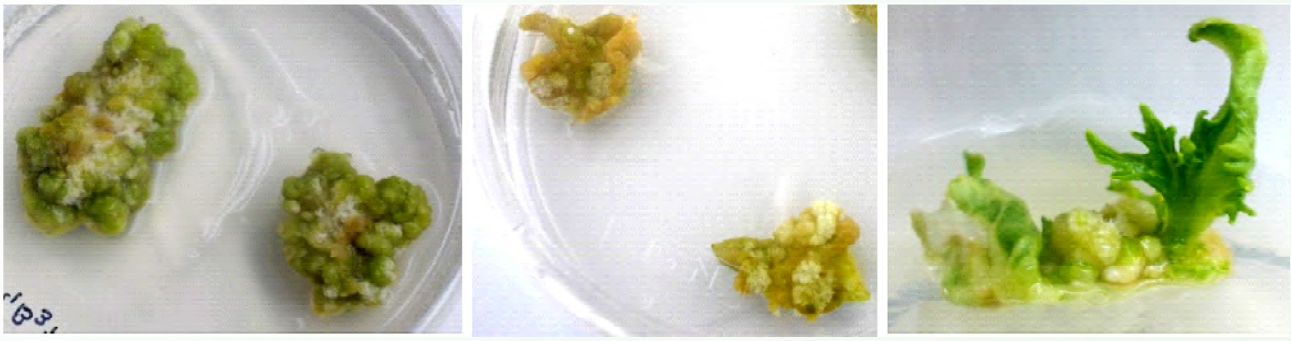
Optimization of *Agrobacterium* -mediated genetic transformation of bitter gourd (*Momordica charantia L.)*: Surface sterilized seeds of bitter gourd (*Momordica charantia* L.) were grown *in-vitro* on 1/2 MS + 0.5 mg l^{-1} TDZ + 25 mg l^{-1} Kanamycin and 0.5 mg l^{-1} TDZ + 100 mg l^{-1} Kanamycin Shoot induction was observed on 0.5 mg l^{-1} TDZ + 100 mgl^{-1} Kanamycin on half strength of MS medium. 10-12 days old seedling derived cotyledonary leaves were used as explants for transformation. Cotyledonary 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

Fig. 19: a) VRCF-50





19: b) Stained pollen grain of male fertile and sterile plant



0.5 mg l^{-1} TDZ + 25 mg l^{-1} Kanamycin | 0.5 mg l^{-1} TDZ + 100 mg l^{-1} Kanamycin | Shoot induction on 0.5 mg l-1 TDZ + 100 mgl-1 Kanamycin

Fig. 20: Shoot induction in different concentration of TDZ and kanamycin

transformation and the overall gene transfer efficiency such as effect of explant age, different regimes of plant growth regulators, initial selection pressure, pre-culture 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 cotyledonary leaf explants grown on MS medium supplemented with 0.5 mg/l TDZ (Figure 20). 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, 30 explants were used. At 25 mg/l, 30% and at 50 mg/ 18% callus induction was noted. Further increase in kanamycin concentration (100 mg/l) completely inhibited callus induction. The effect of pre-culture (1-4 days) on the frequency of transformation in *M. charantia* was examined on MS medium supplemented with 0.5 mg/l TDZ. On bacterium inoculation, pre-culture for one day resulted in 90% death of explants. Two days of pre-culture improved to some extent but 75% explants turned to necrotic after three days of culture. Three days of pre-culture resulted in survival of 40% explants after inoculation. Four days of pre-culturing resulted into bulging at the cut ends of explants which may inhibited incorporation of *Agrobacterium*. Thus three days of pre-culturing of explants was found to be favorable for transformation. The duration of the co-cultivation period with bacteria affected the infection frequency. Optimum no. of days (1-5) required for the co-cultivation of explant for transformation was optimized. Extended co-cultivation (4-5 days) increased the transformation efficiency and longer co-cultivation periods frequently resulted in *Agrobacterium* overgrowth and subsequent death of explants. Co-cultivation for three days was found to be suitable for the genetic transformation.

Regeneration protocol in okra (*Abelmoschus esculentus* L. Moench)

Surface sterilized seed of okra, cv. Kashi Kranti were grown *in-vitro* on half strength of MS medium. For regeneration purpose hypocotyl, cotyledon and meristematic tissue were selected as explants from 5-15 old seedlings. A total of 112 combination of media supplemented with different concentration of plant growth regulators were tested for regeneration response. Plant growth regulators BA, 2iP, 4-CPPU, TDZ were used in combination with IAA ranging 0.1-5.0 mg/*l*. In all the tested combination only callus and root were induced (Figure 21). Callus induced in all combination of IAA, BA and 2iP were light green,

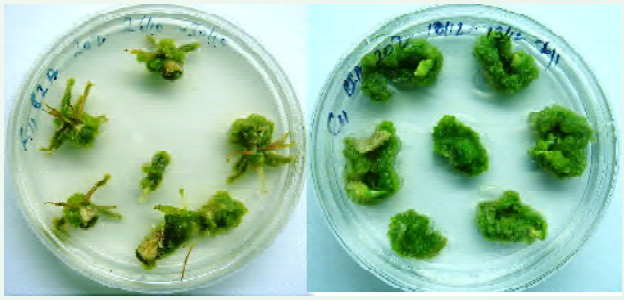


Fig. 21: Hypocotyls and cotyledon explants on MS medium supplemented with 2.0 mg/l BAP and 0.2 mg/l IAA

Fig. 22: Dark green nodular callus induced on hypocotyl explant MS medium supplemented with 1.0 mg/l 4-CPPU and 0.2 mg/l IAA

Fig. 23: Dark green callus on hypocotyl explant on MS medium supplemented 1.0 mg/l TDZ and 0.2 mg/l IAA

globular and friable while in NAA, TDZ and CPPU were dark green, compact and larger in size in comparison to both BA and 2iP (Figure 22). On all the combination of medium tested for regeneration, hypocotyl and cotyledon explants induced only callus or root or both. The IAA in combination with BA and 2iP induced light green, globular and friable callus while on the combination of IAA with TDZ and 4-CPPU induced dark green, nodular and compact callus (Figure 23). The callus induction frequency were higher than BA and 2iP in TDZ and 4-CPPU. The root induction frequency were higher in the combination supplemented 0.1- 0.2 mg/*l* IAA and 1.0-2.0 BA or 2iP, the rooting were prominent in 2iP supplemented medium than BA.

Micro-propagation of seedless pointed gourd : In order to get disease free planting material of seedless pointed gourd (VRP 101), micropropagation studies has been initiated. Different experiments were conducted for refinement of technique for aseptic culture establishment under *in vitro* conditions (Figure 24). The results are presented in Table 30.

***In planta* transformation protocol in tomato:** In an effort to develop *in planta* transformation protocol in tomato, germinating seeds were co-cultivated with

Table 30. Effect of different sterilizing agents on surface sterilization of nodal explant of VRP 101

S.No	Sterilizing Agent					Results
	Outside LAF		Inside LAF			
1	TWW/30 min	Stirring in 0.5% Bavistin	70% Ethanol/30 Sec.	0.5% NaOCl + 0.5% T20 /5 min		Contamination F&B
2	TWW/40 min	Stirring in 0.5% Bavistin	70% Ethanol/30 Sec.	0.75% NaOCl+ 0.5% T20/5 min		Contamination F&B
3	TWW/50 min	Stirring in 1% Bavistin	70% Ethanol/30 Sec.	1.00% NaOCl + 0.5% T20/10 min		Contamination F&B
4	TWW/60 min	Stirring in 1% Bavistin + Strep 100ppm	70% Ethanol/30 Sec.	1.00% NaOCl + 0.5% T20/10 min	0.2% HgCl2	Contamination B
5	TWW/120 min	Stirring in 1% Bavistin + Strep 200ppm	70% Ethanol/30 Sec.	2.00% NaOCl + 0.5% T20/10 min	0.2% HgCl2	Explant burning No Contamination
6	TWW/130 min	Stirring in 1% Bavistin+ Strep 500ppm	70% Ethanol/30 Sec.	1.00% NaOCl + 0.5% T20/10 min	0.2% HgCl2	No Contamination

TWW= Tap Water Washing, LAF= Laminar Air Flow, Strep= Streptomycin, T20= Tween 20, F&B= Fungal and Bacterial

Fig. 24 A: Culture initiation from nodal explant of seedless pointed gourd; B: culture growth after 15 days of inoculation; C: 45 days old shoots ready for multiplication

Fig 25: Agro inoculated tomato seeds germinating and growing on selection medium

Agrobacterium tumefaciens strain LBA 4404 harboring the binary vector pBinAR. The vector contains *npt II* gene linked to CaMV 35S promoter. In short surface sterilized seeds were vacuum infiltrated with agro inoculum for different timings (Figure 25). Treated seeds were grown on selection medium containing kanamycin and cefotaxime. Seeds germinated and able to grow on selection medium have to be further cheecked for integration of the *npt II* gene.

Project 1.9: Biotechnological interventions for improvement of selected vegetable crops

Marker assisted selection for development of tomato lines resistant to tomato leaf curl virus disease: Marker assisted selection was employed to select *Ty-3* lines from different intraspecific crosses. Large F_2 populations consisting of 200 plants were grown for three crosses that were developed using superior parents. Combination of marker assisted selection and pedigree selection was used to select 22 F_2 plants and F_3 families derived from each of the selected F_2 plants were grown. A total five lines carrying *Ty-3* allele were selected following within family selection. Pedigree selection was performed based on the visual selection criteria for horticultural traits.

Development of tomato hybrids resistant to tomato leaf curl virus disease: A total of 30 hybrids were developed based on combination of *Ty-2* and *Ty-3* lines and these will be evaluated during both early and main tomato growing seasons. The parental lines used in the generation of these hybrids included previously developed *Ty-2* and *Ty-3* carrying lines. Marker assays were performed on both the seed and pollen parent plants using the *Ty-2* and *Ty-3* diagnostic markers. The plants that were positive for these diagnostic markers were selected for hybridization.

Embryo rescue for isolating *S. lycopersicum* × *S. arcanum* interspecific hybrid: The *S. arcanum* accession LA2157 was crossed with tomato cultivar Kashi Amrit. The interspecific hybrid was successfully isolated using embryo rescue. The embryo rescued plants were tested for hybridity using morphological features and marker assay. The difference in the morphology of leaf, inflorescence and fruits confirmed the hybridity of the plant. Similarly, the marker assay performed using CAPS marker located on chromosome 1 of tomato also confirmed the hybridity (Figure 26).

***In silico* analysis of 89 *WRKY* transcription factors in tomato:** Meticulous examination of WRKY domains, zinc finger domains and sequence alignment was done for proposing new classification and to clear ambiguities in nomenclature of WRKY TFs. As a consequence, fifteen SlWRKY proteins of Group 1 (earlier known as Group I) have been numbered from SlWRKY1 to SlWRKY15, sixty two proteins of Group 2 (earlier known as Group II) have been numbered from SlWRKY16 to SlWRKY77. Similarly, twelve proteins of Group 3 (earlier known as Group III) have been numbered from SlWRKY78 to SlWRKY89. Alignment result of WRKY proteins of each group was further thoroughly analyzed and it was found that 9 SlWRKY TFs had divergence in the typical "WRKYGQK" signature motif which may be assumed as the consequence of mutations during the process of evolution. Among these, the most common divergent motif was "WRKYGKK". N-terminal and C-terminal domains of Group 1 SlWRKY proteins were distinguished by the stretch of amino acids on zinc finger domain. Group 1-N domain contains C-X4–C–

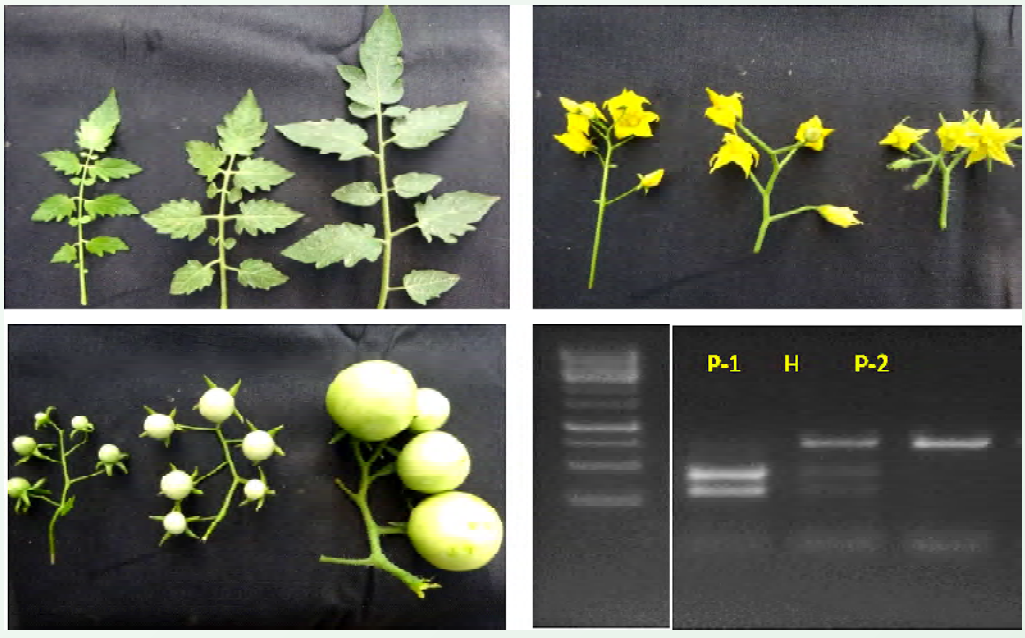


Fig 26: Differences in leaf and inflorescence morphology and marker analysis (CAPS marker: C2At3g12685 digested by Msp-I) between the parents and embryo rescued interspecific hybrid. The interspecific hybrid leaf, inflorescence, fruit and DNA sample are in the middle of the each picture in the panel.

X22–H–X1–H structure while Group 1-C domain contains C-X4–C–X23–H–X1–H stretch of zinc finger. The previous classification of Group II proteins was further simplified and new classes were proposed where, Group II d and II e were merged into a single group named as Group 2.1. Similarly Group II c was renamed as Group 2.2 and Group II a and II b were clubbed into Group 2.3. Group 2.1 and Group 2.3 proteins have C-X5–C–X23–H–X1–H structure while Group 2.2 proteins have C-X4–C–X23–H–X1–H structure of zinc finger domain. Group 3 SlWRKY proteins have a rather different type (i.e. C-X7–C–X23–H–X1–C) of zinc finger domain. Amino acid composition analysis of all the 89 SlWRKY proteins revealed the maximum mole % of serine with 12.1% share, followed by asparagine (7.2%) and lysine (6.6%), while tryptophan was lowest with 0.7% share. Among amino acid properties of SlWRKY proteins, average isoelectric point is 7.312. Average mole % of aliphatic and aromatic amino acids is 15.17 and 10.04, polar and non-polar amino acids is 56.63 and 43.36, and basic and acidic amino acids is 14.28 and 11.64 respectively.

Evolutionary relationship among WRKY family proteins: Phylogenetic analysis of tomato WRKY proteins revealed similarity among various classified groups. Ignoring SlWRKY41, SlWRKY56, SlWRKY57, and SlWRKY58 belonging to Group 2.2, all other SlWRKY proteins were clustered together in their respective groups (Figure 27). Evolutionary relationship between the WRKY transcription factors of tomato was compared with that of Arabidopsis and potato separately. For this purpose, protein sequences of Arabidopsis (*Arabidopsis thaliana*) and potato (*Solanum tuberosum*) WRKY TFs were retrieved from "PLANTTFDB". Among 90 sequences of Arabidopsis retrieved from PLANTTFDB, one sequence (AT2G40740.2) was found to have no conserved WRKY stretch. Thus, only 89 WRKY TFs of Arabidopsis were selected for assessment of evolutionary relationship with tomato. Similarly, among 125 sequences of potato, 9 sequences were found to be ambiguous without WRKY conserved stretch and, thus only 116 WRKY sequences were selected for the evolutionary study with tomato. Evolutionary history of tomato and Arabidopsis, inferred using the neighbor-joining method, indicated fairly close association among the WRKY proteins of various classes. In case of tomato and potato, a high degree of association was observed among the WRKY proteins. Highest intensity of similarity was noticed among the members of Group 2.2 while Group 3 WRKY proteins revealed lowest level of association.

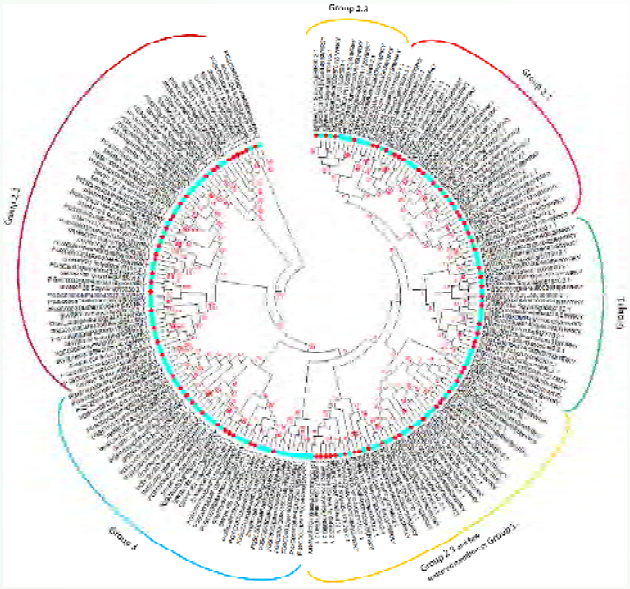


Fig. 27: Phylogenetic relationships among WRKY transcription factors of *Solanum lycopersicum* and *Solanum tuberosum*

Expression analysis of 67 *WRKY* genes: Sixty seven genes selected for quantitative real time PCR analysis represented all the classified groups. qRT-PCR results were analyzed for any characteristic expression pattern that can be revealed by a single group (Figure 28). In view of this, it was found that all the members of Group 1 *SlWRKY* genes were up-regulated except *SlWRKY13*. The expression of *SlWRKY13* was also not much down-regulated. This suggests all Group 1 genes are induced in drought and may be useful targets for development of drought tolerance in plants. Most of the genes of Group 2.1 were up-regulated with only three genes showing down-regulation. Up-regulation observed among the members of this group was highest for *SlWRKY32* followed by *SlWRKY29*. Group 2.2 members also exhibited mixed pattern of expression but down-regulation was not very much significant as it was less than 2 fold. Three members viz. *SlWRKY46*, *SlWRKY47* and *SlWRKY57* of Group 2.2, showed considerable up-regulation. Therefore, it can be stated that members of Group 2.1 and 2.2 will generally show up-regulation in drought situation. In case of Group 2.3 only one gene, *SlWRKY69*, was highly up-regulated (36 fold) while other genes showed mixed pattern of expression. Thus any characteristic expression pattern could not be established for Group 2.3 *SlWRKY* genes. The most peculiar result was observed in Group 3 where a single gene, *SlWRKY82*, was exceedingly up-regulated (125 fold) while almost all other members were found to be down-regulated. The other two genes, *SlWRKY80* and *SLWRKY83*, of this group also showed slight up-regulation.

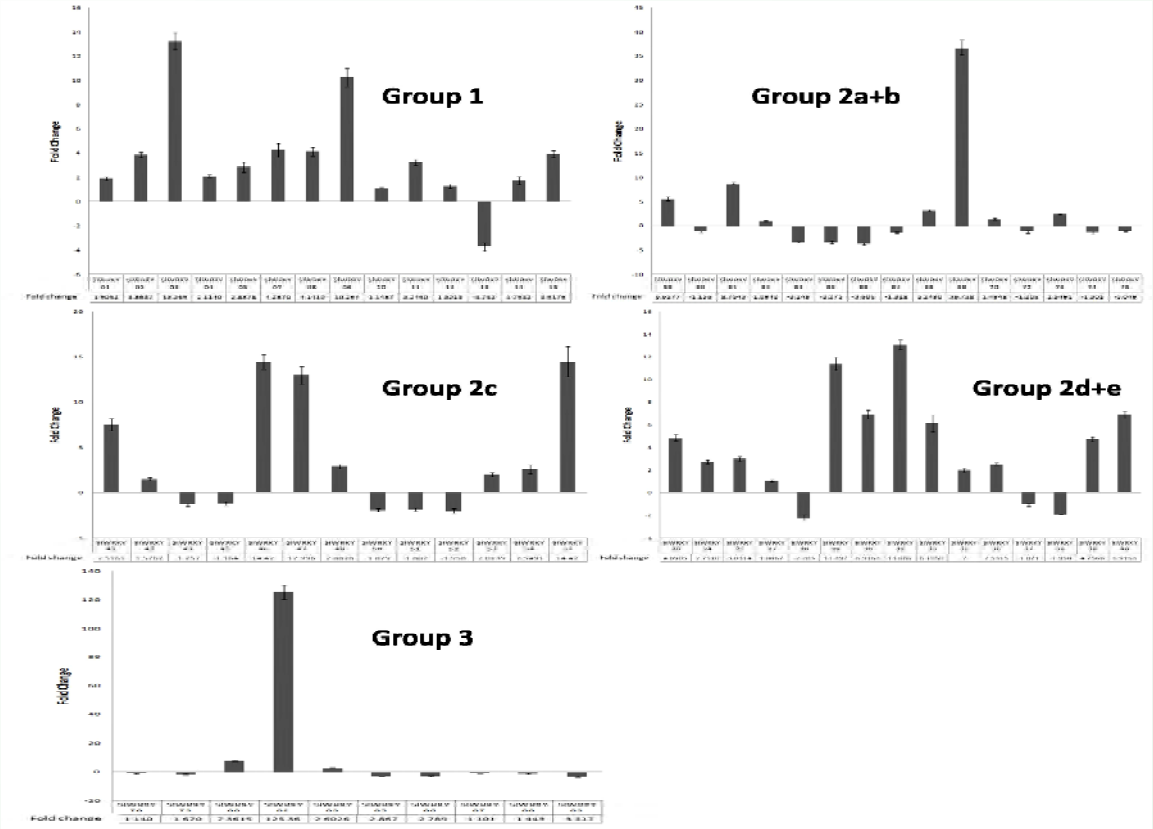


Fig. 28: Expression analysis of WRKY transcription factors in tomato

Study of proline rich proteins in tomato: Microarray experiment in previous studies in tomato revealed a drastic down-regulation of proline rich protein (PRP) under drought stress condition. PRPs are important cell wall proteins with diverse roles in different plant species. PRPs are involved in plant growth and regulation right from germination of seeds to cell death. They play main role in both biotic and abiotic stresses. Its expression is up-regulated in cold, salt and heat stress while interestingly it is down-regulated in drought or osmotic stress. This prompted us to further investigate tissue specific expression of PRP gene.

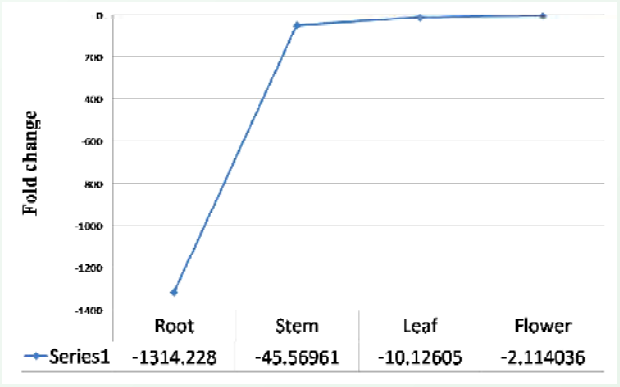


Fig. 29: qPCR expression of SlPRP in various tissues of tomato

Water stress was given to one month old plant by withholding irrigation till the appearance of stress symptoms in plants. Quantitative real time PCR was carried out for PRP gene in both control and stressed plants. Highest down-regulation of PRP was detected in root tissues followed by stem and leaf (Figure 29).

Genome editing in tomato: Reverse genetics is one of the most widely used methods for molecular understanding of genes and their functions. This requires development of mutant plants of a desired gene which is a difficult task. The most recent tool of genome editing, CRISPR/Cas9, has accelerated this process with simple steps. The work on standardization of genome editing protocol in tomato for basic studies has been initiated. For this purpose, CRISPR vectors containing Cas9 nuclease and a gRNA for targeting the desired gene will be used. Presently 2 genes are selected as target genes to develop mutant plants.

Genotype of 114 RILs in brinjal: 894 primers were screened for identification of polymorphic primers between parental lines of RILs. 138 (15.43%) primer pairs were identified polymorphic (Table 31) and 83 were used for genotyping of RILs (Figure 30).

Table 31. Primers for polymorphism studies in RILs of brinjal

Marker systems	Primers used for parental polymorphism survey	Polymorphic primers among parental lines identified	Genotyping of RILs population done
Anchored ISSR	40	10	10
STMS	88	18	16
SSR	320	24	24
SCoT	96	18	15
Transcriptome derived SSR markers	350	68	18
TOTAL	894	138 (15.43%)	83

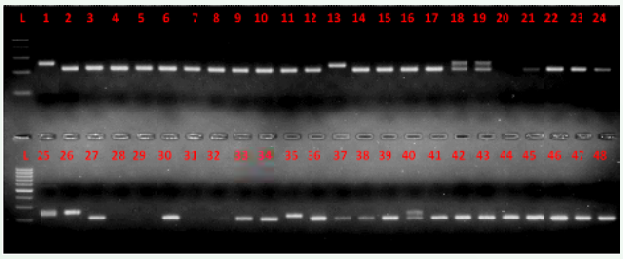


Fig. 30: Amplification of parents P1, P2 and RILs as produced on Agarose gel by STMS primer eme08D09. **Lane L: Ladder 100 bp; Lane P1: S.melongena; Lane P2: S.incanum; Lanes1-114: RILs**

Standardization of DNA isolation protocol in okra genotypes: Okra is known to be difficult crop for the isolation of good quality DNA, since it contains lots of mucilage and other polysaccharides. For DNA isolation from this complex species, the samples from different stages of plant like etiolated seedlings (Figure 31), just germinated seedlings, 10 d, 15 d and 20 d old plants were taken. Further, different DNA isolation protocols, using CTAB buffer (with and without liquid nitrogen) were used and quality of DNA was compared. Amongst all the protocols, best quality DNA was obtained (Figure 32), when etiolated seedlings were used as plant sample, and were crushed using liquid nitrogen and DNA isolation kit (Quiagen) was used for the final isolation of DNA. The quality of DNA obtained was good to be used for molecular studies.

Fig. 31: Okra seedlings used for the isolation of DNA

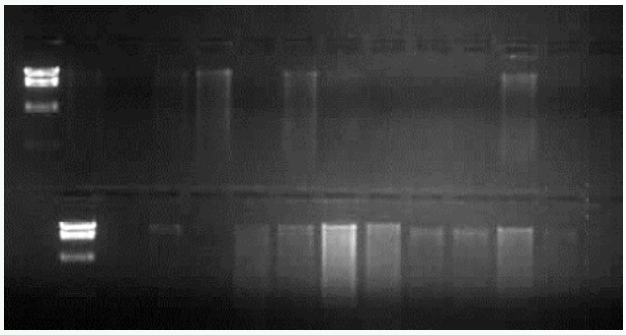


Fig. 32: Okra seedling DNA (poor quality) on 0.8% Agarose gel

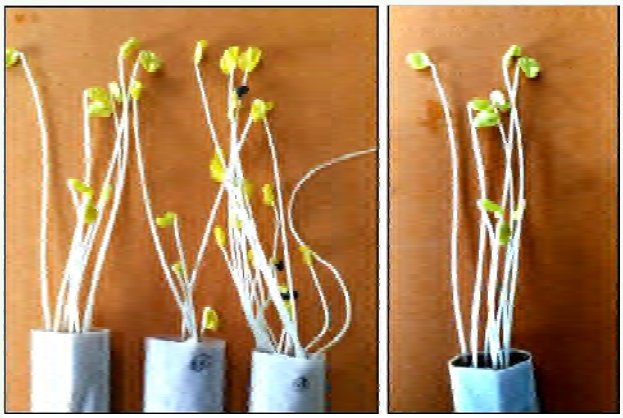


Fig. 33: Etiolated okra seedlings used for the isolation of DNA

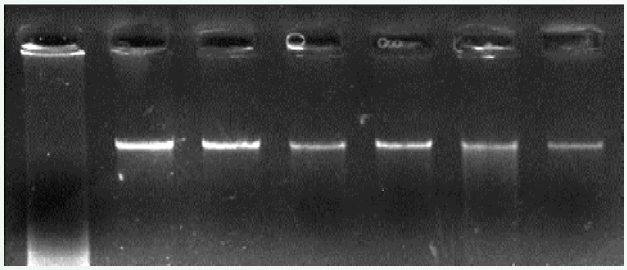


Fig. 34: Etiolated okra seedling DNA (good quality) on 0.8% Agarose gel

Once the DNA isolation protocol was standardized, the DNA isolation was started from the selected genotypes. As of now, good quality DNA has been isolated from 25 okra genotypes which include, released varieties, advanced breeding lines and germplasm lines. Further isolation of DNA from other genotypes is under progress. The aim is to perform the genetic divrsity studies in the selected genotypes so as to decipher their genetic make-up, which is not yet properly deciphered for the genomically orphan crop like okra.

Project 1.10: Genetic improvement of under-utilized vegetables, including vegetable soybean, leafy and root vegetables

Carrot

Seventeen advanced lines and fifty-one germplasm of tropical carrot for various root colour (red, orange, black, yellow and rainbow) were evaluated. The following genotypes were found to be potential root yielder along with better quality traits (self-coloured small core, smooth root, fewer secondary roots and lesser root scars), namely VRCAR-185, VRCAR-186, VRCAR-109, VRCAR-112, VRCAR-201 and VRCAR-117 (red coloured root); VRCAR-91-2 and VRCAR-91-1 (orange coloured root); VRCAR-107-2, VRCAR-171-1 and VRCAR-107-1 (rainbow-type: purple-red coloured root); VRCAR-124, VRCAR-126 and VRCAR-89-1 (black coloured root); and VRCAR-178, VRCAR-153 and VRCAR-127 (yellow coloured root). Among these, two red coloured genotypes i.e. VRCAR-185 and VRCAR-186 excelled having average root weight 106.2 g and 104.9 g, root length 20.4 cm and 20.2 cm, marketable roots 90.4% and 91.8% and self-coloured roots 89.2% and 90.1%, respectively. The seeds of VRCAR-185 and VRCAR-186 are being multiplied (Figure 35).

Fig. 35: Promising carrot genotypes VRCAR-185 and VRCAR-186

Radish

Eighteen advanced lines and thirty-seven germplasm of radish were evaluated during winter season. Among them; eight genotypes were found to be good yielder (>120 g root weight) along with better quality traits (uniform root shape, smooth root and fewer secondary roots) such as VRRAD-150 (white exterior); VRRAD-143, VRRAD-131-2 and VRRAD-160 (red exterior); VRRAD-130 (red exterior and red xylem); VRRAD-131, VRRAD-130-2 and VRRAD-135 (purple exterior); and VRRAD-151 (purple exterior and purple xylem) which have been advanced for next generation. Moreover, two promising genotypes i.e. VRRAD-150 and VRRAD-131-2 are in multi-location testing under AICRP-VC trial. The coloured-rooted radish possessed about 30-250% higher antioxidants, anthocyanin, ascorbic acid and phenolics content as compared to white-rooted cultivars. The coloured radishes are good source of phytochemicals, anthocyanin, ascorbic acid and phenolics content; and varied considerably for the different antioxidants i.e. total phenolics ranged from 12.5–65.0 mg/100 g FW (5.2-fold), anthocyanins content from 4.5–175.0 µg/g FW (38.9-fold), FRAP value from 1.15–5.90 µmol/g FW (5.1-fold), CUPRAC value from 2.75–11.50 µmol/g FW (4.2-fold) and ascorbic acid from 11.5–26.5.0 mg/100 g FW (2.3-fold). With respect to genetic emasculation, populations have been advanced to BC3F1 and BC2F1 stages in various backgrounds (leaf morphology, root shape and colour) through back-cross for transferring male sterility CMS system in radish (Figure 36).

Bathua (*Chenopodium album*)

Two genotypes of bathua, namely VRCHE-2 (green leaves and stem) and VRCHE-4 (IC0619019) (IC0619021) (purplish-green leaves and stem) have been evaluated whose harvested leaf yield potential was 350 q/ha and 400 q/ha, respectively in six pickings. Moreover, total plant growth was measured 18-20 cm, 35-40 cm, 105-110 cm, 125-130 cm, 150-160 cm & 175-190 cm; and 18-20 cm, 40-45 cm, 115-125 cm,

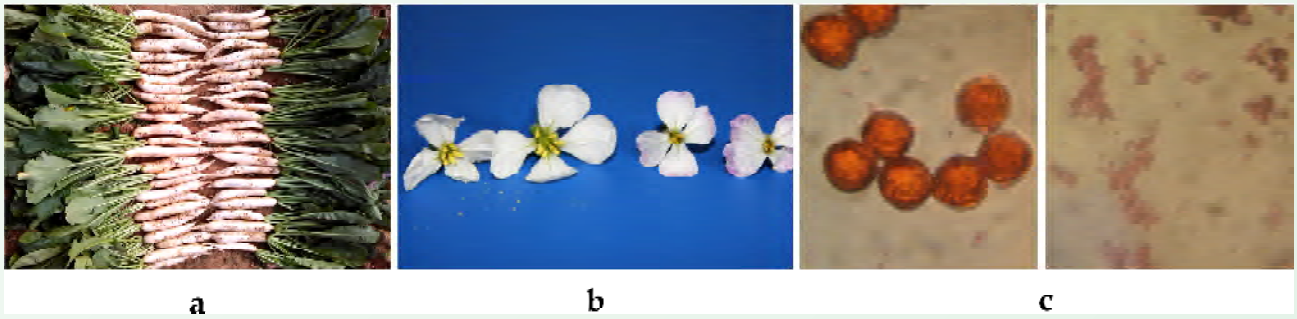


Fig. 36: a) VRRAD-150; b) Male fertile and male sterile flowers of radish, c) Stained pollen grains of male fertile and male sterile plants

VRCHE-2 (IC0619019)

Fig. 37: Promising bathua genotypes VRCHE-2

130-140 cm, 160-175 cm & 195-215 cm at 60 days, 80 days, 100 days, 120 days and 150 days after sowing for VRCHE-2 and VRCHE-4, respectively. In addition, respective plant dry matter content at edible stage was estimated 14.5-15.5% and 15.5-16.5% in VRCHE-2 and VRCHE-4. Both genotypes are under IET stage in the varietal trial of AICRP-VC and their seeds are being multiplied.

Basella

Out of the 52 genotypes evaluated for agro-morphological traits, biochemical traits were estimated in 38 genotypes. Wide range of variation was observed for total carotenoids (0.41-1.55 mg/g fresh wt), total phenol (77.33-285.67 GAE/100g) and antioxidant activity measured through CUPRAC (4.97-24.74µmol TE/g) as presented in Figure 38.

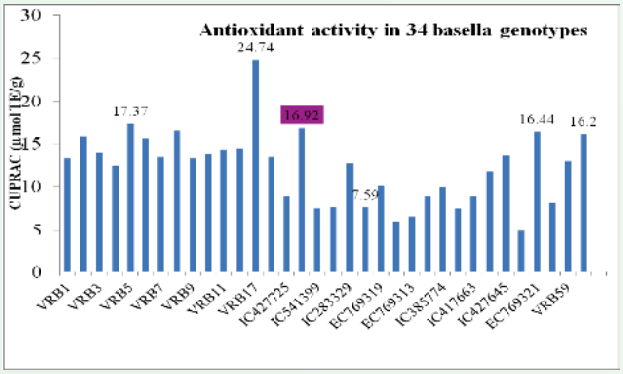


Fig. 38: Genotypic variability for antioxidant activities in basella genotypes

Promising/Unique genotypes: Two basella genotypes VRB-17 and VRB-11 were found promising in terms and yield and nutritional quality. In addition, two unique genotypes were also identified viz., late flowering basella: IC561377 and basella with snow white flower. The details are presented below.

***VRB-17*:** This basella genotype was found to bear soft, succulent green leaves which are 9.5 cm long and 7.2 cm wide. The plant bears soft lush green shoot of about 52 cm length, 125 g weight and 1.35 cm girth. The potential yield is 45 t/ha with high antioxidant activity (24.74 µ mol TE/g) measured through CUPRAC. This genotype can serve as a potential source for developing antioxidant rich basella desirable for health and nutrition. This is relatively free from insect pest and diseases. This seems to be promising for commercial cultivation by the farmers as well as for kitchen gardening as even one plant is sufficient to fulfil the requirement of a small family.

***VRB-11*:** It bears dark green shiny leaves with thick but soft stem weighing about 90 g. The shoot possesses short internodes with more number of leaves per shoot (18.23) for 35 cm shoot length. The potential yield is 38 t/ha. The plant is quite attractive and possesses high leaf stem ratio.

VRB-17 VRB-11

Fig. 39: Promising basella genotypes VRB-17 and VRB-11

Fig. 40: Late flowering Basella, IC561377

***Late flowering Basella: IC561377*:** *Basella alba* var *rubra* accession IC561377, collected from Dantewada district

of Chattisgarh, bears dark green, soft, ovate leaves with purple petiole. The plant is twinning type with bright purple stem. The plant possesses a unique feature i.e. late flowering habit. Flowering is delayed by 35-40 days as compared to other genotypes and the plant continues to produce soft and tender leaves and stem even during fruiting. It possesses high carotenoid content (1.38 mg/g fresh weight) and moderate antioxidant activity (11.74 µ molTE/g). Thisgenotype may besuited for year round production of *Basella* leaves.

Basella genotype with snow white flower: EC769321-1: Usually the flower colour is purple in *Basella alba* var *rubra* and pink or pinkish white with pink or purple tip on the bud in *Basella alba* var *alba*. However, the accession EC769321-1, collected from AVRDC, Taiwan bears snow white flowers which is a rare trait. The plant possesses green, caudate, soft and succulent leaves. Immature fruits are green in colour without any pinkish or purple tinge. Even the mature fruits lack red pigment (betalain) and are greenish black in colour. This trait is also rare in basella.

Fig. 41: White Flower Basella: EC769321-1

Molecular studies in Basella germplasm

DNA isolation has been completed in 40 basella genotypes for PCR amplification. For molecular diversity analysis, 30 arbitrary ISSR primers were screened which produced 86 fragments with an overall average polymorphism of 59.55 %. Screening is continued with more ISSR primers (Figure 42).

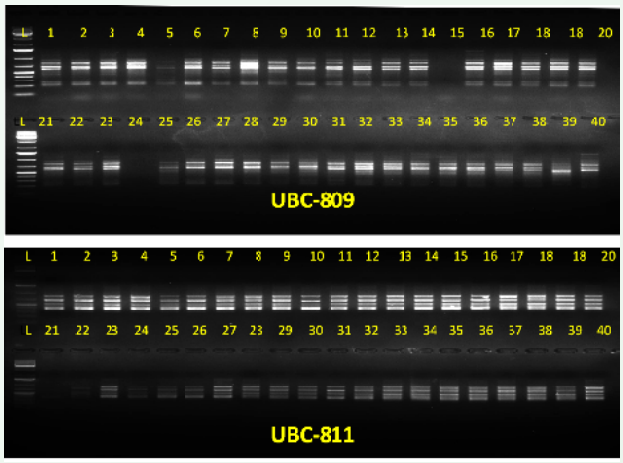


Fig. 42: Amplification in Basella DNA samples with ISSR primer- UBC 809 and UBC 811. Lane L: Ladder 1 Kb; Lane 1-40 represent different accessions of basella

Kale

A genotype of tropical kale i.e. VRKALE-1 has been identified at IIVR, Varanasi which induces bolting and flowering, sets seeds in the North Indian plain and do not require any vernalization (low temperature <7 °C for 6-8 weeks). This genotype initiates bolting and flowering during last week of February in North Indian plain i.e. mean temperature for 60 days before flowering was 11.8-23.5 °C (average of three years i.e. 2014-2016). As like tropical cauliflower, in future, VRKALE-1 will certainly play a pivotal role in expanding its adoption and popularity. The leaves are ready for first picking in 23-28 days after transplanting and thereafter at 7-10 days interval. The leaves measured 22-30 cm in length, weighed 13.3-16.2 g in weight and had 13-14% dry matter content. A plant produces 100-125 leaves in 9-12 pickings producing 1.5-1.8 kg leaf biomass. It has leaf yield potentialof >55 t/ha.

Fig. 43: Tropical kale VRKALE-1

Tropical Cabbage

One genotype of tropical cabbage (VRCAB-101) having slightly-flattish and compact head that induces robust bolting and flowering at 10.1-22.4 °C temperature (average of two seasons i.e. December 2014 to January 2015 and December 2015 to January 2016) has been observed, and the population has been advanced to next generation for further evaluation.

MEGA PROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES

Programme Leader: *P.M. Singh*

Studies on pollen storability: The pollen from different cucurbitaceous crops *viz.* bottle gourd (Kashi Ganga), sponge gourd (Kashi Divya) and bitter gourd

(Kalyanpur Baramasi) were collected and stored under different storage conditions *viz.* at ambient temperature, 8-10 °C and in deep freezer at -20 °C, for testing the viability at periodic intervals. The observations recorded (Table 32) indicate that the better pollen viability was maintained at -20 °C in all the three crops. The pollen viability reduced with increasing storage period.

Table 32: Effect of storage conditions on pollen viability (%)

Crop	Storage temperature	Storage period	
		3 months	6months
Sponge gourd (Kashi Divya)	RT	94.3	91.3
	8-10 °C	94.7	93.3
	- 20 °C	100.0	96.3
Bottle gourd (Kashi Ganga)	RT	88.7	85.0
	8-10 °C	95.3	94.7
	- 20 °C	98.0	97.7
Bitter gourd (Kalyanpur Baramasi)	RT	92.0	89.0
	8-10 °C	96.3	95.3
	- 20 °C	96.3	96.0

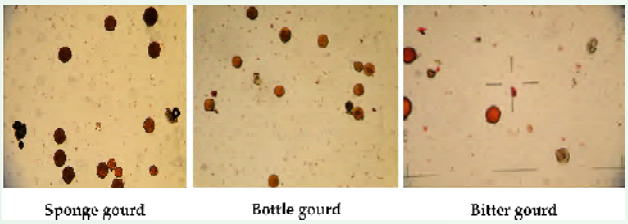


Fig. 44: Pollen of different crops after three months of storage at room temperature

Foraging behaviour of different insect fauna: Diurnal activity of different insect fauna was also observed during the summer months to know about activity of different pollinators, the dominant pollinator and the time of maximum activity of the pollinators.

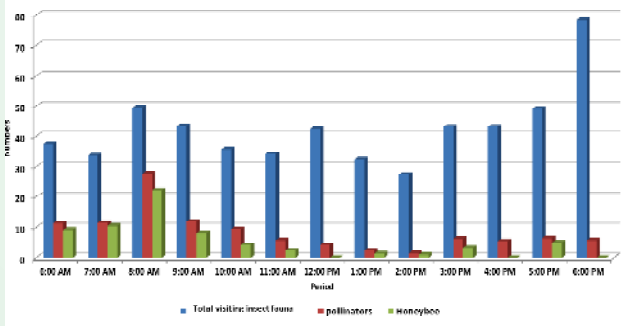


Fig. 45: Diurnal activity of different insect fauna on sponge gourd

The observations (Fig. 45) indicate that the maximum pollinators' activity was recorded during 6-10 AM. Pollinators included honeybees, bumblebees, carpenter bees, solitary bees, hoverflies, beetles, butterflies and moths. The dominant honey bee species was *Apis florea*.

Fig. 46 : Different pollinators on sponge gourd flowers

Studies on increasing pollination efficiency : In order to enhance the pollination efficiency, the following treatments were given in bottle gourd cv. Kashi Ganga at the time of anthesis and 5th day from anthesis to attract the pollinators for improving the pollination

1. 10% Sugar solution
2. 5% Sugar + 5% jaggery
3. 10% Jaggery
4. 5% Sugar + 5% jaggery + multi-vitamin
5. Hand pollination
6. Open pollination
7. Caging

The preliminary results showed that maximum seed yield per plant was obtained form 10% jaggery (134.77 g seed/plant) followed by 10% sugar solution (89.92 g seed/plant) (Table 33). Interestingly, under caging no seed set was observed due to lack of pollination. The results are to be confirmed next year.

Table 33: Effect of different pollinator attracting treatments on seed yield in bottle gourd

Treatments	Seed yield/ plant (g)
10% Sugar solution	89.92
5% Sugar + 5% jaggery	61.21
10% Jaggery	134.77
5% Sugar + 5% jaggery + multi-vitamin	84.54
Hand pollination	78.99
Open pollination	53.82
Caging	0

Seed quality enhancement through priming and polymer coating: The priming of okra seed was done with three concentrations each of inert osmotica PEG 6000, mannitol and sorbitol along with distilled water as control. The duration of treatment was 24 to 168 hours (1-7 days) in two replications at 25 °C. The treated seeds were evaluated under lab conditions. Priming in distilled water exhibited protrusion within 24h.

Priming with mannitol 2, 3 and 4% and sorbitol 4% exhibited protrusion after 72 h. Priming with sorbitol 5 and 6% exhibited protrusion after 120 h.

Observations recorded indicate that the okra seeds primed with osmotica for 24h showed better germination, seedling length and vigour index. Now, the germination at lower (15^{0}C) and higher (35^{0}C) temperatures to be tried to see the effect of priming treatments on enhancing temperature range for germination.

For polymer coating, four concentrations each of four chemicals viz. PEG (Poly Ethylene Glycol), PVCR (Poly Vinyl Chloride resin), PVA (Poly Vinyl Acetate) and PVP K-30 (Poly Vinyl Pyrodidone) along with a control were tried on brinjal seeds. The data recorded after the respective treatments (Table 34). Next observations are under process.

Vegetable seed production: At IIVR farm, the overall seed production programme (Breeder+TL) was undertaken in 29 varieties of 17 vegetable crops. The breeder seed production was undertaken for 21 varieties in 10 different vegetable crops viz tomato, brinjal, chilli, cowpea, peas, pumpkin, bottle gourd, ash gourd, okra and radish. A total of 835 kg breeder seeds were produced against the targeted National indents of 773.50 kg from Deputy Commissioner (Seeds). In addition to National indent, 1739 kg breeder seeds of different varieties of IIVR were also produced.

Table 34: Effect of polymer coating on brinjal seed quality

Treat-ment	Concen-tration (%)	Germi-nation (%)	Seed-ling length (cm)	Dry wt (mg/ seed-ling)	Vigour index I	Vigour index II
PEG	0.5	72	16.02	3.1	1153.44	223.2
	1	70	15.45	2.8	1081.5	196
	1.5	76	15.02	2.7	1141.52	205.2
	2	71	15.44	3	1096.24	213
PVA	0.2	70	15.45	2.9	1081.5	203
	0.4	72	13.87	2.6	998.64	187.2
	0.6	70	15.01	2.8	1050.7	196
	0.8	76	16.05	3	1219.8	228
PVCR	0.2	71	13.99	2.6	993.29	184.6
	0.4	70	12.83	2.7	898.1	189
	0.6	70	12.37	2.6	865.9	182
	0.8	79	12.68	2.7	1001.72	213.3
PVP-K 30	0.2	72	14.35	2.8	1033.2	201.6
	0.4	70	15.3	3	1071	210
	0.6	73	13.99	2.7	1021.27	197.1
	0.8	70	13.8	2.6	966	182
Control	--	74	16.71	3.1	1236.54	229.4

Fig. 47: Seed production of pumpkin cv. Kashi Harit, bitter gourd cv. K. Baramasi, sponge gourd cv. Kashi Divya

Fig. 48 : Seed production of pea cv. Kashi Nandini and cowpea cv. Kashi Kanchan

Fig. 49: Team monitoring the breeder seed production field on 29 Sept., 2015 at ICAR-IIVR Farm

Hybrid seed production: The hybrid seed production programme was undertaken during the year for Tomato-Kashi Abhimaan, Brinjal- Kashi Sandesh and Chilli- Kashi Surkh & Kashi Tej under the protected conditions. An amount of 1.2kg of tomato (Kashi Abhiman), 2.3kg of brinjal (Kashi Sandesh), 290g of chilli (Kashi Surkh) and 2.20kg of chilli (Kashi Tej) F_1 seeds were produced for the growers.

Fig. 50: Hybrid seed production programme under protected conditions

Division of Vegetable Production

MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCES MANAGEMENT

Programme Leader: R. N. Prasad

Project 3.1: Technologies for protected and off-season vegetable production

Standardizing the potting medium for vegetable nursery

Experiments were conducted to confirm the previous year findings. It was found that the best combination was coco peat + rice husk. However, the treatment combinations FYM + rice husk or vermicompost + rice husk in the ratio of 3:1 were also noted *at par* with the treatment combination coco peat + rice husk in the same ratio. The seedling height, seedling vigour and safe removal from the potting plugs were also noted better under these treatments (Fig.1 and 2).

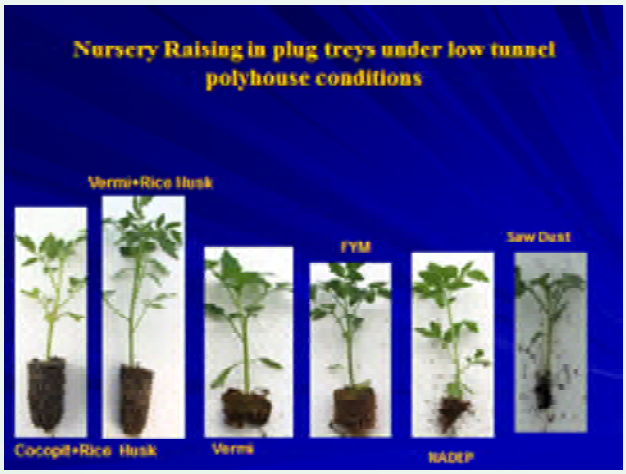


Fig. 1: Nursery raising in plug tray in different media

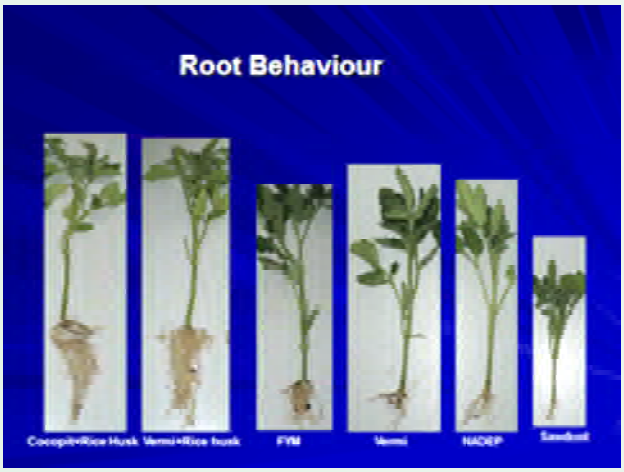


Fig. 2: Root morphology of plants under different treatments

Performance of tomato under different growing conditions: The growth, yield and quality parameters of tomato grown under semi-protected conditions *i.e.* polyhouse and net house conditions were compared with the open field condition along with three sprays of WSF (NPK-19:19:19). The tomato indeterminate hybrid Tolstoi was raised under net house conditions and 24 days old seedlings were transplanted under all the three growing conditions on 10th October, 2015 in randomized block design and 6 plants were considered as one treatment. WSF @5 g/ liter of water were sprayed in all the conditions after 30 and 40 DAT (days after transplanting) in all the plots as common for crop care and repeated at 50, 60 and 70 DAT as treatments. The maximum per plant yield (2.07 kg/plant), plant height (147.3 cm), number of fruits per plant (25.6) and average fruit weight (65.7 g) was recorded under polyhouse condition (Fig.3).

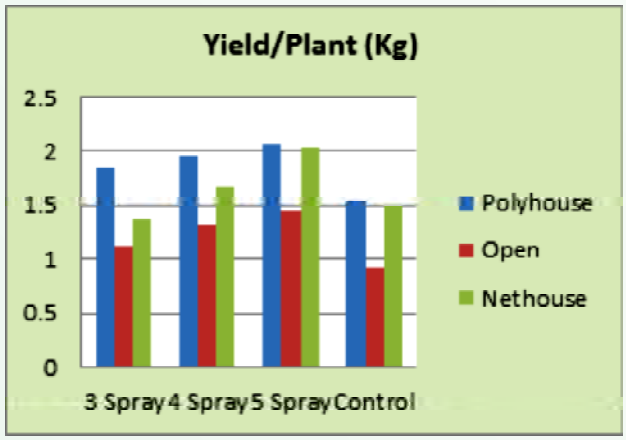


Fig. 3: Per plant yield of tomato under protected condition

Performance of capsicum under semi protected conditions: The seedlings of 5 capsicum hybrids were raised under low tunnel polyhouse condition in plug trays and transplanted under polyhouse (Fig. 4). The plant height, average fruit weight and yield of Swarna

Fig. 4 : Capsicum varieties evaluated under polyhouse condition

(yellow coloured) grown under low cost protected structure were noted better in comparison to other hybrids. The maximum yield of fruits (1.35 kg/plant), average fruit weight (170g) and plant height (56.2 cm) was recorded in Swarna, the yellow coloured variety. The number of fruits per plant was maximum in Popti.

Project 3.2: Precision farming in vegetable crops

Effect of different dates of sowing on performance of cowpea and okra: The field experiments were conducted during *Zaid* and *Kharif* season 2015 to study the performance of cowpea and okra under different sowing/planting environments. In cowpea, the maximum yield of 139.62 q/ha, 128.74 q/ha and 124.38 q/ha was obtained in Kashi Nidhi, Kashi Kanchan and Kashi Unnati, respectively with second date of sowing *i.e.* on 25th March. Similarly, in okra, the maximum yield of 136.23 q/ha, 118.41 q/ha and 124.34 q/ha was recorded in Kashi Pragati, Kashi Vibhuti and Kashi Kranti, respectively with first date of sowing *i.e.* on 24th July (Table 1). The maximum above ground biomass accumulation was noticed in the first date sown crop of okra (Fig. 5). The biomass production and yield in both cowpea and okra crops were found to be closely related to the accumulation of growing degree days (GDD). Quantitative relationship of GDD with biomass production and yield were developed (Table 2). The coefficient of determination ranged from 0.76 to 0.84 in cowpea and 0.72 to 0.88 in okra suggesting that these equations so developed can be used satisfactorily for prediction of biomass production and yield in cowpea and tomato using GDD.

Table 1: Yield of cowpea and okra under different sowing/planting environments

Variety	Ist sowing date	IInd sowing date	IIIrd sowing date
Cowpea yield (Q/ha)			
	10.03.2015	**25.03.2015**	**09.04.2015**
Kashi Nidhi	132.32	139.62	112.31
Kashi Kanchan	124.46	128.74	107.42
Kashi Unnati	120.82	124.38	100.98
Okra yield (Q/ha)			
	24.07.2015	**09.08.2015**	**24.08.2015**
Kashi Pragati	136.23	130.53	100.01
Kashi Vibhuti	118.41	113.14	87.50
Kashi Kranti	124.34	114.42	90.32

Table 2: Relationships between growing degree days (GDD), biomass accumulation and yield in cowpea and okra

Cowpea	
Biomass = 0.064GDD – 24.32	R^2 = 0.84
Yield = 0. 057GDD + 10.12	R^2 = 0.76
Okra	
Biomass = 0.072GDD - 32.53	R^2 = 0.88
Yield = 0. 045GDD +23.34	R^2 =0. 72

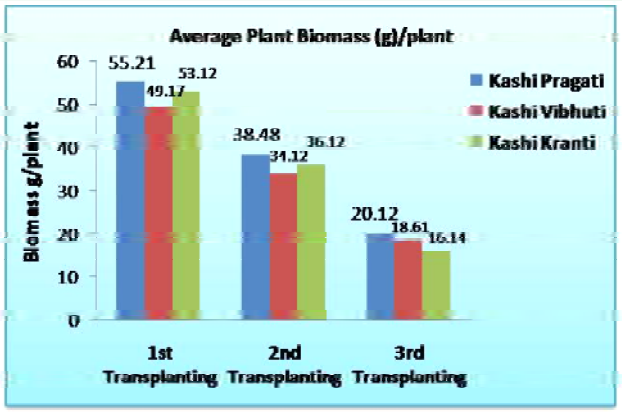


Fig. 5: Above ground biomass accumulation and yield of okra on different dates of sowing

Studies on the effect of N levels on growth and yield of tomato: An experiment was conducted to study the response of tomato cv. Kashi Aman to graded levels of nitrogen (0, 40, 80, 120, 160, 200 and 240 kg N/ha) during rabi 2015-16. The results reflected in Fig. 6 revealed that there was an increasing trend in growth, biomass accumulation, chlorophyll content and yield of tomato up to 160 kg N/ha. The maximum values with these traits such as; biomass (53.71g/plant), chlorophyll content index (55.76) and fruit yield (641.8 q/ha) were reported with application of 160 kg N/ha. Beyond this level, there was a decreasing trend in all the parameters due to detrimental effects of higher doses of nitrogen on physiological activities of the plant, resulting in poor growth and yield.

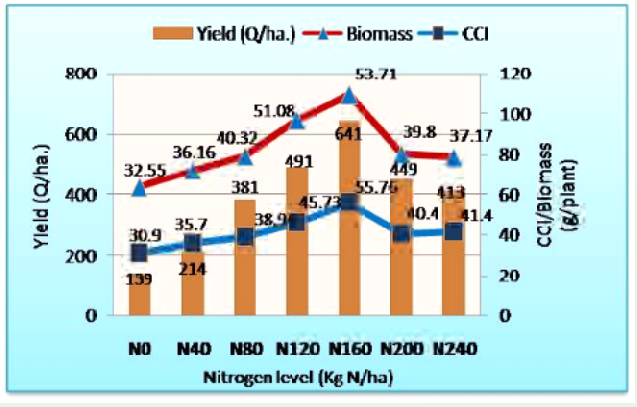


Fig. 6: Effect of nitrogen fertilization levels on yield, biomass and chlorophyll content index (CCI) of tomato

Project 3.4: Impact of organic and inorganic management systems on vegetable productivity, quality and soil health

A study on the effect of sources and levels of organic management systems on vegetable productivity, quality and soil health was conducted in vegetable based cropping systems. The experiment aimed at evaluating the effect of the recommended mineral fertilizers *vis-a-vis* different types of organic manures and its doses on growth, fruit yield and quality of brinjal, cabbage and pea. The treatment combination comprised of three organic sources and its three levels (T1= FYM @ 15 t/ha, T2= FYM @ 20 t/ha, T3= FYM @ 25 t/ha , T4= NADEP compost @ 15 t/ha, T5= NADEP compost @ 20 t/ha, T6= NADEP compost @ 25 t/ha, T7= Vermicompost @ 5t/ha, T8= Vermicompost @ 7.5 t/ha, T9= Vermicompost @ 10 t/ha, and its combination such as; T10= FYM @ 10 t/ha + NADEP compost @ 10t/ha, T11= FYM @ 10 t/ha + vermicompost @ 3.5 t/ha, T12= NADEP compost @ 10t/ha + vermicompost @ 3.5 t/ha) with one absolute control (T14= no manure or fertilizer). It was compared with inorganic control (T13= recommended dose of NPK). The three cropping systems were C1= brinjal-bottle gourd-sesbania green manuring, C2= Cabbage-cowpea-sesbania green manuring-radish and C3= pea-okra-sesbania green manuring-cucumber. The organic sources were applied 15 days before transplanting and well mixed in soil during field preparation. Need based plant protection measures comprising of organic insecticides were also applied.

Effect of organic management on crop performance: Results indicates that all the three organic source produced significantly higher fruit yield of brinjal as compared to absolute control, and it was comparable to the yield level obtained with application of inorganic fertilizer at recommended dose (T13). Soil fertilized with 25 t/ha FYM produced the superior growth of plant and the highest total fruit yields. In all the three sources, the yield increased with increasing dose and significantly higher yield was recorded with the highest dose. Combined application of organic manures did not prove effective over its sole application. The increase in yield was associated with more number of fruits/plant and higher average fruit weight. In pea, the organic sources produced significantly higher green pod yield over control. However, no significant increase in green pod yield was observed due to application of organic sources over recommended dose of fertilizer (T13). Interestingly the combination of organic sources recorded 25.37 to 37.51% higher pod yield as compared to inorganic control. It was also observed that increasing dose of all the three sources increased the green pod yield in pea. The promising combination was NADEP compost @ 10 t/ha combined with farm yard manure (10 t/ha) produced the best response. In cabbage, all the three sources produced significantly higher yield over control. Among different organic sources there was no significant difference with regards to yield and head size of cabbage. It was also observed that increasing dose of all the three sources increased the cabbage yield.

Effect of organic management on quality parameters: The quality of vegetables in terms of vitamin C content was better under organic system as compared to inorganic system in brinjal, pea and cabbage. The vitamin C content varied from minimum 32.15 mg/100g in inorganic control to maximum 36.54 mg/100g in cabbage with FYM treated plots (25 t/ha). Similarly in pea and brinjal, the vitamin C content varied from 10.24 to 13.12 mg/100g and 18.32 to 24.15 mg/100g, respectively in inorganic control and FYM @ 25t/ha treated plots. There was no consistent trend in colour and texture in cabbage, pea and brinjal.

Effect of organic management on soil properties: The analysis of soil samples revealed that organic management systems recorded higher organic carbon (0.54-0.57%) and available N in soil (210-255 kg/ha). The total microbial activity in terms of fluorescein diacetate hydrolysis was also higher under organic systems as compared to inorganic control. The soil microbial activity was minimum (1.032U g/g soil) under inorganic control and maximum (1.46U g/g soil) with application of FYM (25 t/ha). Among the organic sources it varied between 1.20 (application of NADEP 15 t/ha) to 1.46 U g/g soil. The soil moisture content under organic systems was higher in brinjal, cabbage and pea as compared to inorganic and absolute control treatments.

Effect of organic management on incidence of pest and diseases: The incidence of pod borer in brinjal and pea and population of nematodes was less under organic management systems as compared to inorganic system.

Project 3.5: Improving soil health and carbon sequestration in vegetable production system through conservation tillage and residue incorporation

In this sub-project, two sets of experiment was conducted during the summer, *kharif* and *rabi* season 2015-16 to study the effect of conservation tillage on the production potential and soil heath in vegetable based cropping systems. In first experiment, three tillage systems were evaluated with or without residue

retention in cowpea-pea-cowpea cropping system. The tillage treatment combination were T1= Zero tillage (ZT) with residue retention, T2= Zero tillage without residue retention, T3= Reduced tillage with residue retention, T4= Reduced tillage without residue retention, T5= conventional tillage with residue retention, T6= conventional tillage without residue retention. The reduced tillage consisted of one cross ploughing with harrow/cultivator while conventional tillage consists of two-three cross ploughing with cultivator/ one harrowing followed by ploughing with cultivator, depending on the crop. In the second experiment, only two tillage systems were adopted *i.e.* reduced tillage and conventional tillage with or without residue incorporation, and was studied in three cropping systems *viz.* C1= cowpea-cabbage-cowpea, C2= cowpea- tomato and C3= cowpea-chilli. The twelve treatment combinations were tested in RBD with three replications.

In the first experiment, it was evident that the maximum yield of 12.85 t/ha in cow pea and 12.11t/ha in pea was obtained with ZT with residue retention on the surface (Table 3). The net return and benefit cost ratio was also maximum in this treatment. Soil organic carbon content was higher in zero tillage (0.49%) and with residue incorporation. Available nitrogen content was higher under zero tillage (252 kg/ha) with residue retention. Microbial activity was also higher under conservation tillage and residue incorporation treatments. Residue retention in general improved the yield in all the tillage treatment which may be due its positive influence on weed suppression as well as moisture conservation and increase in organic carbon in the soil. The economics was better in the ZT due increased yield and also lower cost of cultivation.

In the second experiment it was evident from the data that conventional tillage though increased the yield of all the crops except tomato; however yield increase was significant only in cabbage, while it was *at par* in chilli and cowpea (Table 4). The performance of summer season cowpea was similar in all the three sequences and it ranged between 9.52 to 10.05 t/ha. Among the tillage practices, it was *at par* in both conventional and reduced tillage. Residue incorporation increased the yield of cowpea by 7.10 % irrespective of the cropping sequence.

The highest productivity in terms of rice equivalent yield (REY) was realized in cowpea-cabbage-cowpea sequence; however the benefit cost ratio was higher in cowpea –tomato sequence (Table 5). There was no significant increase in REY due to conventional tillage over reduced tillage irrespective of the sequence. Moreover, there was saving on field preparation in reduced tillage as a result the benefit cost ratio was better in reduced tillage. The energy use efficiency and benefit cost ratio was higher under conservation tillage. The incorporation of residues had significant effect on the productivity of the system as it increased the REY by 10.50% over its removal. The incorporation of residues of previous crop in general increased the yield of all the subsequent crops probably due to its positive influence on moisture conservation and increase in soil organic carbon content, as a result the microbial activity was also more under this treatment.

Table 3: Effect of tillage practices on yield, net return and B:C ratio in Cowpea – Pea sequence

Treatment	Summer cowpea (t/ha)	Kharif cowpea (t/ha)	Pea (t/ha)	Net return (Rs/ha)	B: C ratio
Zero tillage without residue	10.33	9.54	10.44	209830	2.06
Zero tillage with residue	12.85	11.45	12.11	272680	2.68
Reduced tillage without residue	9.14	9.64	11.39	206230	2.03
Reduced tillage with residue	9.67	10.62	11.95	222580	2.19
Conventional tillage without residue	8.57	10.45	10.27	180880	1.78
conventional tillage with residue	11.78	11.20	11.00	239980	2.36
CD (P=0.05)	1.45	1.62	1.37	-	-

Table 4: Effect of tillage practices on productivity in vegetable based sequences

Tillage practices	Cropping sequence						
	C1			C2		C3	
	cow-pea	cow-pea	cabbage	cow-pea	tomato	cow-pea	chilli
Reduced tillage without residue (T1)	8.75	11.48	246.35	8.84	14.05	9.57	4.37
Reduced tillage with residue (T2)	9.67	13.78	278.40	10.24	15.24	9.35	4.40
Conventional tillage without residue (T3)	9.45	12.28	282.54	9.54	11.5	9.85	5.73
Conventional tillage with residue (T4)	10.24	14.06	312.5	9.95	13.4	11.45	6.95
CD (P=0.05)	1.37						

Table 5: Effect of tillage practices on yield, net return and B: C ratio in vegetable based sequences

	Rice equivalent yield (T/ha)	Net return	B:C ratio	OC
Cropping system				
C1	23.53	185616	1.29	0.52
C2	21.94	180387	1.42	0.48
C3	20.35	150417	1.12	0.44
CD (P=0.05)	2.4	-	-	0.02
Tillage				
T1	20.31	151361	1.14	0.45
T2	21.88	173240	1.31	0.54
T3	21.38	162314	1.18	0.42
T4	24.19	201647	1.47	0.51
CD (P=0.05)	2.5	-	-	0.02

Project 3.7: Enhancing water and nutrient use efficiency in vegetable crops

K-Fertigation study in tomato: Fertigation study in tomato (cv. Kashi Aman) was carried out with four K-levels (40, 60, 80 and 100 kg K_2O/ha) along with control (conventional fertilization). For K- fertigation, 40% K_2O was supplied as soil application, and the rest was supplied through Muriate of Potash (MOP) by drip fertigation. K was fertigated in 5, 7, 9 and 11 split doses, respectively under 40, 60, 80 and 100 kg K_2O/ha. In all treatments N was fertigated @ 150 Kg/ha through Urea in 10 splits. Experimental finding revealed that drip fertigation at 80 or 100 kg K_2O/ha registered the maximum fruit yields (2.38 and 2.13 kg/plant; 58.17 and 57.00 tones/ha, respectively) (Table 6 and Fig. 7). These two treatments have registered 66.6 to 70% higher fruit yield over conventional fertilization; however their yields were noticed *at par* to each other. In this study, the maximum nutrient use efficiency (98.5 kg yield/ kg K_2O) was reported with fertigation of K @ 60 kg/ha. The maximum dry matter production (215.53 g/plant) was reported with K fertigation at 100 kg/ha.

Drip fertigation study in hybrid chilli: Drip fertigation study using various fertilizer sources was carried out in hybrid chilli (cv. Kashi Surkh) during September 2015 to March 2016 (Figure 8). Fertigation study revealed that the maximum fruit yield *i.e.* 110.6 and 105.63 q/ha, and BC ratio (1.75 & 1.62), respectively were reported under 100% NPK fertigation with water soluble fertilizers (WSF) or 75% fertigation with WSF and rest 25% as soil application (Table 7).

Fig. 7: Tomato fruiting with K-fertigation at 100 kg/ha

Drip irrigation and mulching study in okra: Drip irrigation and mulching study was carried out during spring-summer okra (cv. Kashi Pragati). Experimental findings revealed that drip irrigation daily with 100% PE coupled with black-silver polyethylene mulching registered maximum fruit yields (195 g/plant and 87.55 q/ha) with BC ratio of 1.11 (Table 8). The maximum water use efficiency (3.32q/ha/cm) was reported with drip irrigation daily at 60% PE + Black-silver polyethylene mulching.

Table 7: Effect of fertigation on fruit yield in chilli

Treatment	Plant height (cm)	Fruits/ plant (No.)	Fruit yield/ plant (g)	Fruit yield (Q/ha)	B:C ratio
T_1 NPK fertigation with WSF	55.3	132.5	635.67	110.6	1.75
T_2 NK fertigation with WSF	52.6	106	545.44	95.87	1.55
T_3 NPK fertigation with normal fertilizers	48.7	78.5	487.20	85.05	1.51
T_4 NK fertigation with normal fertilizers	48.5	83.25	445.70	81.3	1.45
T_5 75% fertigation with WSF	53.4	124.75	603.15	105.63	1.62
T_6 Control: drip irrigation and soil application of the recommended fertilizer	47.6	75.5	387.55	72.25	1.35
CD $_{0.05}$	NS	9.63	53.44	7.37	-

Table 6: Effect of K-fertigation on plant growth, yield traits, water and nutrient use efficiency in tomato

Treatment	Total dry matter (g)	CCI	Fruits per plant	Single fruit wt. (g)	Fruit yield/ plant (kg)	Fruit yield/ ha (tones)	NUE (kg yield/ kg K)	WUE (q/ha/ cm water)
K 40 kg/ha	103.10	40.20	14.2	98.2	1.40	39.40	57.0	9.98
K 60 kg/ha	167.50	43.52	17.0	101.8	1.78	50.34	98.5	12.74
K 80 kg/ha	177.95	46.93	20.6	103.0	2.38	58.17	83.9	14.73
K 100 kg/ha	215.53	41.50	21.6	90.6	2.13	57.00	72.7	14.43
Conventional fertilization	111.25	37.45	12.0	85.6	1.11	34.21	57.0	7.60
CD $_{0.05}$	13.41	3.44	2.21	8.80	0.37	6.32	-	-

Fig.8 : Hybrid chilli (Kashi Surkh) under drip fertigation system

Table 8: Effect of drip irrigation scheduling and mulching on yield of okra

Treatments	Plant height (cm)	No. of fruits/ plant	Single fruit wt. (g)	Fruit yield/ plant (g)	Fruit yield (q/ha)	WUE (q/ha /cm)
T1= Drip irrigation daily with 100% PE + black-silver polyethylene mulch	91.3	14.2	15.2	195	87.55	2.37
T2= Drip irrigation at alternate day with 100% PE + black-silver polyethylene mulch	85.1	12.2	14.9	143	73.40	1.98
T3= Drip irrigation daily with 80% PE + black-silver polyethylene mulch	80.4	12.8	16.0	171	78.07	2.60
T4= Drip irrigation at alternate day with 80% PE + black-silver polyethylene mulch	74.0	10.8	14.7	114	70.55	2.35
T5= Drip irrigation daily with 60% PE + black-silver polyethylene mulch	70.7	11.4	14.6	168	73.67	3.32
T6= Drip irrigation at alternate day with 60% PE + black-silver polyethylene mulch	64.7	9.6	13.2	121	56.04	2.52
T7= Surface irrigation at 100% PE	51.3	8.4	13.7	104	53.25	1.36
$CD_{0.05}$	7.15	1.6	1.48	21.7	6.11	-

Integrated nutrient management in bottle gourd: Integrated nutrient management (INM) study was carried out in bottle gourd. In this study, the N requirement of the crop was fulfilled by either sole application organic manures or in various combinations of organic manures and inorganic N. Experimental findings indicated that maximum fruit production (14.10 kg and 13.62 kg/ plant; 428.95 q/ ha and 418.25 q/ ha, respectively) was achieved under T_5 (FYM 12.5 t/ ha + ½ Rec. N from fertilizers) and T_8 (FYM 4 t/ ha + VC 1.4 t/ ha + PM 1 t/ ha + ½ recommended dose of N from fertilizers) (Figure 9 and Table 9). These

Fig.9 : Bottle gourd crop under integrated nutrient management system

treatments noticed an increase of 16-19% higher yield over recommended NPK (360.44 q/ha). The individual fruit weight were noticed insignificant in all treatments, and it range between 0.722 to 0.922 g. The maximum number of fruits was also noticed under treatments T_5 and T_8 (16.7 and 15.7 fruits/ plant).

Table 9: Effect of integrated nutrient management on fruit yield in bottle gourd

Treatment	Fruits/ plant	Single fruit weight (kg)	Fruit yield/ plant (kg)	Fruit yield (Q/ha)
T_1 - FYM 25 t/ ha (120 kg N)	9.0	0.794	10.30	297.49
T_2 - Vermicompost (VC) 8 t/ ha (120 kg N)	7.7	0.813	9.07	240.66
T_3 - Poultry manure (PM) 6 t/ ha (120 kg N)	6.3	0.731	7.82	215.97
T_4 - FYM 8 t/ ha + VC 2.7 t/ ha + PM 2 t/ ha (40 kg N from each)	12.3	0.842	12.59	378.15
T_5 - FYM 12.5 t/ ha + ½ Rec. N from fertilizers	16.7	0.922	14.10	428.95
T_6 - VC 4 t/ ha + ½ Rec. N from fertilizers	8.3	0.722	9.56	254.77
T_7 - PM 3 t/ ha + ½ Rec. N from fertilizers	6.7	0.778	8.85	234.61
T_8 - FYM (4 t/ha) + VC (1.4 t/ha) + PM (1 t/ha) + ½ Rec. N from fertilizers	15.7	0.862	13.62	418.25
T_9 - Recommended NPK (120:60: 60 kg/ha)	13.0	0.855	12.16	360.44
SEm±	0.70	0.041	0.04	16.68
CD $_{0.05}$	2.11	NS	1.21	50.02

Micronutrient study in broccoli: Micronutrient study was carried out in Broccoli (cv. Fantasy) wherein various kinds of micronutrient mixtures were sprayed thrice at 10 days intervals. Experimental findings revealed that all micronutrients sprays significantly enhanced the growth and yields of broccoli, but the

maximum head yield (288.0 q/ha) was recorded with 3 foliar sprays of boron at 50 ppm (Table 10). Head yield under B at 50 ppm was 67.8% higher than the control (recommended NPK only).

Table 10: Effect of micronutrient spray on plant growth and yield of broccoli

Treatments	Plant height (cm)	Canopy (cm)	Curd weight (g)	Yield (q/ha)
T1- Control	48.37	52.63	510.00	171.60
T2- Multiplex commercial 1 mL/1	56.33	60.97	683.33	245.60
T3- Multiplex commercial 2 mL/1	57.60	62.63	668.33	246.50
T4- Micromix + EDTA mixture (C1)-1g/1	55.67	63.70	606.67	218.40
T5- Micromix + EDTA mixture (C1)-2g/1	52.27	61.60	666.67	240.00
T6- Micromix + DTPA mixture (C2)-1g/1	56.03	59.17	661.67	238.40
T7- Micromix + DTPA mixture (C2)-2g/1	55.40	59.00	663.33	238.40
T8- Boron 25 ppm	55.20	60.07	700.00	252.80
T9- Boron 50 ppm	56.87	60.93	680.00	288.00
T10- Boron 100 ppm	56.03	61.63	673.33	242.20
CD $_{0.05}$	3.74	4.55	58.40	25.67

Project 3.8: Performance of vegetable crops under subsurface drip irrigation system

Experiments were laid to study the performance of tomato, pointed gourd and cucumber under varying levels of water application through subsurface drip irrigation (SDI) with lateral placed at 10 cm depths below the soil surface. Water was applied to the crops based on irrigation scheduling to the tune of 50% crop evapotranspiration (ET), 60% ET, 80% ET and 100% ET through SDI and 100% ET through surface drip. Kashi Vishesh variety of tomato was transplanted at plant to plant spacing of 50 cm under SDI with laterals placed at 10 cm depth below soil surface, surface drip and control furrow irrigation to study its response under varying level of water application. The findings indicated yield enhancement at increased level of water application from 50% ET to 100% ET under SDI. Study on response of pointed gourd under varying level of water application through SDI with laterals placed at 10 cm depths was initiated. Pointed gourds were planted at plant to plant spacing of 1 m and row to row spacing of 3 m.

Cucumber responded positively with varying level (50, 60, 80 and 100% ET) of water application from 50% ET to 100% ET through subsurface drip irrigation (Figure 10). The yield obtained under 100% ET was 1.38 times higher than that with conventional furrow irrigation method (Figure 11).

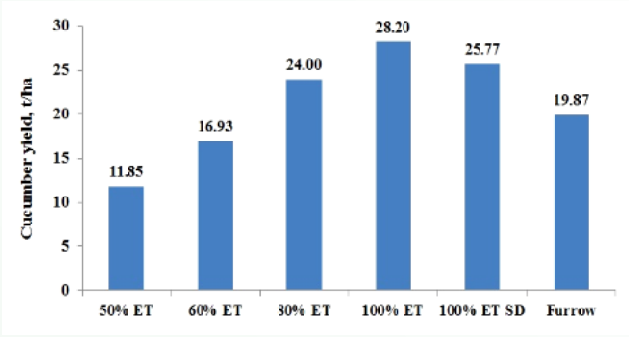


Fig. 10: Yield of cucumber at varying level of water application

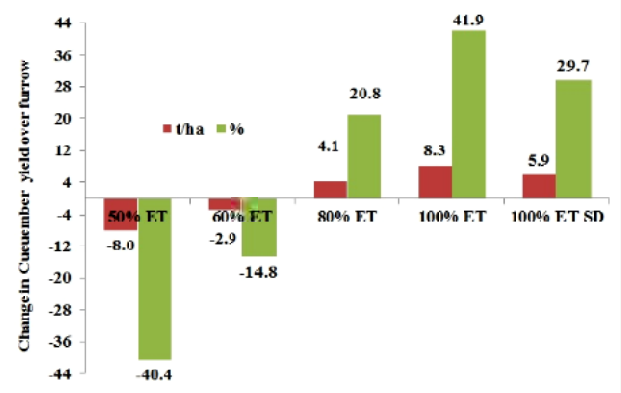


Fig. 11: Change in yield of cucumber under varying level of water application

Cucumber yield declined faster with decreasing amount of water from 100% ET to 50% ET. Fruit yield with 80% ET, 100% ET and 100% ET surface drip were higher than the conventional furrow irrigation method. However, yield at 60% ET and 50% ET were less than that obtained under conventional method. Yield obtained at 50% ET (9.85 t/ha) was one third of that with 100% ET (27.5 t/ha). Water use efficiency (WUE) of cucumber was 65.23, 93.55, 97.80 and 91.17 kg/mm, respectively under 50, 60, 80 and 100% ET. The WUE of cucumber was highest under 80% ET. However, it was found more than 90 kg/mm for 60, 80 and 100% ET. The WUE was 85.32 and 36.19 kg/mm, respectively for surface drip and conventional furrow irrigation method.

MEGA PROGRAMME 4: POST HARVEST MANAGEMENT AND VALUE ADDITION

Programme leader: Sudhir Singh

Project 4.1: Shelf life extension of vegetables

Effect of shellac based edible coating on shelf life of capsicum (*Capsicum annum* L.): To improve the shelf life of capsicum edible coating was formulated and applied. The stable shellac emulsion was standardized with the dissolution of shellac in 0.5-0.7%

alkaline solution along with addition of 2-4% polyvinyl alcohol as binding and coating agent. The dissolved shellac mixture was mixed thoroughly with 1-2% tri-ethanol amine as a surfactant. Oleic acid (0.5-1.5%) was added as lubricant, binder and defoaming agent with proper mixing. Finally the pH of shellac emulsion was adjusted to pH 7.0. The coating efficiency was further improved by the addition of 0.5% sodium alginate (T1), 0.5% pectin (T2), 0.5% sodium alginate and 0.5% pectin (T3) and coating of different additive was further compared with fully control capsicum (T4) for shelf life extension. The coated capsicum samples with different treatments were stored at ambient (25-26 °C) and storage at 10°C at RH of 88% (Max) and 54% (min) (Fig. 12).

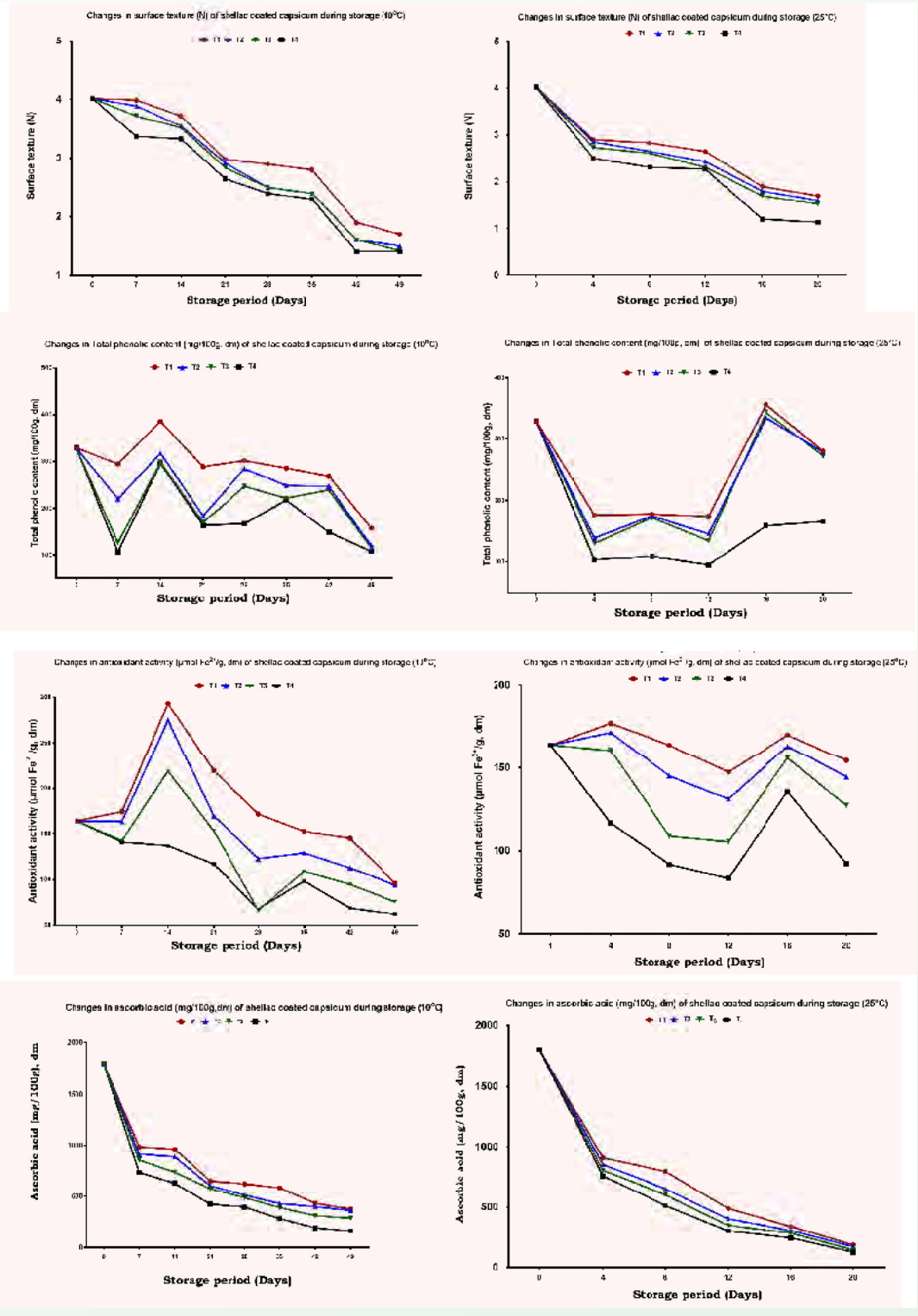


Fig. 12: Changes of physical and biochemical parameters in shellac coated Capsicum

The green colour intensity decreased in all shellac treated capsicum samples during storage at 10 and 25 °C. However, the minimum decrease (40.5%) in green colour intensity in terms of coordinate "a value" was obtained in T1 treated shellac coated capsicum which was followed by 43% in T2 treated capsicum, 49.6% in T3 treated capsicum, whereas, maximum loss (57.8%) in the green colour was reflected in fully control capsicum during 49 days of refrigerated storage. Minimum softening was reflected in T1 treated capsicum while maximum softening was obtained in fully treated capsicum during storage. Maximum firmness of 2.9N was reflected with T1 treated capsicum while minimum firmness of 2.4N was noted in fully control capsicum after 28 days of refrigerated storage. However, the minimum decrease in ascorbic acid was noted in T1 treatment followed by treatments T2, T3 and T4 in shellac treated capsicum during storage at 10 and 25°C. The decrease in total phenol and antioxidant activity was maximum in fully control capsicum samples. However, the minimum decrease of total phenol and antioxidant activity was obtained in T1 treatment after 49 days of refrigerated storage, which was subsequently followed in T2 and T3 treatments.

Project 4.2 Exploration of vegetable nutraceuticals for the development of functional food

Evaluation of bitter gourd genotype for their antioxidant potentiality: Fifty bitter gourd genotypes including cultivated variety and land races were evaluated for their bioactive compounds and antioxidant activity. Total phenol content varied from 28.8 to 88.8 mg GAE/100g fw, whereas total flavonoids content varied 8.47to 50.14 mg CE/100g fw. Antioxidant activity were evaluated using four *in vitro* methods *viz.* FRAP, CUPRAC, TEAC and DPPH. Antioxidant activity measured by FRAP was range from 2.8 to 8.9 µmol/g. CUPRAC value was slightly higher compare to FRAP value which varied from 6.87 to 82.81 µmol/g. Free radical scavenging activity measured by radical DPPH was ranged from 0.08 to 4.38 µmol/g, whereas and ABTS was ranged from 2.27 to 10.9 µmol/g. Some of the promising lines of bitter gourd having high antioxidant potential are IC-588072, IC-68238, IC-8565-1B, IC-4459 VRBTG-3 and VRBTG-15.

Evaluation of microgreens from summer season vegetable for their bioactive compounds and antioxidant potential: Twelve vegetables including leafy vegetables viz. bottle gourd, cucumber, pumpkin, amaranths-red, amaranths-green, amaranths cv. katwa, sweet corn, basella, jute, Water spinach, radish and palak were evaluated both at microgreens and mature leafy stage for their antioxidants and mineral content. The total phenol content among twelve mature leafy vegetables was ranged from 95.73 to 379.58 GAE mg/100g. In microgreens the total phenol contents were ranged from 25.00 to 221.44 mg GAE/100 g. In general phenol content was higher in mature stage compare to microgreen stages. A similar trend was observed for flavonoids and antioxidant potential measured by four in vitro antioxidant methods. In general potassium content was higher in microgreen than mature stages: K content varied from 1329 to 10578 mg/kg in mature stages whereas it varied from 4328 to 31819 mg/kg in microgreen stages. A similar trend observed in zinc content. However no specific trend was observed in case of iron, manganese and copper content.

Evaluation of legume microgreen for their bioactive compounds and antioxidant potential: Eight different legumes genotypes viz. lentil, green gram, black gram, chickpea cv. desi, chickpea cv. kabuli, methi, alfalfa and pea were analysed for total phenolics, flavonoids, and antioxidant activity (Fig. 13). Antioxidant activity was measured using FRAP, CUPRAC, DPPH, ABTS. Compounds and antioxidant activity was generally higher in microgreens in comparison to seeds and germinated seeds. In the seed the phenolics content were ranged from 38.7 to 243.1 mg GAE/100 g dwb whereas in germinated seed it was ranged from 75.9 to

Fig. 13: Legume microgreens

345.6 mg GAE/100 g dwb. Phenolic content was much higher in microgreen. More or less similar trend was observed for all other parameter assessed. Various bioactive compounds were investigated using LCMS/MS. Various phenolics compounds viz. anthocyanins (delphinidinglucoside and their derivatives), flavone, (apigenin, luteolin, crysoeriol, vitexin, isovitexin), flavonols (quercetin II, rhamnetin II) were tentatively identified.

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

Programe leader: Neeraj Singh

Project 5.1: Research prioritization for vegetable crops

The study on usage of chemicals in vegetable cultivation revelaed that, there is gap between knowledge and actual practice by the farmers in chemical use. In spite of having knowledge about proper usage many of them does not follow the same in actual situation. In this regard in the year 2015-16 a study was undertaken to identify the gap between knowledge and actual practice in chemical usage in the area of crop protection. Data was collected from 750 farmers from the districts Varanasi, Mirzapur and Chandauli and the result found as follows (Table 11):

The paired mean difference indicates the gap between knowledge and actual practice performed by the farmers in the area of crop protection. Maximum difference found in case of usage of proper nozzles in spray and different aspects of self-protection measures that should be followed by the farmers during spray.

Table 11: Paired mean difference between knowledge and actual practice on crop protection.

Statements	Paired mean difference
Seed treatment before sowing	5.75
Use herbicide before sowing	1.00
Applying pesticides as per the dose prescribed	2.75
Taking bath after pesticide spray	4.75
Covering face when spraying pesticides	4.75
Proper washing of sprayer after spraying	5.75
Use different nozzle for different pesticides	7.75
Do you have kitchen garden	6.5
Awareness about pheromone trap	4.5
Awareness about bio-control agents	6.0
Knowledge about antitode	1.5
Spray pesticide after harvesting vegetables	5.5

Another study was undertaken to analyse consumer preference of different vegetables among the tribal families in Sonbhadra district of Uttar Pradesh. Data was collected from 120 tribal families of Padrach block of Sonbhadra. and the results found as follows (Table 12):

Table 12: Preference towards vegetables among tribes of Sonbhadra

Vegetables	Like very much (%)	Like (%)	Like somehow (%)	Don't like (%)
Ash gourd	-	65	35	-
Bitter gourd	100	-	-	-
Bottle gourd	100	-	-	-
Cucumber	35	65	-	-
Moringa	-	-	100	-
Rajma	-	-	100	-
Radish	35	65	-	-
Pointed gourd	100	-	-	-
Pumpkin	30	35	35	-
Ridge gourd	-	-	70	30
Snake gourd	35	-	-	65
Sponge gourd	35	65	-	-
Brinjal	100	-	-	-
Cabbage	35	65	-	-
Cauliflower	100	-	-	-
Carrot	65	-	35	-
Pea	35	65	-	-
Tomato	100	-	-	-
Elepant foot yam	100	-	-	-
Beet root	35	-	30	35
Okra	-	65	35	-
Sem	100	-	-	-
Cowpea	-	70	30	-
Leafy vegetable	-	100	-	-

It was found that, respondents had less preference towards moringa as the area did not have moringa plants. In this regard intervention was made and improved variety of moringa (PKM-1) introduced and awareness programmes carried out to sensitize the nutritional importance of moringa and how it can boost up nutritional security in the tribal area. Respondents showed high preference towards dolichos bean and ICAR-IIVR variety Kashi Haritima performed well in that area.

Project 5.2 Impact of Improved Vegetable Technologies Developed by IIVR

ICAR-Indian Institute of Vegetable Research since its inception has developed 09 hybrids and 49 varieties in 18 different vegetable crops. Some of these varieties like Kashi Kanchan, Kashi Nidhi & Kashi Unnati in cowpea; Kashi Uttam & Kashi Taru in brinjal; Kashi Anmol in chilli, Kashi Kranti, Kashi Pragati & Kashi

Vibhuti in okra; Kashi Nandini, Kashi Uday & Kashi Mukti in pea; Kashi Harit in pumpkin; Kashi Vishesh, Kashi Anupam & Kashi Amrit in tomato; Kashi Sweta & Kashi Hans in radish are very popular among farmers not only in the adjoining areas *viz.*, Bihar, U.P, M.P., Chattishgarh, Jharkhand *etc.* where 20-30 percent of total vegetable cropped area is under IIVR developed varieties. However with the concerted efforts of vegetable research and emergence of corporate sector in vegetable seeds have contributed immensely in enhancing vegetable productivity and production of vegetables in our country but, still 62.1% (18 out of 29 states) states in the country are having lower productivity in compare to national productivity of vegetable (17.8 t/ha).

Therefore, a study was made through focus group discussions to analyze the constraints faced by the growers in adoption of improved vegetable production technologies. Focus Group Discussions were conducted for data collection from 345 farmers/farm women from Bihar and Madhya Pradesh during training programme at institute and 834 farmers/farm women during Farmers' Interface of 50 villages in Sonbhadra, Varanasi, Mirzapur, Jaunpur, Gazipur Chandauli and Mau districts of Uttar Pradesh because personal interview can be very useful; but they usually can't capture all that a person is thinking or feeling. On the other hand, responses in focus group discussions were typically spoken, open-

ended, relatively broad and qualitative. They had more depth, nuance and variety. Non-verbal communications and group interactions were also observed. Focus groups discussions therefore get closer to what people were really thinking and feeling, even though their responses were harder or impossible to score on a scale. The total number of respondents for this study was 1179 and the results were classified into 04 different categories ie., Social Constraints, Technological Constraints, Economic Constraints and Organizational Constraints.

More than 83% farmers felt that lack of entrepreneurial ability, community awareness, achievement motivation and innovativeness among growers in the society (Table 13) are the major social constraints in adoption of improved technologies since majority of vegetable growers are small to marginal with low risk taking temperament. Poor education (72.43%) and groupism (78.12%) in village also affects the adoption process which can be managed through awareness programme and capacity building.

Table 13: Social constraints faced by vegetable growers in adoption of improved production technologies

Social constraints	Response (%)	Rank
Lack of entrepreneurial ability	1003 (85.07)	I
Lack of community awareness	997 (84.56)	I
Lack of achievement motivation	984 (83.46)	I
Lack of innovativeness	983 (83.38)	I
Non availability of cultivable land as well as Lack of land consolidation	967(82.02)	II
Lack of commitment & coordination among farmers	967 (82.02)	II
Lack of low responsiveness	944 (80.07)	III
Low adoption by neighbours	938 (79.56)	III
Poor sources of information	927 (78.63)	IV
Groupism	921 (78.12)	IV
Lack of education	854 (72.43)	V

While studying technological constraints (Table 14) it had been observed that 90% of respondents felt lack of technical know-how along with poor pests management. It was the major constraints in vegetable production which not only increases the cost of cultivation but also fetched low productivity. Location specific crop recommendations (83.72%), demonstration of new technology (82.53%), capacity building (77.7%), soil testing & management (76.42%), post-harvest management (75.23%), mechanization (74.55%) etc are some of the need of hour for enhancing vegetable production and productivity.

High cost of technologies (84.05%) including seeds, fertilizers, pesticides etc are major economic constraints (Table 15) faced by growers in vegetable production. Low purchasing power of farmers (73.54%), Non-availability/complicated procedure of

Table 14: Technological constraints faced by vegetable growers in adoption of improved production technologies

Technological Constraints	Response (%)	Rank
Lack of technical know-how	1064 (90.25)	I
Poor knowledge of IPM	1059 (89.82)	I
Lack of location & crop specific recommendation	987 (83.72)	II
Inadequate demonstration of new technology	973 (82.53)	II
Inadequate follow-up services	924 (78.37)	III
Inadequate training programme	916 (77.70)	III
Lack of regular soil testing & Inadequate soil management	901 (76.42)	IV
Lack of post harvest technology	887 (75.23)	V
Lack of mechanization in agriculture	879 (74.55)	V
Inadequate availability of mass media sources of information	881 (74.72)	V
Lack of knowledge on conserving of natural resources	871 (73.88)	V

agriculture credit (66%) and Poor packaging & transportation facility (61.12%) were another economic constraints in vegetable farming. Non availability of quality inputs on time, proper monitoring and guidance by field workers, inadequate storage and marketing facilities are some of the major organizational constraints (Table 16) felt/ faced by the farmers.

Table 15: Economic constraints faced by vegetable growers in adoption of improved production technologies

Economic Constraints	Response (%)	Rank
High cost of technology	991 (84.05)	I
Low purchasing power of farmers	867 (73.54)	II
Non-availability of agriculture credit	783 (66.41)	III
Complicated procedure in available loans	771 (65.39)	III
Poor packaging & transportation	723 (61.32)	IV
Low risk bearing capacity	698 (59.20)	V

Table 16: Organizational constraints faced by vegetable growers in adoption of improved production technologies

Organizational constraints	Response (%)	Rank
Non availability of quality inputs timely	1141 (96.77)	I
Lack of effective supervision and monitoring by ext. worker	993 (84.22)	II
Poor linkage with line departments	931 (78.97)	III
Lack of timely advice and guidance by extension personnel	927 (78.63)	III
Low credibility of ext. worker	923 (78.29)	III
Inadequate storage facility	881 (74.72)	IV
Inadequate marketing net works	877 (74.39)	IV
Lack of crop insurance facility	813 (68.96)	V

Division of Vegetable Protection

MEGA PROGRAMME 6: INTGERTED PLANT HEALTH MANEGEMENT

Programme Leader: A.B. Rai

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

Evaluation of IPM modules for the management of diamond back moth (DBM), *Plutella xylostella* in cabbage: Different pest management modules *viz.*, bio-intensive, integrated and chemical modules were evaluated against DBM in cabbage (Hybrid Mahi Kranthi). Among these, integrated module comprising spray of azadhiractin 0.03% @ 5ml/l, rynaxpyr 18.5 SC @ 0.15 ml/l, novaluron 10 EC @ 1.5ml/l, emamectin benzoate 5 SG @ 0.35g/l at 10-15 days interval, was most effective with 88.43% reduction in DBM (Table 1). Highest yield of 146.45 q/ha (69.64 % increase) was obtained in the integrated module with C: B ratio 1:8.68. Highest numbers of predatory spiders were observed in bio-intensive module followed by integrated module.

Table 1: Effect of different pest management modules against DBM, *Plutella xylostella* in cabbage

Modules	No. of larvae		Flea Beetle		Yield (q/ha)	
	Pooled mean	PROC*	Pooled mean	PROC*	Avg.	PIOC*
Biointensive Module	4.05	71.61	19.82	42.31	121.27	40.47
Integrated Module	1.65	88.43	12.58	63.37	146.45	69.64
Chemical Module	4.37	69.39	9.08	73.56	130.25	50.87
Untreated Control	14.27		34.35		86.33	-
SEm ±	0.16	-	1.52	-	1.52	-
CD (p = 0.05%)	1.39	-	3.45	-	4.20	-

*PPOC- Per cent protection over control; #PIOC: Percent increase over control

Project 6.2: Toxicological investigations on the novel insecticide molecules and plant origin insecticides against major insect pests of vegetables

Dose standardization of flonicamid 50 WG for the management of sucking pests of okra: A field experiment was conducted to standardize the doses of flonicamid 50 WG against sucking insect pests of okra (cv. Kashi Pragati) during summer season 2015. Flonicamid 50 WG 0.4g/l was most effective with 93.26 and 85.91% reduction in leafhoppers and whitefly population, respectively compared to control (Table 2).

Table 2: Bio-efficacy of flonicamid 50 WG against leafhoppers and whitefly of okra

Treatment	Dose (g/l)	leaf hoppers*/ 3 leaves/plant			white fly*/3 leaves/plant		
		Before Spray	Avg.	PR	Before Spray	Avg.	PR
Flonicamid 50 WG	0.2	91.33	11.05	90.78	24.00	7.97	**78.73**
Flonicamid 50 WG	0.3	78.33	9.53	92.05	21.33	6.64	**82.28**
Flonicamid 50 WG	0.4	80.67	8.08	93.26	22.00	5.28	**85.91**
Imidacloprid 17.8 SL	0.35	75.00	24.28	79.75	23.33	15.75	**57.97**
Thiomethoxam 25 WG	0.35	85.33	25.20	78.99	25.33	16.28	**56.56**
Dimethoate 30 EC	2	87.33	32.33	73.04	27.67	17.70	**52.77**
Control	-	75.00	119.92	90.78	24.33	37.47	**78.73**
SEm (±)			1.64			0.68	
CD			4.88			2.01	
CV			**10.38**			**5.32**	

**Pooled data of three sprays; PR= Percent Reduction*

Dissipation studies/degradation behavior and safety evaluation of flonicamid in okra fruits: Flonicamid residue dissipation followed first order kinetics with half-lives ranging between 3 and 3.5 days; the pre harvest interval (PHI) was 16 and 20 days for the recommended and double the recommended doses, respectively. The residues dissipated to below the MRL of 0.01 mg kg^{-1} on the same day. The dietary exposure of the measured residues for flonicamid was lower than the MPI of 0.576 mg $person^{-1}$ day^{-1} on all the sampling days for single as well as double dose (Table 3 & Figure 1) indicating low risk of acute toxicity and safety regarding use of these chemicals.

Table 3: Persistence and dissipation of flonicamid 50 WG in okra fruits

Order	Parameters	European Union MRL = 0.01 (mg kg^{-1})	
		Recommended dose	Double the recommended dose
1st+1st	R2	0.99	0.989
	a (mg kg^{-1})	0.264	0.216
	b (day^{-1})	0.251	0.227
	c (mg kg^{-1})	0.259	0.646
	d (day^{-1})	0.251	0.222
	DT50 (days)	3	3.5
	PHI (days)	16	20
1st	R2	0.99	0.989
	a (mg kg^{-1})	0.585	1.39
	b (day^{-1})	0.328	0.29
	DT50 (Days)	3	3.5
	PHI (days)	16	20

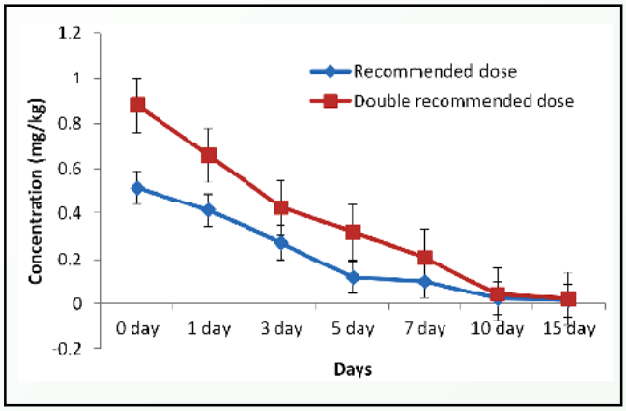


Fig. 1: Dissipation of flonicamid 50 WG in okra fruits

Field evaluation of different insecticide use strategies as resistance management and control tactics for sucking pests of okra: Different insecticide use strategies against sucking insect pests of okra (cv. Kashi Pragathi) were evaluated during *kharif* season 2015. Among these, rotational strategy I with spray of flupyridifuron 2.5ml/l followed by flonicamid 0.3g/l and cyantarniliprole 1.8ml/l and rotational strategy II comprising flonicamid 0.3ml/l followed by cyantarniliprole 1.8ml/l and flupyridifuron 2.5ml/l were effective in reducing the leafhopper and whitefly populations both the stratigies were at par with the sequential spraying of individual insecticides like flupyridifurone, flonicamid and cynatraniliprole (Table 4). Native PAGE analysis of leafhoppers collected from different treatments showed less expression of esterage enzyme in flupyridifurone, flonicamid and rotational Strategy I, indicating the effectiveness of treatments (Figure 2).

Table 4: Effect of different insecticide use strategies for control sucking pests and yield of okra

Sl No.	Treatments	Dose (ml/L)	Avg. No of leaf hoppers* (3 leaves/plant)		Avg. no of white fly* (3 leaves/ plant)	
			Avg.	PPOC	Avg.	PPOC
T1	Flupyridifuron 200 SL	2.5	12.24	73.04	14.87	70.67
T2	Flonicamid 50 WG	0.3	11.67	74.32	14.87	70.67
T3	Cyantarniliprole 10 OD	1.8	15.58	65.70	13.91	72.56
T4	Imidacloprid 17.8 SL	0.5l	21.91	51.76	45.62	10.00
T5	Thiomethoxam 25 WG	0.35	18.84	58.51	48.87	3.59
T6	Rotational Strategy I	-	12.67	72.11	19.29	61.95
T7	Rotational Strategy II	-	13.02	71.33	18.58	63.35
T8	Untreated Control		45.42		50.69	
	SEm		0.38		0.12	
	CD(P=0.05)		1.10		0.35	

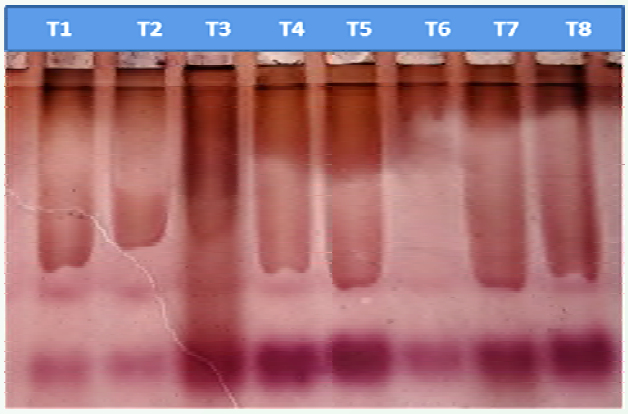


Fig. 2: Native PAGE analysis of leafhopper

Biosafety evaluation of certain insecticides against a predator, rove beetle: Among different insecticides evaluated, cyzapyre, flonicamid and spiromesifen were harmless (< 30% mortality) to adult rove beetle, when tested by direct spray and film residue bioassay method (Figure 3).

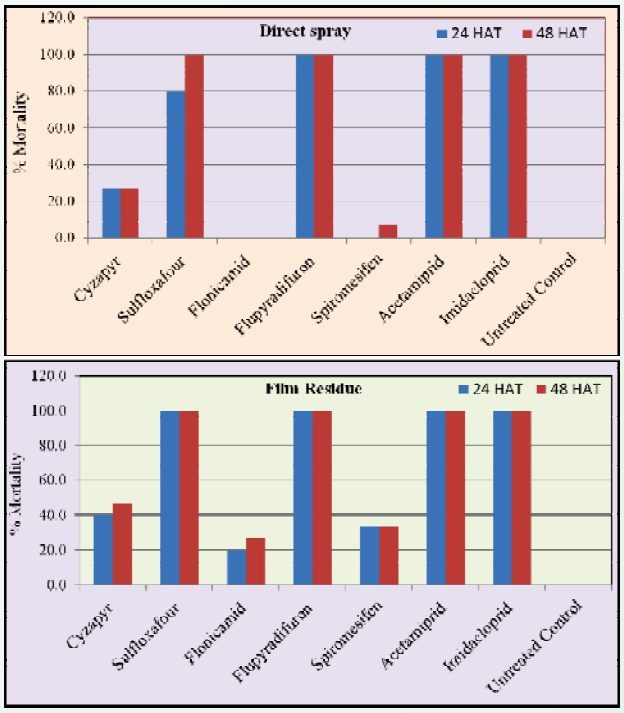


Fig. 3: Effect of different newer insecticides against rove beetle -a predator

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

Occurrence of *Microplitis tuberculifer*, a solitary koinobiont, larval endoparasitoid: A solitary, koinobiont, larval endoparasitoid *Microplitis tuberculifer* (Fig. 4.5) was recovered from *Spodopteralitura* infesting cauliflower in Varanasi, UP. The maximum of 7.55% parasitization was recorded during October 4th week. The parasitoid parasitizes host larvae in their early and mid-developmental phase, most preferably

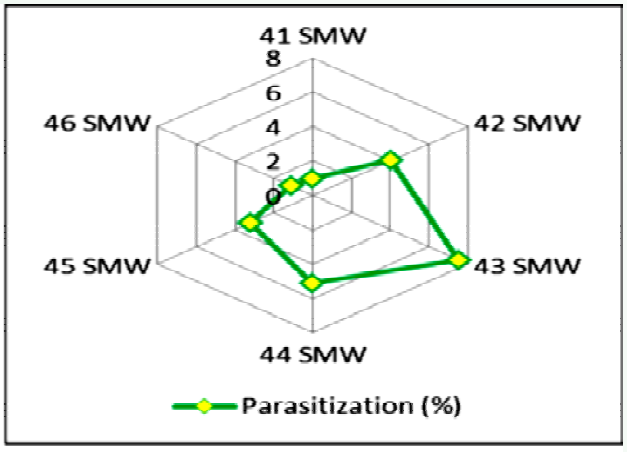


Fig. 4. Seasonal incidence of *M. tuberculifer* on *S. litura*

Fig. 5: Adult of *Microplitis tuberculifer*

first or second instar, and finally kills the larvae before reaching to pupation.

Incidence of parasitoids *Aenasius arizonensis* of *Phenacoccus solenopsis* and *Dinarmus basalis* of *Callosobruchus chinensis:* The solitary endo-parastitoid collected from *P. solenopsis* infesting okra during June-July was identified as *Aenasius arizonensis* (Encyrtidae: Hymenoptera) with 18.85% parasitization. Similarly, *Dinarmus basalis* (Pteromalidae: Hymenoptera) was identified as an endemic, solitary, larval-pupal ecto-parasitoid of *C. chinensis* infesting pea during August–September, 2015.

Biology and life cycle of *E. furcellata* feeding on *S. obliqua*: A polyphagpous predator, *Eocanthecona furcellata* (Pentatomidae: Hemiptera) (Figure 6) was collected and mass reared under laboratory conditions, using *Spilosoma obliqua* as fastidious host. The neonate nymphs were reddish pink in colour with black appendages. There were five nymphal instars which lasted for 22.25 to 27.25 days. The mean duration of first, second, third, fourth and fifth instar nymphs were 2.75, 5.07, 5.20, 5.97 and 5.24 days, respectively. The duration of male and female adults varied from 15-16 days and 27-28 days, respectively. Freshly laid eggs were oval in shape, bright golden yellow in colour and laid in small batches of 5-17 in numbers. Before hatching the eggs turned reddish in colour. Incubation period varied from 5.5 to 8.25 days (Table 5)

Fig. 6: Adult *E. furcellata* feeding on *S. obliqua*

Table 5: Biological events in life cycle of *E. furcellata* on *S. obliqua* under laboratory conditions

Biological parameters	Minimum	Maximum	Mean* ± SD
Fecundity (Nos.)	249	370	303.6 ± 22.56
Egg viability (%)	77	94	85.4 ± 5.13
Oviposition period (days)	21	28	24.31 ± 2.16
Incubation period (days)	5.5	8.25	7 ± 0.55
Nymphal duration (days)			
First instar	2.5	3.25	2.75 ± 0.25
Second instar	4.5	6.25	5.07 ± 0.26
Third instar	4.75	5.5	5.20 ± 0.71
Fourth instar	5.5	6.5	5.97 ± 0.46
Fifth instar	5.0	5.75	5.24 ± 0.39
Total nymphal period	22.25	27.25	25.15 ± 2.37
Adult longivity (days)			
Male	15	18	17.18 ± 0.97
Female	21	28	24.31 ± 2.16

The average consumptions of third instar larvae of *S. obliqua* by the neonate, second, third, fourth and fifth instar predatory nymphs were 1.6, 7.73, 11.93, 12.13, 18.67 larvae, respectively (Figure 7). The adult female devoured higher (125.5 at 3rd instar larvae) than its male counterpart (84.25).

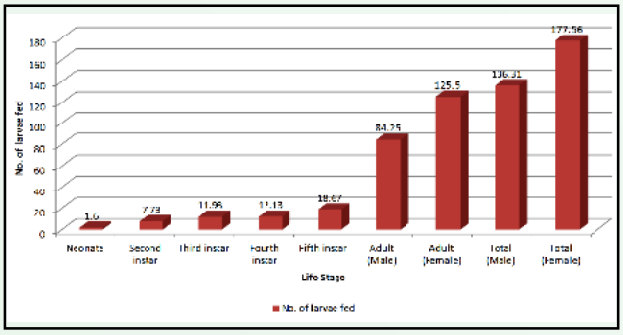


Fig.7: Feeding potential of *E. furcellata* under laboratory conditions

Evaluation of different biopesticides alone and in combination with neem oil (1:1) against painted bugs: Bioefficacy of entomopathogenic microorganisms *viz*., *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, *Bacillus subtilis*-2 and botanical, neem oil were tested alone and their 1:1 combination with neem oil against painted bugs (*Bagrada hilaris*). Neem oil (1%), amongst all the biopesticides was most effective against painted bug infesting radish and the median lethal time (LT_{50}) was 102.03 h. Among the entomopathogens, *L. lecanii* had the lowest LT_{50} values (103.72 h) followed by *M. anisopliae* IIVR strain (111.16 h) and *B. bassiana* IIVR strain (121.42 h). All the entomopathogenic fungi showed compatibility with neem oil. Lowest LT_{50} of 50.37 h was recorded in case of *M. anisopliae* IIVR strain + Neem oil followed by *B. bassiana* IIVR strain + Neem oil (60.62 h). The co-toxicity coefficient values of neem oil with *B. bassiana*, *M. anisopliae*, *B. bassiana* IIVR strain, *M. anisopliae* IIVR strain, *L. lecanii* were 1.580, 1.383, 1.683, 1.633 and 2.026, respectively indicating compatibility (Table 6).

Table 6: Median lethal time of different entomopathogens and neem oil alone and their 1:1 combinations against *B. hilaris*

Biopesticides	Heterogeneity		Regression Equation (Y=)	LT_{50} (Hr)	Fiducial Limit	CC*
	df	χ^2				
B. bassiana	3	2.918	6.989X – 9.733	128.20	150.16 – 109.45	--
M. anisopliae	4	2.013	7.175X– 10.145	129.03	162.03– 102.76	--
B. bassiana IIVR Strain	4	0.196	1.936X + 0.964	121.42	202.29 – 72.88	--
M. anisopliae IIVR Strain	4	1.304	4.662X – 4.538	111.16	137.29 – 90.01	--
L. lecanii	4	1.693	4.255X – 4.615	103.72	124.09 – 93.51	--
B. subtilis - 2	4	1.212	4.319X – 4.761	131.96	151.08 – 111.91	--
Neem oil (1%)	4	0.984	5.123X – 5.291	102.03	121.90 – 85.40	--
B. bassiana + Neem oil (1:1)	6	0.413	2.976X – 0.169	64.58	77.69 – 54.01	1.580
M. anisopliae + Neem oil (1:1)	5	0.826	3.372X – 0.532	73.76	74.30 – 55.26	1.383
B. bassiana IIVR Strain + Neem oil (1:1)	4	2.989	4.793X – 2.712	60.62	67.48 – 44.75	1.683
M. anisopliae IIVR Strain + Neem oil (1:1)	3	3.329	7.657X – 6.575	62.48	67.10 – 58.44	1.633
L. lecanii + Neem oil (1:1)	5	0.215	4.860X – 3.273	50.37	58.06 – 43.70	2.026
B. subtilis – 2 + Neem oil (1:1)	4	0.326	2.170X + 0.552	112.07	229.33 – 54.77	0.910

*CC= Co-toxicity coefficient (CC = LT_{50} values of neem oil alone/ LT_{50} value of mixtures)

Bioefficacy of different entomopathogens alone and in combination with neem oil (1:1) against adults of melon weevil: Among biopesticides, neem oil (1%) was most effective and registered lowest median lethal time (64.94 h), whereas among entomopathogenic fungi, *L. lecanii* at recommended dose was most effective (87.84 h) followed by *M. anisopliae* IIVR strain (101.08 h). Among the mixure of these EPFs individually with neem oil at 1:1 ratio (at half of their recommended doses), *L. lecanii* + neem oil proved most effective against adults of melon weevil showing compatibility and synergistic activity as evidenced by lowest median lethal time of 63.78 h (Table 7). Thus the white halo fungus, *L. lecanii* apart from controlling sucking insect pests, could be utilized for the control of coleopteran pests like melon weevil. The bacteria, *B. thuringiensis* and *B. subtilis*-2 were ineffective.

Whether susceptibility of *Phenacoccus solenopsis* towards *Lecanicillium lecanii* alone and in combination with neem oil is host mediated?: Effects of *L. lecanii* alone and in 1:1 combination with neem oil were tested against mealy bug, *P. solenopsis* infesting major vegetable crops (eggplant, tomato, chilli, okra, pointed gourd and cucumber) and compared with cotton and the weed, *Parthenium hysterophorus*. Marked differences were observed in the mortality as affected

Table 7: Bioefficacy of different entomopathogens alone and in combination with neem oil (1:1) against adults of melon weevil

Biopesticides	Heterogeneity		Regression Equation (Y=)	LT_{50} (hr)	Fiducial Limit
	df	χ^2			
Metarhizium anisopliae IIVR strain	7	3.155	3.878X – 2.774	101.08	111.31 – 91.80
Beauveria bassiana IIVR strain	8	8.064	4.102X – 3.700	132.05	148.30 – 117.58
Lecanicillium lecanii	6	9.563	5.720X – 6.112	87.84	94.36 – 81.76
Neem oil (1%)	6	8.952	2.444X + 0.569	64.94	77.35 – 54.53
Metarhizium anisopliae IIVR strain + Neem oil	7	3.157	4.949X – 5.133	111.55	125.51 – 99.14
Beauveria bassiana IIVR strain + Neem oil	6	3.033	8.043X – 11.342	107.60	116.11 – 99.71
Lecanicillium lecanii + Neem oil	6	3.736	3.308X – 0.969	63.78	76.30 – 53.31

by different host involved. In case of *L. lecanii*, the highest mortality (66.21 and 90.23% at 3 and 5 DAT, respectively) was recorded in okra whereas the lowest was in *Parthenium* (13.98 and 29.91) (Table 8). The lowest median lethal time was noted in case of *L. lecanii* when *P. solenopsis* fed on okra and their ascending order of median lethal time was Okra > Pointed gourd > Tomato > Chilli > Cotton > Eggplant > Cucumber > *Parthenium*. Almost same trends were also followed in neem oil and 1:1 mixture of *L. lecanii* and Neem oil. The ascending order of median lethal time for neem oil was Okra > Pointed gourd > Tomato > Chilli > Eggplant > Cotton > Cucumber > *Parthenium*. Considering the median lethal time of mealy bug reared on okra as base (1), time required for *L. lecanii* for 50% killing of 6±1 day old nymphs of *P. solenopsis* was 1.15, 1.38, 2.20, 2.72, 2.75, 2.90 and 4.80 times higher when fed on Pointed gourd, Tomato, Chilli, Cotton, Eggplant, Cucumber and *Parthenium*, respectively (Table 9). Thus a strong host mediated variations observed with uniform dosages of same biopesticides when applied to the same stage of *P. solenopsis* collected from different hosts.

Table 8: Median lethal time of *L. lecanii* and neem oil alone and their combination (1:1) against *P. solenopsis* infesting different host plants

Biopesticides	Heterogeneity		Regression Equation (Y=)	LT_{50} (hour)	Fiducial Limit
	df	χ^2			
Okra					
L. lecanii	5	0.630	1.537X + 2.564	38.4	51.86 – 28.46
Neem oil	6	1.467	1.459X + 2.770	33.7	53.07 – 21.45
L. lecanii + Neem oil (1:1)	6	7.786	2.911X + 0.677	30.6	39.17 – 23.87
Pointed gourd					
L. lecanii	5	0.543	1.852X + 1.953	44.2	55.24 – 35.29
Neem oil	5	0.973	2.119X + 1.606	39.9	49.54 – 32.21
L. lecanii + Neem oil (1:1)	5	0.450	1.188X + 3.194	33.2	55.73 – 19.78
Tomato					
L. lecanii	5	0.773	1.897X + 1.732	52.9	65.42 – 42.78
Neem oil	5	0.984	2.426X + 0.978	45.5	54.01 – 38.32
L. lecanii + Neem oil (1:1)	5	0.329	2.203X + 1.455	40.7	49.71 – 33.26
Chilli					
L. lecanii	6	1.834	2.342X + 0.485	84.6	102.20 – 70.05
Neem oil	6	4.136	1.573X + 2.068	73.2	91.15 – 58.75
L. lecanii + Neem oil (1:1)	6	0.275	1.586X + 2.185	59.5	75.70 – 46.77
Eggplant					
L. lecanii	7	1.263	2.017X + 0.918	105.7	134.19 – 83.30
Neem oil	8	2.601	3.769X – 2.586	103	115.54 – 91.83
L. lecanii + Neem oil (1:1)	8	5.401	4.184X – 3.256	93.91	103.51 – 85.20
Cucumber					
L. lecanii	4	1.256	2.303X + 0.285	111.5	144.91 – 85.72
Neem oil	4	0.116	1.869X + 1.153	114.3	165.42 -79.01
L.lecanii +Neem oil (1:1)	5	2.465	2.444X + 0.378	77.8	92.11 – 65.73
Cotton					
L. lecanii	4	2.944	5.898X – 6.909	104.5	116.47 – 93.77
Neem oil	5	1.989	5.163X – 5.397	103.3	115.77 – 92.08
L. lecanii + Neem oil (1:1)	5	8.374	5.074X – 4.703	81.7	89.18 – 74.85
Weed (*Parthenium hysterophorus*)					
L. lecanii	5	8.641	2.518X – 0.704	184.3	273.33 – 124.23
Neem oil	6	7.992	2.636X – 0.897	172.8	232.08 – 128.62
L. lecanii + Neem oil (1:1)	5	0.880	2.464X – 0.357	149.2	230.89 – 96.41

Table 9: Relative lethal time of *L. lecanii* alone and its combinations with neem oil (1:1) against *P. solenopsis* infesting major vegetables and associated weed

Host plants	*L. lecanii*	Neem oil	*L. lecanii* + neem oil (1:1)	CD at 5% (host wise)
Okra	38.4 (1)*	33.7 (1)	30.6 (1)	1.45
Pointed gourd	44.2 (1.15)	39.9 (1.18)	33.2 (1.09)	3.21
Tomato	52.9 (1.38)	45.5 (1.35)	40.7 (1.33)	3.29
Chilli	84.6 (2.20)	73.2 (2.17)	59.5 (1.95)	5.27
Eggplant	105.7 (2.75)	103.01 (3.05)	93.9 (3.07)	2.24
Cucumber	111.5 (2.90)	114.3 (3.39)	77.8 (2.54)	7.33
Cotton	104.5 (2.72)	103.3 (3.06)	81.7 (2.67)	4.74
Parthenium hysterophorus	184.3 (4.80)	172.8 (5.12)	149.2 (4.88)	5.02
CD at 5% (treatment wise)	9.73	8.05	8.66	

*Figures in the parenthesis are the relative lethal time.
Relative lethal time = LT_{50} worked out for *P. solenopsis* feeding on different crops (other than okra) and weed / LT_{50} worked out in *P. solenopsis* infesting okra

Compatibility and synergism of major neonicotinoids with different entomopathogenic fungi (EPF) against *Lipaphis erysimi* : Entomopathgens *Beauveria bassiana*-IIVR strain, *Metarhizium anisopliae*-IIVR strain, *Lecanicillium* (=*Verticillium*) *lecanii* and neonicotinods imidacloprid 17.8 SL, thiamethoxam 25 WG at half of their recommended doses were compatible and synergistic against *L. erysimi* infesting cabbage and cauliflower. Combination of imidacloprid and *L. lecanii* took the lowest median lethal time (24.31 hour) with highest Co-toxicity coefficient (1.39) (Table 10). Similar observation was also noted where *L. lecanii* when mixed with thiamethoxam 25 WG at half of their recommended doses took the lowest median lethal time (15.66 hour) with highest Co-toxicity coefficient (1.27) (Table 11).

Table 10: Effect of different entomopathogens alone and their combination with Imidacloprid 17.8 SL (1:1)

Biopesticides	Heterogeneity		Regression equation (Y=)	LT_{50} (hr)	Fiducial limit	Co-toxicity coefficient
	df	$\chi 2$				
Beauveria bassiana (IIVR strain)	5	0.329	2.230X + 1.150	53.22	64.39 – 43.99	--
Metarhizium anisopliae (IIVR strain)	5	3.191	2.367X + 0.649	68.83	85.86 – 55.18	--
Lecanicillium lecanii	5	1.469	1.851X + 1.956	44.09	54.85 – 35.44	--
Imidacloprid 17.8 SL	4	2.089	2.088X + 1.810	33.69	42.91 – 26.46	--
Beauveria bassiana (IIVR strain) + Imidacloprid (1:1)	3	1.362	3.498X – 0.084	28.41	33.34 – 24.21	1.19
Metarhizium anisopliae (IIVR strain) + Imidacloprid (1:1)	4	0.249	3.637X + 0.319	28.99	33.90 – 24.80	1.16
Lecanicillium lecanii + Imidacloprid (1:1)	4	0.084	3.523X + 0.118	24.31	28.32 – 20.51	1.39

*Co-toxicity coefficient (CC) = LT_{50} value of imidacloprid alone / LT_{50} values of mixtures

Table 11: Effect of different entomopathogens alone and their combination with Thiamethoxam 25 WG (1:1)

Biopesticides	Heterogeneity		Regression equation (Y=)	LT_{50} (hr)	Fiducial limit	Co-toxicity coefficient
	df	$\chi 2$				
Beauveria bassiana (IIVR strain)	5	0.329	2.230X + 1.150	53.22	64.39 – 43.99	--
Metarhizium anisopliae (IIVR strain)	5	3.191	2.367X + 0.649	68.83	85.86 – 55.18	--
Lecanicillium lecanii	5	1.469	1.851X + 1.956	44.09	54.85 – 35.44	--
Thiamethoxam 25% WG	4	0.290	4.463X – 0.796	19.88	23.38 – 16.92	--
Beauveria bassiana (IIVR strain) + Thiamethoxam (1:1)	4	0.634	1.796X + 2.758	17.72	23.24 – 13.51	1.12
Metarhizium anisopliae (IIVR strain)+ Thiamethoxam (1:1)	4	0.798	1.890X + 2.553	19.69	25.18 – 15.40	1.01
Lecanicillium lecanii + Thiamethoxam (1:1)	4	1.221	1.948X + 2.673	15.66	20.56 – 11.92	1.27

*Co-toxicity coefficient (CC) = LT_{50} value of thiamethoxam alone / LT_{50} values of mixtures

Project 6.4: Management of important fungal diseases of vegetable crops

Isolation of pathogens causing gummy stem blight disease on bottle gourd: Brown leaf spots were noticed on leaves of bottle gourd plants. Spots starts at margin of the leaf then slowly extends towards centre of the leaf. Spots coalesce together to give blighting appearance. Often the spots are surrounded by the yellow halo (Figure 8). At the crown region, cankers were formed giving splitting appearance of the stem. Infected portion harbored numerous black dots called pycnidia (Figure 9). Sometimes, gum exudates were observed on the infected portion of the stem (Figure 10). At the later stage plant leads to drying (Figure 11). Its Incidence was 55%.

Fig. 8: Blighting of leaves

Fig. 9: Splitting of stem with numerous black dots

Fig. 10: Exudation of gum from infected stem

Fig. 11: Drying of infected plants

To prove the pathogenicity, culture prepared was inoculated on the 30 days old bottle gourd plants. Mycelial disc was placed on the pinpricked stem portion and then covered with the moist cotton. Entire set up is covered with the polythene bag sprinkled with the water to maintain the humidity for 24 hours. After 7 days of inoculation, symptom appeared on the stem as browning of the tissue at the inoculated site (Figure 12). But it was not observed in the mock inoculated plants. For molecular characterization, DNA was extracted from the mycelial mat of the fungus and subjected to the PCR assay using the ITS region with the help of ITS 1/4 primer pair. The fungus showed amplification to a size of around ~600bp (Figure 13).

Fig. 12: Proving Koch's postulate with the fungus isolated from the diseased portion

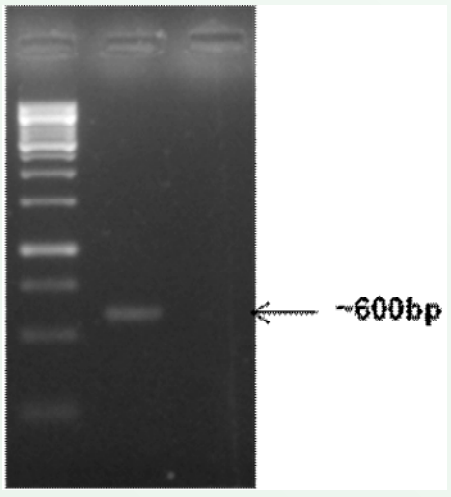


Fig. 13: PCR amplification of fungus causing gummy stem blight disease on bottle gourd using ITS 1/4 primer pair

Isolation of *Fusarium* spp. causing wilt disease on pea: Fusarium wilt disease was observed on the pea crop with the incidence ranging from 10-20% in different lines. Symptoms observed were, yellowing of leaves followed by drooping of leaves and complete death of the plant observed upon advancement of disease (Figure 14). If stems of such plants were split open browning of vascular region was observed (Figure 15). Upon isolation, *Fusarium* sp. was found to be the causal agent of the disease both in the IIVR farm and farmers' field. One culture was found to produce pinkish pigmentation and another culture pure white without any pink pigmentation (Figure 16).

Fig. 14: Drying of entire plant upon wilt infection

Fig. 15: Browning of vascular bundles in infected pant

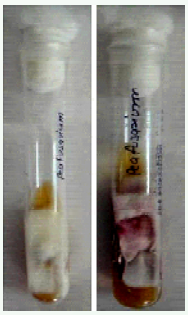


Fig.16: Pure cultures of *Fusarium* spp. infecting pea

Isolation of *Sclerotium rolfsii* causing collar rot disease on bottle gourd and induced sclerotium production on wheat straw: Infected collar region showed rotting and was found to have white strands of mycelia with numerous milky white sclerotia on it (Figure 17). Pathogen was isolated on the PDA medium (Figure 18). To induce sclerotium production, sterilized wheat straw was inoculated with the mycelial disc. Sclerotium production was observed 7-10 days after inoculation (Figure 19).

Fig. 17: Characteristic white strands of mycelia with numerous sclortia on the collar rot infected bottle gourd stem

Fig. 18: Pure culture of *Sclerotium rolfsii* from bottle gourd

Fig. 19: Indiction of Sclerotium production on wheat straw

Isolation of *Alternaria* spp. causing leaf blight on brinjal and chilli: On brinjal, symptoms observed were brown irregular lesion with concentric rings on leaves, later covered by black powdery growth. Coalescence of such lesions resulted in drying of entire leaf. Pathogen causing leaf blight was isolated on the PDA medium (Figure 20) and spores were observed under microscope (Figure 21). Similarly leaf blight causing pathogen on chilli was also isolated in the PDA medium (Figure 22).

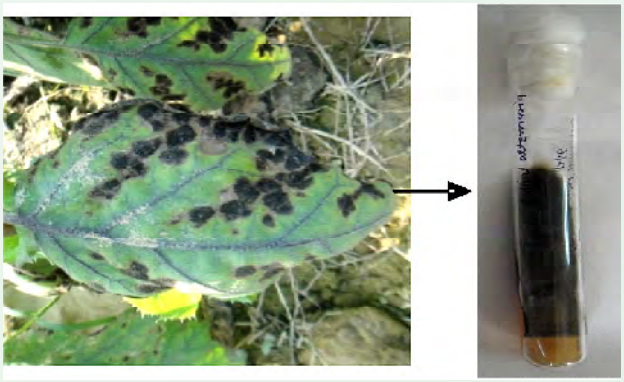


Fig. 20: *Alternaria* sp. isolated from leaf blight of brinjal

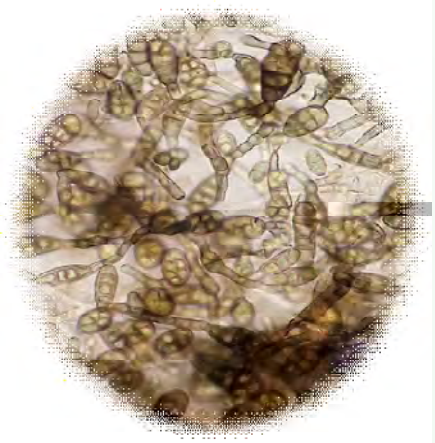


Fig. 21: Muriform conidia of *Alternaria* spp. from brinjal

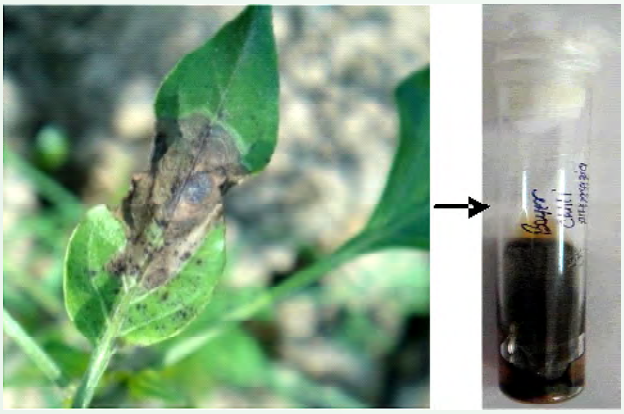


Fig. 22: *Alternaria* spp. isolated from leaf blight of chilli

Isolation of *Colletotrichum* sp. causing anthracnose on chilli : Infection occurs on different parts of the plants. On leaves circular brown leaf spot with white centre was observed from the chilli crop. White mycelial growth of *Colletotrichum* was observed on the isolation made from the infected portion and pure culture was made (Figure 23).

Fig. 23: Anthracnose symptom on chilli leaf and pure culture of *Colletotrichum* sp.

Isolation of *Sclerotinia sclerotiorum* causing white rot on pea, field bean and French bean: *S. sclerotiarum* infection was observed in vegetable legumes such as pea, field bean and French bean. Infected plant parts show rotting covered with white mycelial growth followed by formation of hard black sclerotia on it (Figure 24a, b, c). Fungal cultures were isolated from the infected portion and pure cultures were maintained.

Management of disease complex caused by *Meloidogyne incognita* and *Sclerotium rolfsii* in tomato: A pot experiment was conducted on management of disease complex caused by root knot nematode, *M. incognita* and collar rot fungi, *S. rolfsii* in tomato *var* Kashi Aman. Different treatments including bio-control agents and their combination @0.5% and 1% were applied (Table 12, Figure 25). Among these, Nematicides + Fungicides + TRB4+CRB2 @1% reduced 64.5% of galls, 28.0% soil population and disease severity scale to 1 and gall index 3 and reproductive factor 0.2 over inoculated control. The perusal These bio-controls agents also stimulated plant growth parameters and yields compared with inoculated control (Table13, Fig-25). Among treatments, nematicides+fungicides+TRB4+CRB2 @1% increased the plant height (41.3%), root length (47.7cm) and yield (77.5) compared to other treatments and inoculated control.

Fig. 24a. Symptoms on Pea

Fig. 24b: Symptoms on French bean

Fig. 24c: Symptoms on field bean

Table 12: Management of disease complex caused by root knot nematode, *M. incognita* and collar rot fungi, *Sclerotium rolfsii* in tomato

Treatments	Galls/ plant	% reduction of galls	Gall Index (0-10)	Soil population	% Reduction	Rf (Pi/Pf)	Disease severity (0-5scale)
T1-Healthy control	0.0 (0.7)a	100.0	0	0.0 (0.7)g	100	0	0
T2-Inoculated control	366.0 (10.1)g	0.0	7	582 (24.1)a	0	1.3	3.5
T3-Nematicides @1kg/ha	95.0 (19.2)b	74.1	3	297 (17.2)ef	29	0.2	3.2
T4-Fungicides @0.25%	338.0 (18.4)g	7.7	6	518.3 (22.8)ab	5.6	1.6	1
T5-TRB4 @0.5%	261.3 (16.2)ef	28.7	5	579.7 (24.1)ac	0.2	1.5	1
T6-TRB4 @1%	240.3 (15.1)e	34.5		365.0 (19.1)	20.9	1.4	1
T7-CRB2 @0.5%	253.3 (15.9)e	30.9	5	568.3 (23.8)a	1.2	1.4	2
T8-CRB2 @1%	244.7 (15.7)e	33.3	5	368.0 (19.2)c	20.4	1.4	2
T9-TRB4 + CRB2@0.5%	194.7 (14.0)d	46.9	4	357.0 (18.9)cd	21.7	1.0	1
T10-TRB4 + CRB2@1%	142.7 (12.0)c	61.1	3	307.0 (17.5)e	27.4	0.2	1
T11-Nematicides +Fungicides	85.0 (9.2)b	76.8	3	282.0 (17.0)f	30.0	0.2	3
T12-Nematicides+ Fungicides TRB4+ CRB2@0.5%	178.7 (13.4)d	51.3	4	340.0 (18.5)d	23.5	0.4	1
T13-Nematicides + Fungicides + TRB4 + CRB2@1%	130.0 (11.4)c	64.5	3	301.7 (17.4)ef	28.0	0.2	1
$CD_{P=0.05}$	1.05			0.64			
SEd	0.51			0.31			

Note- Figures presented in parentheses are square root transformed values, Nematode inoculums level $2J_2$/g soil; Fungus inoculums 2g fungal mat mix with 18g and: Root colonisation index was calculated as per Shahzed and Ghaffar (1992)

Table 13: Management of disease complex of root knot nematode and collar rot in tomato

Treatments	Plant height (cm)	% increase over inoculated control	Root length(cm)	Yield Kg/pot	% increase over control
T1-Healthy control	73.3(8.6)	17.0	22.7(4.8)cd	1.0	40.0
T2-Inoculated control	62.7(7.9)	0.0	13.3(3.7)e	0.2	0.0
T3-Nematicides@1kg/h	74.2(8.6)	18.4	22.0(4.7)cd	0.6	21.7
T4-Fungicides@0.25%	75.3(8.7)	20.2	21.7(4.7)d	0.6	20.0
T5-TRB4 @ 0.5%	75.4(8.7)	20.3	22.3(4.8)cd	0.7	25.0
T6-TRB4 @ 1%	82.1(9.1)	31.0	33.0(5.8)b	1.0	38.3
T7-CRB2 @ 0.5%	75.3(8.7)	20.2	21.0(4.6)d	1.0	41.7
T8-CRB2 @ 1%	85.2(9.3)	35.9	34.0(5.9)b	1.3	52.5
T9-TRB4+CRB2 @ 0.5%	82.0(9.1)	30.9	28.0(5.3)bc	1.5	65.0
T10- TRB4+CRB2 @ 1%	86.2(9.3)	37.5	45.0(6.7)a	1.7	73.3
T11-Nematicides +Fungicides	74.4(8.7)	18.8	29.3(5.5)b	0.6	21.7
T12-Nematicides+ Fungicides+TRB4 +CRB2 @ 0.5%	84.5(9.2)	34.8	32.7(5.8)b	1.2	50.0
T13 Nematicides +Fungicides+TRB4 +CRB2 @ 1%	88.5(9.4)	41.3	47.7(6.9)a	1.8	77.5
$CD_{P=0.05}$	NS		0.60	1.12	
SEd	0.66		0.29	0.06	

Note-Figures presented in parentheses are square root transformed values, Nematode inoculums level $2J_2$/ g soil; Fungus inoculums 2g fungal mat mix with 18g and Root colonisation index was calculated as per Shahzed and Ghaffar (1992)

Fig.25: Management disease complex caused by root knot nematode, *Meloidogyne incognita* and collar rot fungi, *Sclerotium rolfsii* in tomato

Fig.26: Artificial screening for late blight of tomato

Management of late blight through host resistance: 38 varieties/ advanced lines/ germplasm of tomato against late blight were screened under challanged inoculation in indigeneously designed moist chamber during February-March. Observations were recorded at 3-days on 5 point rating score. The pathogen-host reaction was categorized based on mean PDI (Figure 26). Out of 38 lines only two line viz, VRT-265 (17.5%) and VRT-808 (20.0%) were found moderately resistant.

Project 6.5: Bioprospecting of microorganisms associated with vegetables against plant pathogens

Evaluation of different microbial formulations in bottle gourd: The field evaluation of microbials listed in Table 14. was done using bottle gourd crop (cv. Kashi Ganga) (Figure 27).

Fig. 27: Influence of different treatments on bottle gourd (a-T1, b-T4, c-T8, d-T7, e-T5)

The plant defense related enzyme, peroxidase, polyphenol oxidase (PPO) and total phenol were estimated at 75 and 117 DAS.

Table 14: Details of microbial formulations evaluated under field conditions

Sl. no.	Treatment detail
T1	Control
T2	Carbendazim 50 WP
T3	*Pseudomonass fluorescens*
T4	*Pb-3*
T5	*Isaria farinosa*
T6	*Serratia marcesens*
T7	*Trichoderma asperellum*
T8	*Stenotrophomonas maltophila*
T9	*Alcaligenes sp.*

Maximum PPO activity was recorded in T9 followed by T1 and T2, whereas at harvest stage T6, T3 and T9 recorded highest activity (Figure 28a and 28 d).

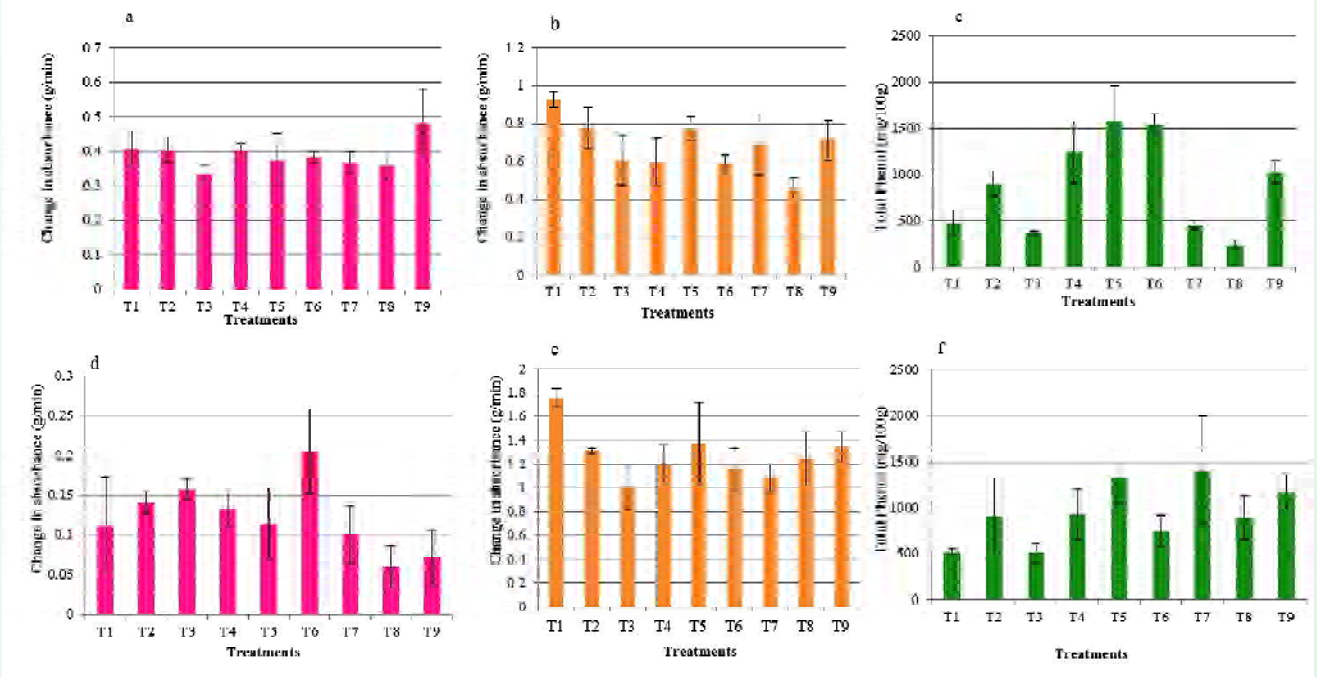


Fig. 28 (a-f): Analysis of polyphenol oxidase (a and d), peroxidise (b and e) and total phenol (c and f), a-c: 75 DAS; d-f: 117 DAS

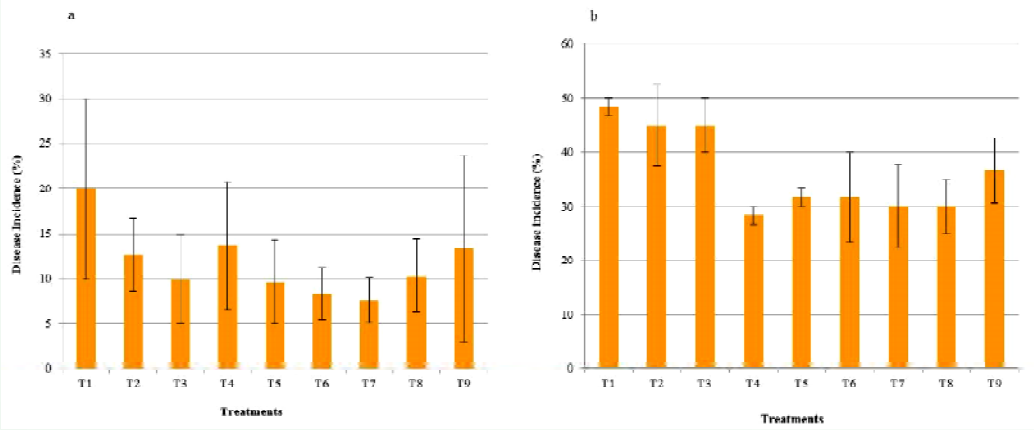


Fig. 29(a &b): Incidence of leaf blight disease in bottle gourd

Less PPO activity was observed at harvest stage in comparison with the mid stage. Maximum peroxidase activity was observed in T1, T2, T3 and T1, T2, T9 at mid and harvest stage respectively (Figure 28b and 28e). Peroxidase activity was maximum at harvest stage than at mid stage (Figure 28b and 28e). Total phenol content was maximum in T5, T6, T4 and T5, T7 and T9 at mid and harvest stage respectively (Figure 28c and 28f). The leaf blight disease incidence was highest in T1, T9, T2 and T1, T2, T3, respectively in mid and harvest stage, respectively (Figure 29a and 29b).

The microbial formulations significantly influence the yield compared to control. The maximum yield was recorded in T5 followed by T4 and T8 (Figure 30).

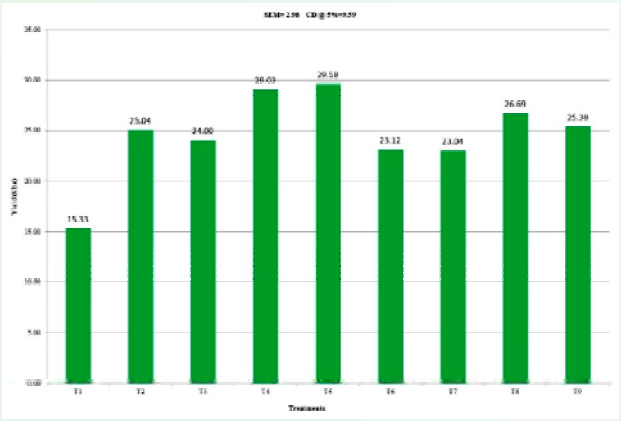


Fig. 30: Effect of different treatments on yield of bottle gourd

Isolation and characterization of *Trichoderma asperellum:* Out of four media, the isolate *T. asperellum* grew rapidly on PDA and OMA with a radial growth of 4.5cm after 72 h of incubation. On CMA and Czapekdox agar the radial growth was 2.82 and 4.33 cm respectively (Figure 31).

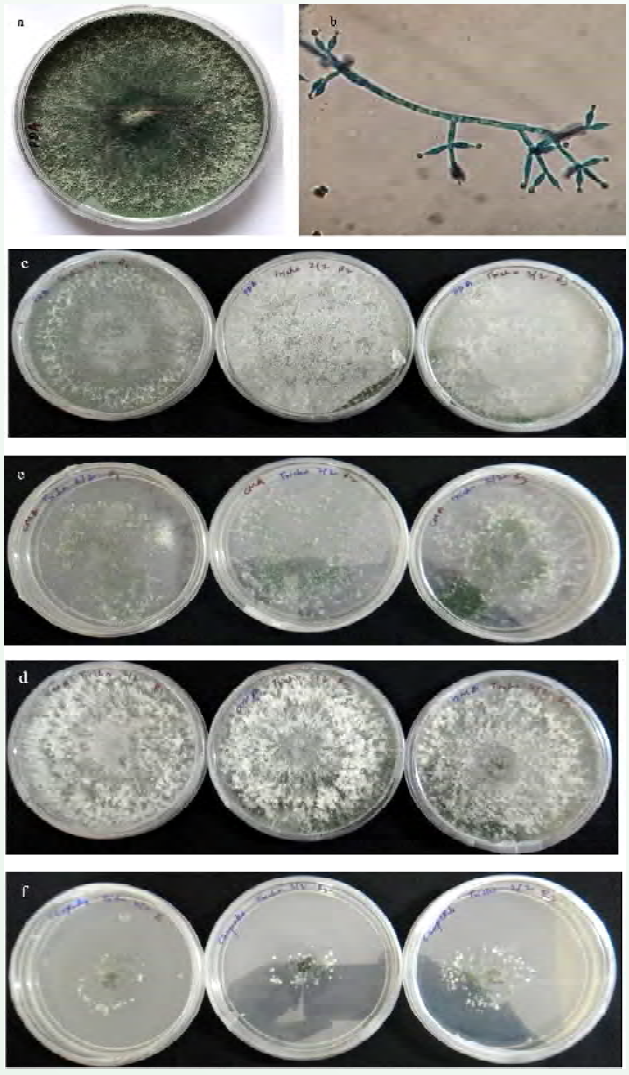


Fig 31(a): Colony morphology (b) Microphotograph of the *Trichoderma* isolate (c) Growth of *Trichoderma asperellum* on different media Potato Dextrose Agar (d) Oat Meal Agar; (e) Corn Meal Agar; (f) Czapek Dox Agar

Molecular identification: The total genomic DNA was isolated and ITS region was amplified and sequenced. The sequence deposited in gene bank (NCBI) with an

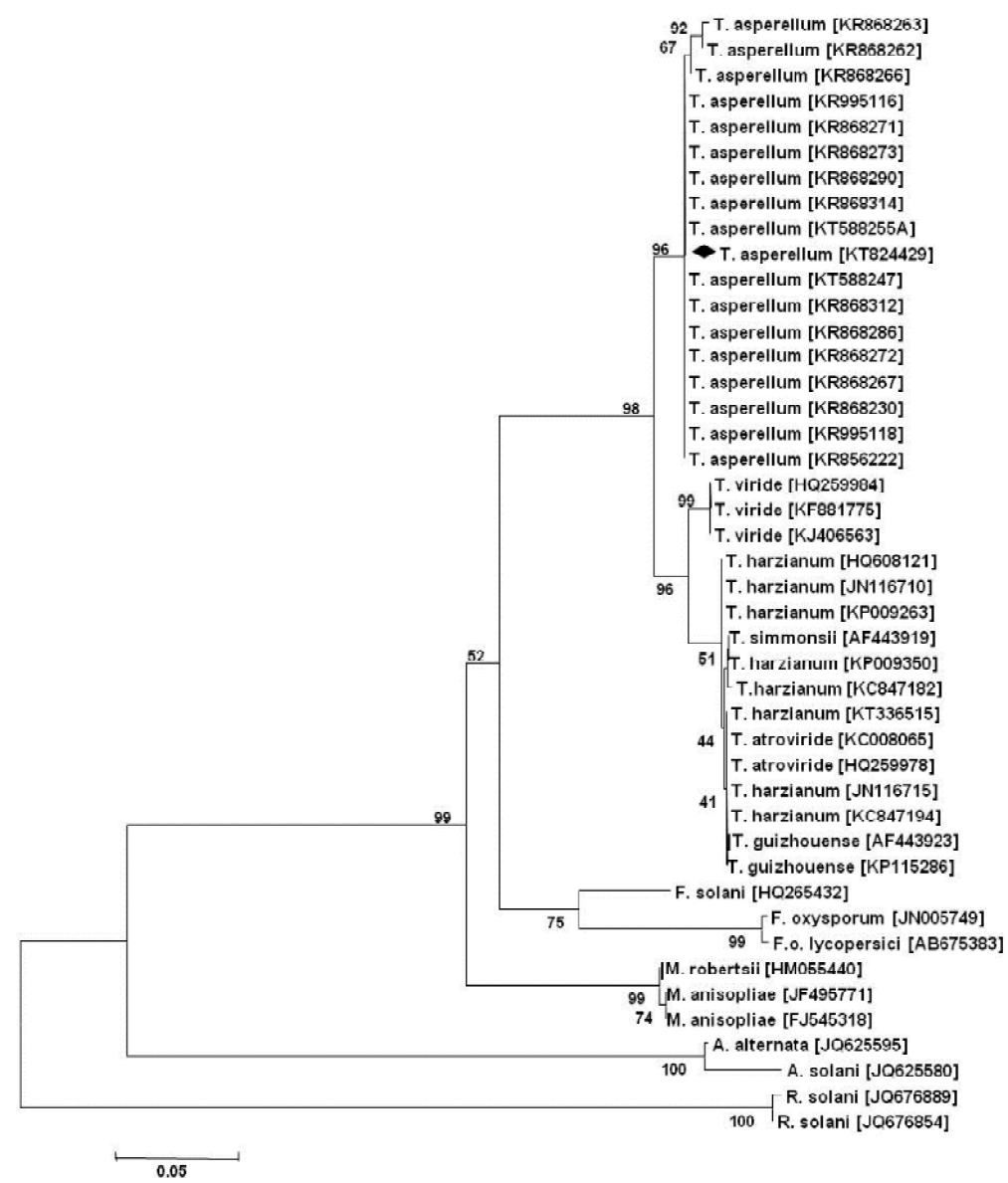


Fig. 32: Phylogenetic tree based on the comparison of ITS sequences of *T. asperellum* and other *Trichoderma* spp. and fungi registered in gene bank

accession no. KT824429. In *silico* analysis revealed 100% similarity to *T. asperellum*. The phylogenetic analysis revealed close clustering of the isolate with other *T. asperellum* isolates (Figure 32).

***In vitro* confrontation studies:** The antagonistic capability of *T. asperellum* was assessed through *in vitro* confrontation studies. The highest inhibition of 43.57, 38.16, 42.56 and 54.87% were obtained for *Pythium aphanidermatum*, *P. debaryanum*, *S. rolfsii* Sr1 and *S. rolfsii* Sr3, respectively after 6 d of *T. asperellum* inoculation. It also inhibited mycelia growth of *Fusarium oxysporum* f.sp. *lycopersici* (FOL) and *Alernaria solani* to the extent of 26.27 and 24.17% after 5 and 6 d of incubation (Table 15&Figure 33).

Table 15: Inhibitory activity of the *Trichoderma* isolate against selected phytopathogenic fungi, as measured in dual culture assays after 5 and 6 days of incubation

Pathogen	Mycelial Inhibition (%)					
	5 d			6d		
Pythium aphanidermatum	38.71	±	2.24	43.57	±	4.68
Pythium debaryanum	37.43	±	2.78	38.16	±	2.60
Sclerotium rolfsii Sr-1	47.43	±	0.67	42.56	±	0.92
Sclerotium rolfsii Sr-3	57.69	±	0.44	54.87	±	0.67
Fusarium oxysporum f.sp. *lycopersici*	26.27	±	10.06	Parasitisation		
Alternaria solani	24.17	±	13.15	Parasitisation		

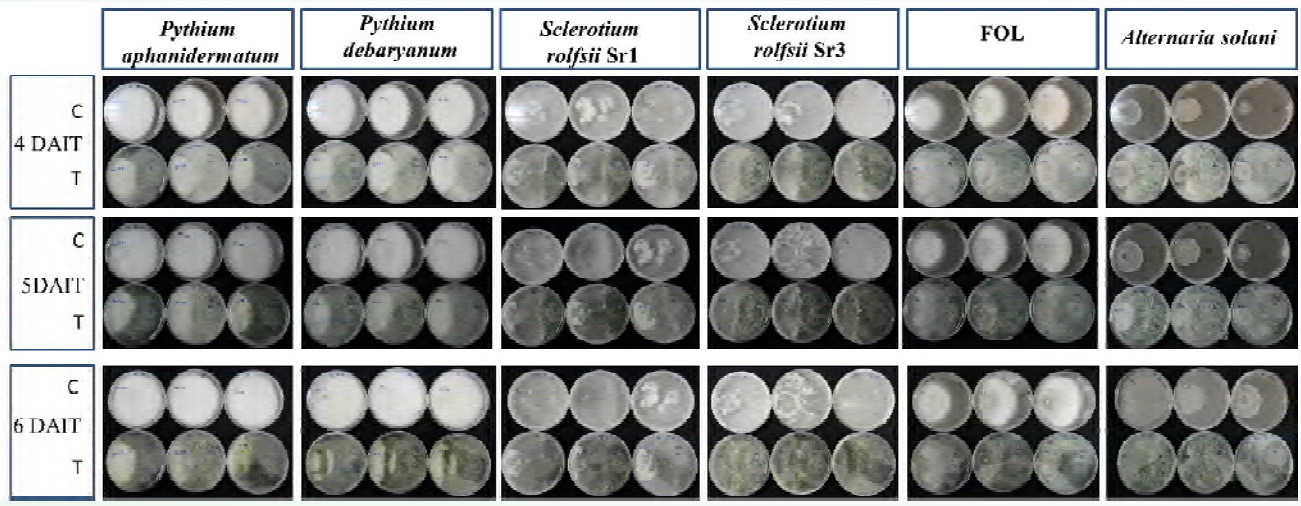


Fig. 33: Confrontation test of *Trichoderma asperellum* against different plant pathogens

FOL- *Fusarium oxysporum* f.sp. *lycopersici*; DAIT-Days after inoculation of *T. asperellum*; C-Control, T-Treatment

It caused 83.24% mycelia inhibition and complete parasitization of *S. sclerotiorum* after 4 and 7 day of inoculation (Figure 34).

Compatibility with fungicides: The fungicides used in the study are given in Table 16. *T. asperellum* was 100% compatible with mancozeb, azoxystrobin, cymoxanil + mancozeb, metalxyl+ mancozeb at 100, 200 and 300 ppm. It was 98.15, 74.82 and 50.38% compatible with carbendazim at 100, 200 and 300 ppm concentrations. The compatibility percentage for carbendazim+ mancozeb was 90.38, 70.38 and 47.41% at 100, 200 and 300 ppm, respectively (Figure 35).

Fig. 34: Confrontation test of *Trichoderma asperellum* against different plant pathogens

Table 16: Fungicides used for compatibility studies with *Trichoderma asperellum*

S. No.	Active constituent	Formulation type
1.	Cymoxanil (8%) + mancozeb 64%	WP
2.	Metalaxyl 4% + mancozeb 64%	WP
3.	Carbendazim 12%+ Mancozeb 63%	WP
4.	Carbendazim 50%	WP
5.	Azoxystrobin (23.1% w/w)	SC
6.	Mancozeb 75%	WP

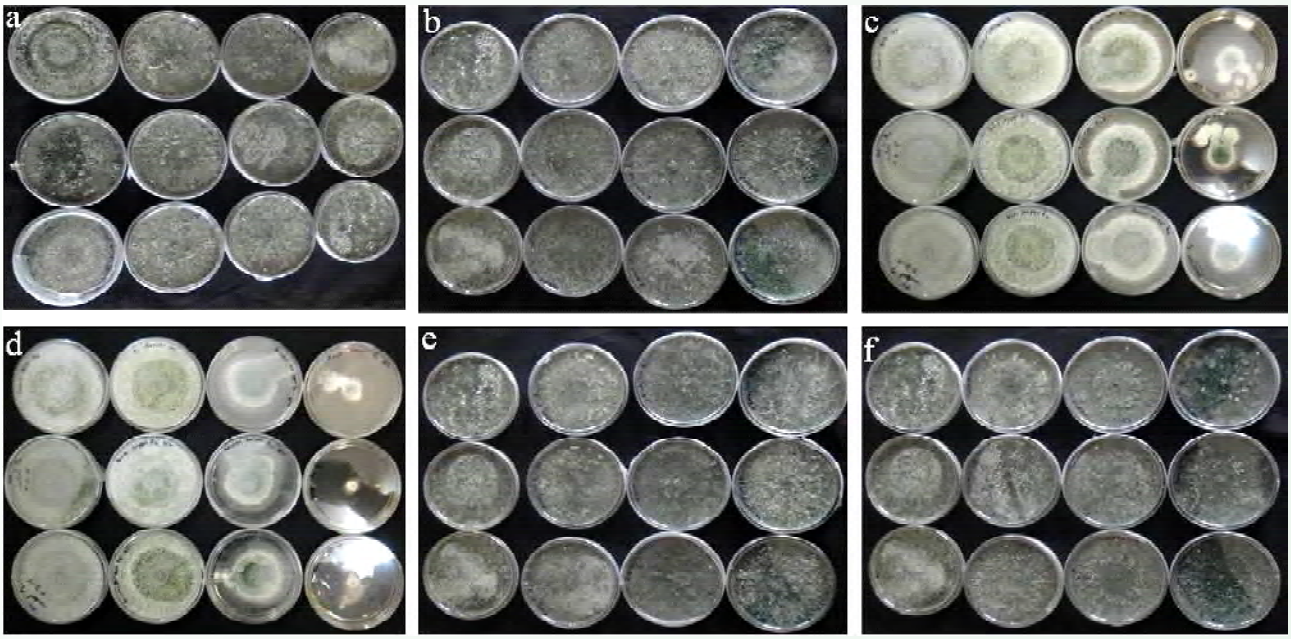


Fig. 35: Compatibility of *Trichoderma asperellum* with different fungicides. a.cymoxanil+mancozeb; b. metalxyl+mancozeb; c. carbendazim+ mancozeb; d. carbendazim; e. azoxystrobin; f. mancozeb. Right to Left: Control, 100, 200, 300 ppm concentrations

Project 6.6: Management of important bacterial diseases of vegetable crops

Isolation and characterization of bacterial black rot of cole crops: Incidence of bacterial black rot caused by *Xanthomonas compestris* pv *compestris* in Cole crops were recorded at IIVR, Research Farm, Varanasi during January–March, 2016. Symptoms of the black rot started as drooping of lower leaves, appearance of large V- shaped chlorotic discoloration in the veins/margin of the leaves (Figure 36). The phenotypic characteristics of the isolates *viz.*, colony size (small), colony shape (irregular), colony margin (undulate), Gram staining (Gram negative) with rod shaped bacterial cells recorded (Figure 37).

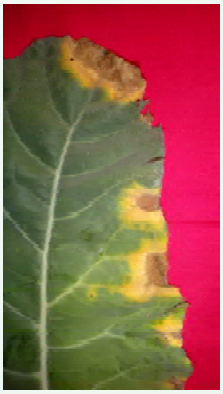


Fig. 36: Bacterial black rot

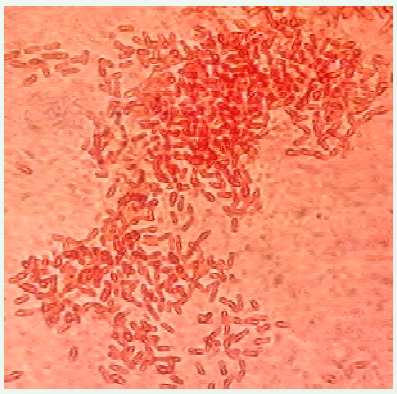


Fig. 37: Microphotograph

Project 6.7: Development of diagnostics kits for major viruses infecting vegetable crops

PCR based detection of *Tospovirus* on tomato, brinjal and *Solanum torvum*: Total RNA was extracted from plants showing characteristic tospovirus symptoms along with the healthy plants. RT-PCR assay was performed with the universal tospovirus degenerate primer pair (gL3637/gL 4435c). An amplicon size of ~800bp was amplified in all the symptomatic samples confirming presence of *Tospovirus* (Figure 38).

Detection of *Begomovirus* and its associated satellite particles from bitter gourd and sponge gourd using PCR assay: Bitter gourd samples were collected from the farmers' field at Mahagaon village, Mirzapur and sponge gourd samples from IIVR farm showing symptoms such as mosaic mottling of leaves, reduction of leaf size, leaf and stem malformation and bunching of leaves. *Parthenium* and wild cucumber samples were also collected. Extracted DNA from symptomatic and nonsymptomatic samples were subjected to PCR using geminivirus primer pairs corresponding to DNA A and DNA B. In addition, PCR was made with the universal primer pairs for α- and β-satellite. Out of 20 samples, 19 samples were infected with bipartite begomovirus. Three samples were associated with both α- and β-satellite; three samples only with α- satellite and only one sample with β-satellite (Table 17).

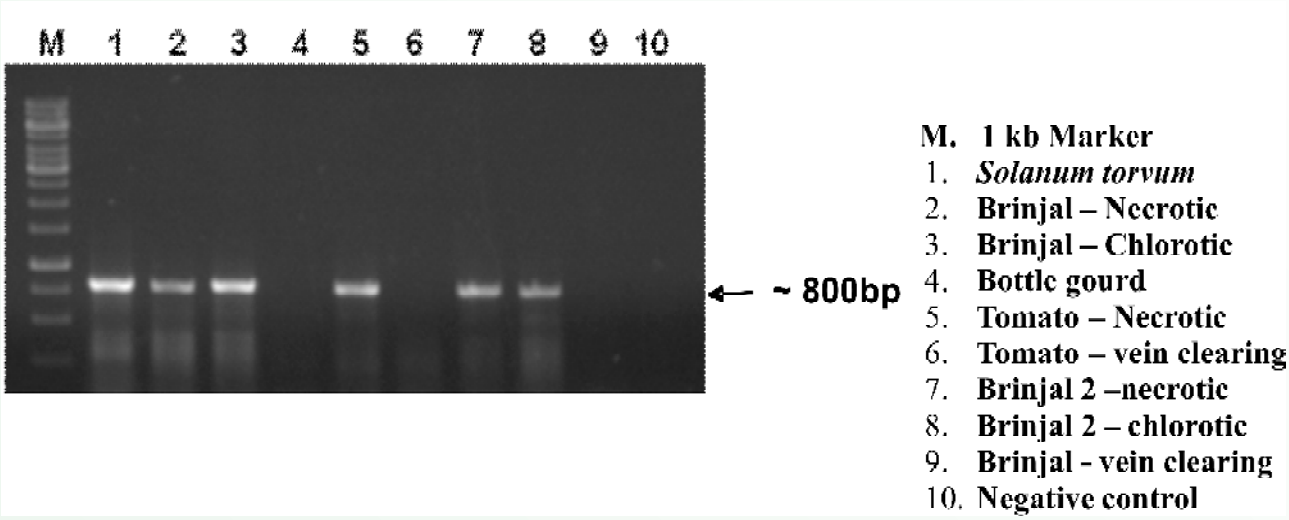
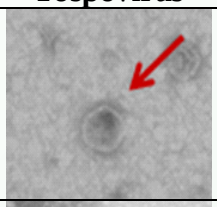
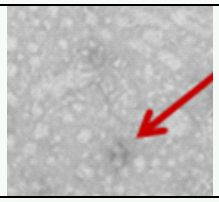
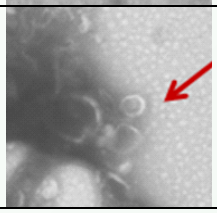
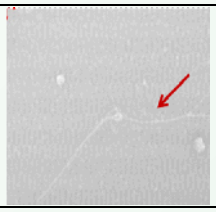
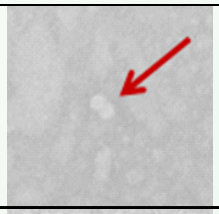
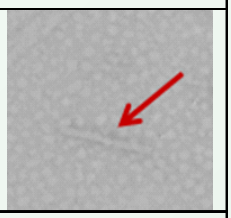
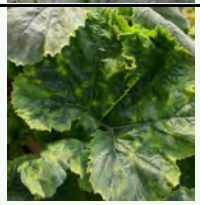
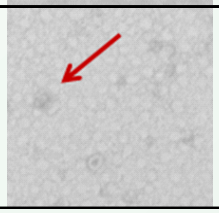
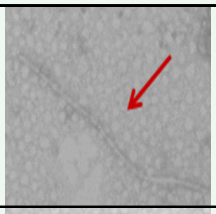
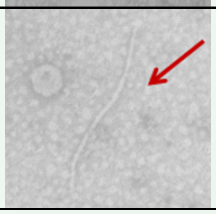
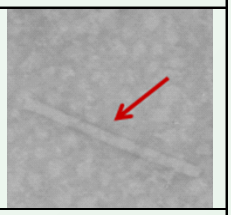
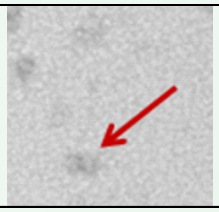
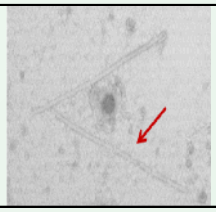


Fig. 39: PCR amplification of ~800bp on RdRp gene of *Tospovirus* using universal *Tospovirus* primer (gL3637 /gL 4435c) infecting solanaceous vegetables

Table 17: Detection of bipartite begomovirus on the bitter gourd and sponge gourd along with its associated satellite DNA's

Crop	Sample	DNA A	DNA B	α-satellite	β-satellite
Bitter gourd	BG1	+	+	+	+
	BG2	+	+	+	-
	BG3	-	-	-	-
	BG4	+	+	-	-
	BG5	+	+	-	-
	BG6	+	+	-	-
Wild cucumber	WC1	+	+	+	-
Parthenium	PA	+	+	+	-
Sponge gourd	SG1	+	+	-	-
	SG2	+	+	-	-
	SG3	+	+	-	-
	SG4	+	+	+	+
	SG5	+	+	+	+
	SG6	+	+	-	-
	SG7	+	+	-	-
	SG8	+	+	-	-
	SG9	+	+	-	-
	SG10	+	+	-	-
	SG11	+	+	-	-
	SG12	+	+	-	+

Transmission electron microscopic visualization of *Tospovirus/ Begomovirus/ Potyvirus/ Tobamovirus* particles in virus infected vegetables: Virus infected samples of brinjal, tomato, bottle gourd, *Solanum torvum*, summer squash and chilli were sent to Division of Plant Pathology, IARI, New Delhi for virus particle observation in transmission electron microscope. Virus particles of *Tospovirus* (Spherical), *Geminivirus* (Twin particles), *Potyvirus* (Flexuous rod) and *Tobamovirus* (rigid rod) were observed among the infected samples. Most of the samples were infected with multiple viruses. Interestingly, little leaf diseased brinjal samples were found to harbor *Potyvirus* particles also.

Crop	Symptom	Tospovirus	Geminivirus	Potyvirus	Tobamovirus
Brinjal					
S. torvum					
Tomato					
Summer squash					
Bottle gourd					
Chilli					
Brinjal little leaf					

Project 6.8: Management of Important Viral Diseases of Vegetable Crops

Incidence of thrips transmitted Tospovirus was recorded to 46% on brinjal at IIVR farm and 21% on tomato at farmer's field in Mirzapur. In brinjal symptoms observed were chlorotic irregular to circular spots with concentric rings and necrotic circular spots with green centre on leaves (Figure 40). On tomato, bud necrosis (drying of plants at the tip); concentric circular necrotic spots with green centre on leaves (Island symptom); necrosis on the petals of the flower buds; and necrotic streaks on the stem were observed (Figure 41). *Solanum torvum,* one of the resistant sources for bacterial wilt disease, was infected by *Tospovirus*. Such infected plants exhibited symptoms as circular necrotic spots with green centre and necrosis of veins and veinlets on leaves (Figure 42).

a. Chlortic concentric ringspots on leaves

b. Necrotic circular spots with green centre

Fig. 40: Symptom of tospovirus on brinjal

a. Necrotic circular spots with green centre

b. Necrotic brown streaks on the stem

Fig. 41: Symptom of tospovirus on tomato

Fig. 42: Necrotic circular spots on *Solanum torvum* leaf

Project 6.9: Management of Nematodes Infesting Major Vegetable Crops

Population Dynamics of Root knot nematode at IIVR Farm: The root knot nematode population was estimated during April 2015 to March 2016 at IIVR research farm through Baermann modified funnel technique. The maximum population was noted during Oct (2.8 J_2/ g soil) followed by Apr and Nov (2.6). The minimum population was recorded during Jul (1.0 J_2/ g of soil) and Jan (1.1 J_2/ g soil) (Fig.43).

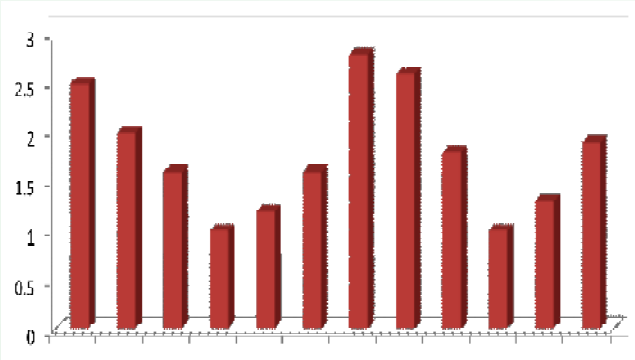


Fig.43 Population dynamics at IIVR farm during 2015-16

At IIVR farm, all the vegetable crops were infected with root knot nematodes. The minimum population was observed on cowpea at 198 nematodes/200 g soil and the maximum population was in pointed gourd at 496 nematodes/200 g soil. In all the crops nematode was found to be above ETL except cowpea (Table 18).

Table 18: Survey of nematodes infection at different vegetable crops at IIVR farm

Major Crops	RKN Infestation	RKN*** Population (200 cc of soil)	EITL** /ETL*
Tomato	Present	480	Above EITL
Brinjal	Present	495	Above EITL
Okra	Present	405	Above EITL
Chilli	Present	207	Above ETL
Bitter gourd	Present	358	Above ETL
Pointed gourd	present	496	Above EITL
Cowpea	Present	198	Below ETL

Note- ***Average of 3 counts; **EITL-Economic injury threshold level i.e. 2 J_2/g of soil; *ETL-Economic threshold level i.e. 1-2 J_2/g of soil under field condition.

Management of root knot nematode through grafting of *Solanum torvum* with different tomato scions: Root knot nematode *M. incognita* tested in grafted plants between *Solanum torvum* and different tomato scions (Table 19 & Figure 44). The root stock grafted with Hissar lalith, Kashi vishesh and Kashi aman as well as their seedlings challenged under pot condition in net house. Root knot index has reduced in grafted plants treatment viz., *S. torvum* +Hissar Lalit (1), *S. torvum* +Kashi Vishesh (1), *S. torvum* + Kashi Aman (1). In *S. torvum* and Hissar Lalit seedling treatments showed less gall index similar to grafted plants treatments (1, 1), and reproductive factor (0.3, 0.3), respectively. Soil population was less on grafted plants T5, T6 and T7 over non grafted plants T3 and T4 which were significantly different over control T1 and T2. Reproductive factor was less on resistant seedling T1 (0.3) and T2 (0.3) and grafted with *S.* torvum plants T5 (0.3), T6 (0.3) and T7 (0.3) and more was on susceptible seedlings T3 (1) and T4 (1). Yield (kg/pot) was recorded less on grafted plants T5 (0.7), T6 (0.9) and T7 (0.6) which was significantly different with resistant plants control treatments T2 (1.5), and susceptible seedling T3 (1.6) and T4 (1.6).

Table 19: Management of root knot nematode through grafting of *Solanum torvum* with different tomato scions

Treatments	Gall Index (0-5)	Soil population (SP) 200g soil	% SP increase over control	Rf (Pf/Pi)	Yield Kg/ pot
T1- *Solanum torvum*	1	33.3 (5.8)a	0	0.3	NA
T2 -Hissar Lalit	1	32.0 (5.7)a	0	0.3	1.5
T3 -Kashi Vishesh	3	203.3 (14.0)b	51	1	1.6
T4- Kashi Aman	3	215.0 (15.0)b	55	1	1.6
T5 St + Hl	1	40.0 (6.4)a	2	0.3	0.7
T6 St + Kv	1	37. 3(6.2)a	1.2	0.3	0.9
T7 St + Ka	1	38.0 (6.2)a	1.4	0.3	0.6
CD at *0.05P*		0.72			0.27
SEd		0.33			0.12

Note- Data presented in parentheses ( ) are square root transformed value; Pot size 12"Dia.; St-*Solanum torvum;* HI-Hissar Lalith; Kv-Kashi Vishesh; Ka-Kashi Aman; NA-Not Applicable

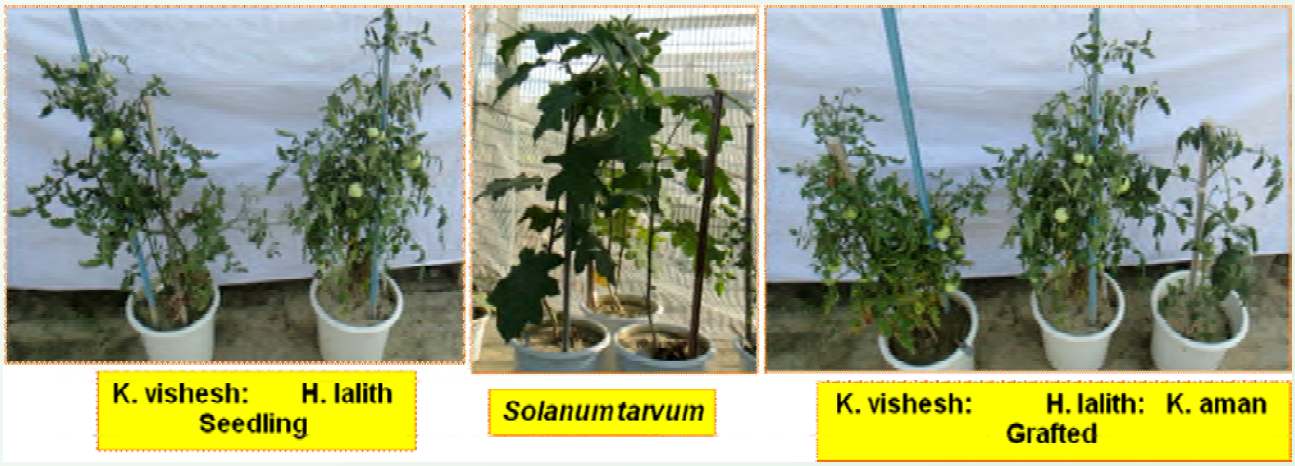


Fig. 44: Managment of root knot nematode (*meloidogyne incognita*) in tomato through grafting

Project 6.10: Dynamics of pest and diseases and development of forecasting models

The periodical incidence of fruit fly, *Bactrocera cucurbitae* in cucurbits and shoot and fruit borer, *Leucinodes orbonalis* in brinjal was recorded by installing the cue lure and sex pheromone traps, respectively. Large fluctuation in the incidence of BSFB in brinjal was observed with 1st peak during 2nd week of May (3.7 moth/trap, and 2nd peak during 1st week of Oct (4.3 moth/trap) (Fig. 45). Weekly recording of fruit fly incidence of cucurbits revealed its peak incidence during first week of Nov (102.67 fruit fly/trap) followed by third week of Oct (99.67). The fruit fly activity was less during rainy months and winter season (Fig. 46).

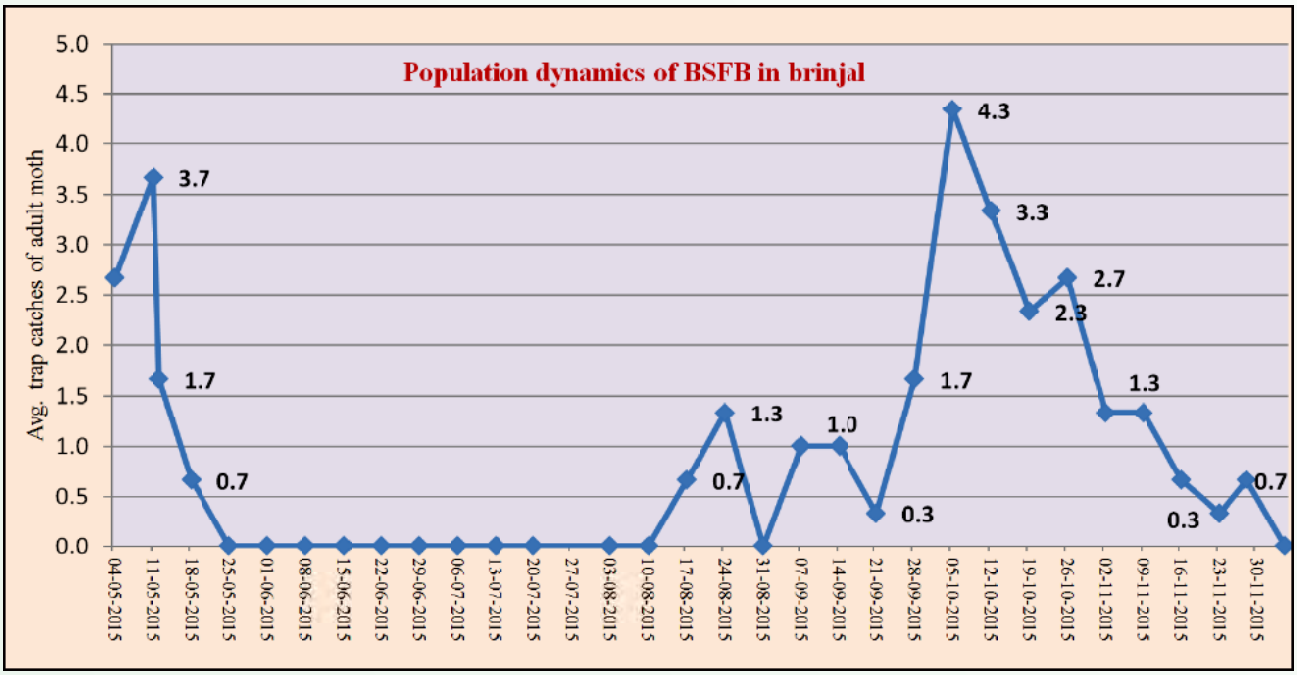


Fig. 45: Population dynamics of BSFB, *Leucinodes orbonalis*

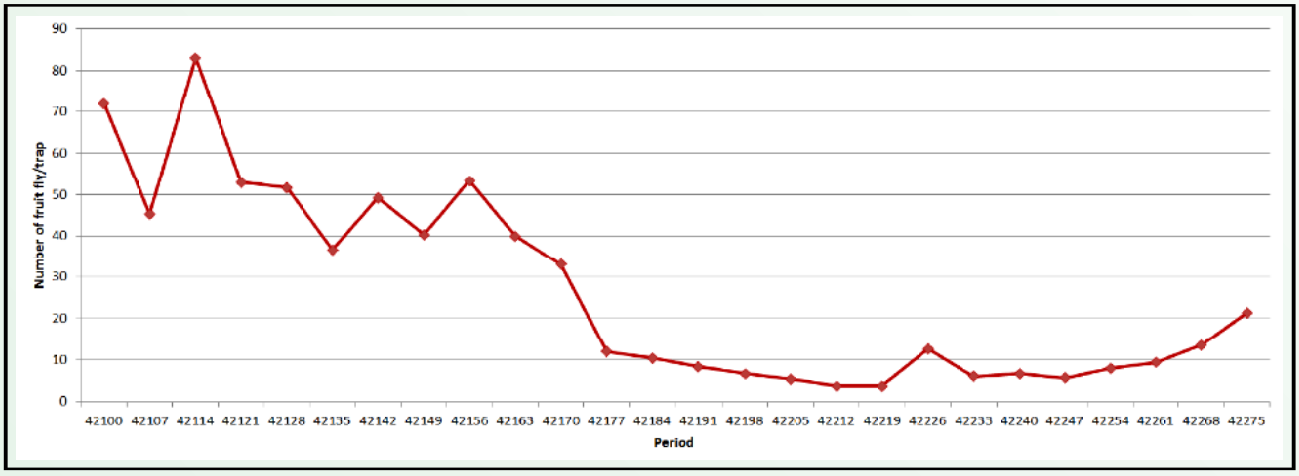


Fig. 46: Population dynamics of cucurbit fruit fly

Externally Funded Project

Externally Funded Project

Project 1: Gene expression studies and development of functional markers for anthracnose disease in *Capsicum* species

The project was funded by SERB-DST, New Delhi for the period July 17, 2012 to July 16, 2015 with the objectives (i) Identification of contrasting parents with respect to *Colletotrichum capsici* based on molecular and pathological characterization (ii) Development of mapping population (F_2) using susceptible and resistant genotypes (iii) Transcriptome analysis through Next Generation Sequencing (iv) Development of functional markers (SSRs and SNPs) and (v) QTL Mapping for anthracnose disease. The summarized report of the achievement is given hereunder:

Identification of contrasting parents with respect to *Colletotrichum capsici* based on molecular and pathological characterization: Based on molecular and pathological characterization in field trials and *in vitro* screening, Pusa Jwala (female) was found to be susceptible and IIVRC-452 (male) was found to be resistant. These contrasting parents were used for developing mapping population and their transcriptome sequencing.

Development of mapping populations (F_2) using susceptible and resistant genotypes: Utilizing the two contrasting parents of chillies, an F_2 mapping population consisting of 260 individuals were developed. These F_2 plants were evaluated for various morphological traits besides the disease severity under field as well as artificially controlled conditions. Several plants were found resistant or highly resistant among the mapping population which are being advanced following the single seed descent method for the identification and development of anthracnose disease resistant genotypes having better yield attributes.

Transcriptome analysis through Next Generation Sequencing: A total number of 53921012 and 50079890 reads from IIVRC-452 (resistant) and Pusa Jwala (susceptible), respectively derived from red ripe chilli fruit tissues were used for the *de novo* transcriptome assembly. Post quality filtering for low quality regions, adaptors and sequencing tags, a total read count of 53704567 reads for IIVRC-452 and 49471665 reads for Pusa Jwala line were withdrawn for further processing. Total high quality paired reads for IIVRC-452 and Pusa Jwala were 107.41 million and 98.94 million, respectively. The overall raw data quality was good with more than 99% and 98% of HQ Paired End Reads in case of IIVRC-452 and Pusa Jwala.

Development of functional markers: A total of 12046 SSR primer pairs in resistant, IIVRC-452 and 11766 SSRs in susceptible, Pusa Jwala were generated. A total of 2572 single nucleotide variations were detected in case of IIVRC-452 and 2450 in case of Pusa Jwala. Out of these, 231 and 219 were homozygous SNVs and 2341 and 2231 heterozygous SNVs were found in IIVRC-452 and Pusa Jwala, respectively. The authenticity of these findings largely depends on wet-lab validation.

Gene expression analysis of chilli for anthracnose disease: Gene expression studies were conducted in order to look at differential gene expression profile of control and infected chilli samples of Pusa Jwala and IIVRC-452. A total of 23831 genes were up-regulated and 22046 down regulated in treated vs. control samples of red fruit of Pusa Jwala while 11886 genes were up-regulated and 12668 genes were down regulated in treated vs. control samples of red fruit of IIVRC-452 (Table 1). Among the differentially expressed genes of these two varieties of chilli, 11 gene (transcript) specific primers were synthesized and validated through quantitative-PCR (qPCR). The analysis showed that the pattern for the gene regulation in the red ripe fruit tissues of IIVRC-452 and Pusa Jwala corroborate with qPCR results, indicating the authenticity of the experiments. The genes validated may serve the purpose of detection of the disease severity/diagnosis of the anthracnose disease in chillies.

The data results for Pusa Jwala and IIVRC-452 were investigated with respect to treated & untreated samples using Agilent GeneSpring GX 12.6. Differential expression patterns were identified among the samples. Significant genes up regulated fold > 1 (logbase2) and down regulated <-1 (logbase2) in the test samples with respect to control sample were identified. Differentially regulated genes were clustered using hierarchical clustering based on Pearson coefficient correlation algorithm to identify significant gene expression patterns. Genes were classified based on functional category and pathways using Biological Analysis tool DAVID (http://david.abcc.ncifcrf.gov/).

Table 1: Differentially regulated genes in treated condition for Pusa Jwala and IIVRC-452

Treated vs. Control	Up	Down
Pusa Jwala Red Fruit	23831	22046
IIVRC-452 Red Fruit	11886	12668

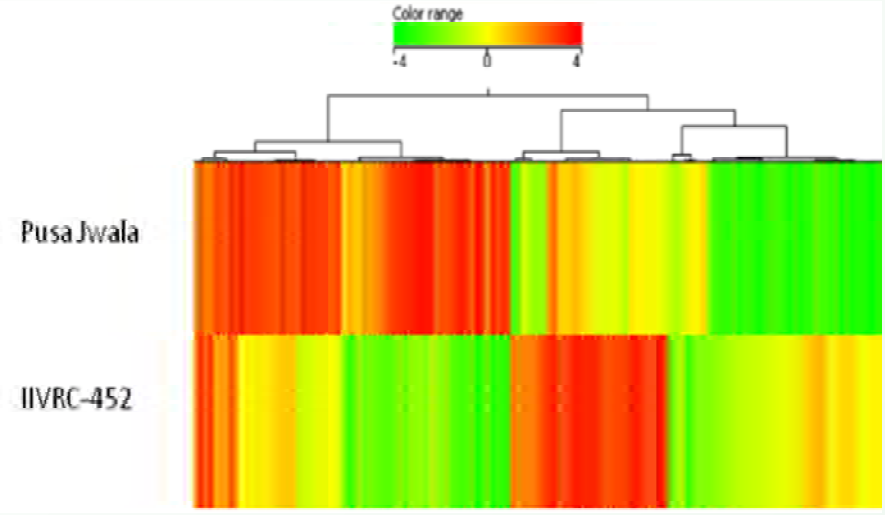


Fig. 1: Overview Cluster of top 1000 differentially regulated genes in both Pusa Jwala and IIVRC-452

QTL mapping for anthracnose disease: Parental polymorphism survey between Pusa Jwala and IIVRC-452 with 695 primers, including 542 simple sequence repeat (SSR) markers were from available public domain, and rest 143 primers EST-SSR were conducted in order to obtain maximum polymorphic primers for QTL mapping. A total of 105 polymorphic primers were obtained for running them in whole of the F_2 population consisting of 260 individuals of the Pusa Jwala / IIVRC-452. BSA (bulk segregant analysis) for quick information for the quantitative trait loci (QTLs) for anthracnose reaction in the said chilli F_2 population was applied. QTL (CAMS-194) for lab testing is at the same position as in case of QTL1 of field testing, while QTL 4 (HpmsE-014) of lab screening share common position with QTL3 of field testing. Therefore, these two QTLs, with contribution of more than 50% phenotypic variation, can be focussed for overall resistance whether screened in lab or in field conditions.

Table 2: Summary of top 20 common differentially expressed genes across Pusa Jwala and IIVRC-452

Gene Names	Protein Names	Pusa Jwala Red Fruit	IIVRC-452 Red Fruit
FAD	Fatty acid desaturase	5.95	6.66
aco	1-aminocyclopropane-1-carboxylate oxidase (EC 1.14.17.4)	4.68	6.47
PGSC0003DMG400009178	Pectinesterase (EC 3.1.1.11)	4.24	4.28
F775_29706	Histone H4	6.44	2.75
Solyc01g094790.2	Cysteine synthase (EC 2.5.1.47)	5.41	2.56
PGSC0003DMG400006108	Auxin-responsive protein	4.36	2.68
CcACO	ACC oxidase	2.77	7.35
PGSC0003DMG400004930	Serine/threonine-protein kinase (EC 2.7.11.1)	2.95	4.91
Solyc08g075700.2	60S ribosomal protein L13	3.90	2.72
APOD	Anionic peroxidase	3.04	3.77
POPTR_0003s03400g	Senescence-associated family protein	4.58	2.28
ATP2 atpD CHLREDRAFT_78348	ATP synthase subunit beta (EC 3.6.3.14)	2.64	4.05
NtMTP1a	NTMTP1A	3.70	2.35
Asc-1	Protein ASC1 (Alternaria stem canker resistance protein 1)	2.37	4.91
H2B-2	Histone H2B.2 (LeH2B-2)	5.59	1.85
ef2	Elongation factor 2 (Fragment)	2.16	4.97
PGSC0003DMG400027665	MLO-like protein	-3.23	-2.14
PPY-AT	Phenylpyruvate aminotransferase (EC 2.6.1.5)	-4.45	-1.62
DPH	NAD(P)H:quinone oxidoreductase	-3.42	-1.74
BA4	Gag-pol polyprotein	-2.99	-2.06
NtPP2C2	Protein phosphatase 2C (Fragment)	-3.00	-1.91
ASR1	Abscisic stress-ripening protein 1	-4.97	-1.47
rps4	Ribosomal protein S4 (Fragment)	-4.08	-1.37
Os09g0128400	Os09g0128400 protein	-2.84	-1.67
str246N	Integrase (Fragment)	-3.28	-1.44
MtrDRAFT_AC147774g2v1	Integrase, catalytic region; Ribonuclease H	-3.31	-1.38
LOX	Lipoxygenase (EC 1.13.11.-)	-4.07	-1.26
CrtZ-2	Beta-carotene hydroxylase 2	-3.51	-1.26
PG	Polygalacturonase	-4.12	-1.22
dea1	Arachidonic acid-induced DEA1	-3.36	-1.26

Gene Names	Protein Names	Pusa Jwala Red Fruit	IIVRC-452 Red Fruit
PGSC0003DMG400029212	Pectate lyase (EC 4.2.2.2)	**-1.68**	**-3.73**
SDM1_42t00023	Polyprotein, putative	**-5.29**	**-1.12**
Solyc04g014510.2	Glutamine synthetase (EC 6.3.1.2)	**-1.70**	**-1.97**
asr4	ASR4 protein (Fragment)	**-8.34**	**-1.09**

Functional Analysis

Top 20 common differentially expressed genes across Pusa Jwala and IIVRC-452: On the basis of prior studies in field of plant pathogen interactions and plant defence mechanism, twenty commonly up regulated and twenty commonly down regulated genes were selected for targeting exact mode of action of these genes in both the capsicum genotypes (Table 2).

Quantitative Real Time (qRT-PCR) analysis: Quantitative-RT PCR was performed to validate both the transcriptional profiling as well as NGS data. A total of 11 genes (both up and down regulated) were selected and their sequences were retrieved from NCBI data base for primer synthesis using Primer-3 software with default settings. Among eleven selected genes, five were able to quantify by qRT PCR which were, LOX- gene, ASC1- gene, Polygalacturonase- gene, Senescence associated- gene and Cytochrome P-450EG7 gene. A total of 11 transcript specific primers were synthesized and were validated through real time qPCR methods.

QTL mapping for anthracnose disease: From the literatures, it was deduced that with a large sample size, bulked segregant analysis (BSA) followed by genotyping of each individual from bulks would offer a quick and less expensive way for identification of genomic regions controlling quantitative traits of interest. Twenty five primers were used for confirmation on P_1, P_2 and the 20 F_2 individuals used to constitute the two bulks gave a total of 25 scorable bands (alleles) with band sizes ranging from 70- 350 bp. The summary of results are: QTL 1 (CAMS-194) for trait 1 is at the same position as in case of QTL1 of trait 2, while QTL 4 (HpmsE-014) of trait 1 share common position with QTL3 of trait 2. Therefore, these two QTLs, with contribution of more than 50% phenotypic variation, can be focussed for overall resistance whether screened in lab or in field conditions.

Project 2: Studies on male sterility system to increase the efficiency F_1 hybrid development in horticultural crops: Chilli

Transfer of male sterility system

Crossing male sterile plant with male fertile plant (GMS & CMS) on individual plant basis: In order to transfer genetic male sterility (GMS3, *ms-3* gene) in desirable backgrounds, BC_1F_1 generation of five crosses (GMS-3 x Kashi Sinduri, GMS-3 x Kashi Anmol, GMS-3 x VR-339, GMS-3 x Pant C1 and GMS-3 x Kashi Gaurav) were raised and selected plants of each cross were selfed for BC_1F_2. The F_1 crosses on the GMS3 (st.) were already developed during previous years with the respective backgrounds for transferring the genetic male sterility trait. The subsequent generations were grown, advanced to F_2 generation and selfed to identify the sterile plants for developing BC_1F_1 population in all the five backgrounds.

Similar progress has been made in other four selected chilli genotypes and are in BC_2F_1 stage. The crossing has been made either on individual plant basis or in bulk method (pollen collected form fertile plants and bulked, and then pollinated to a single male sterile plant).

In addition to GMS system, attempts were also made to transfer cytoplasmic male sterility system in desirable backgrounds. Three crosses, A2 x EC519636, A2 x PBC 904 and A7 x F5-112, were attempted and BC_1F_1 were developed.

Development of cross combination for GMS transfer in sweet pepper genotype: Attempt has also been made to diversify the genetic male sterility in sweet pepper. Two combinations viz. GMS3 (St.) × California Wonder and GMS3 (St.) × Nishat have been developed and will be evaluated further for male sterility and other morphological traits. A total of three cross combinations have been developed for evaluation of their behaviour with respect to yield, morphological traits and reaction to different stresses along with qualities in F_1 generation in chilli type genotypes. These combinations are GMS3 (St.) X R-line, GMS3 (St.) × VR-339, GMS (St.) × KDCS-1810.

Studies on anthesis and dehiscence in GMS 3 line: Assessment of anthesis and dehiscence in GMS-3 plant of chilli was conducted. This study exhibited that chilli plants flowered during January-February, and male and female flowers opened 3 to 5 days after bud formation. Anthesis of male and female flowers occurred between 09:00 a.m. to 11:00 a.m. Anther dehiscence was observed after 12:00 noon hours. Anthesis itself mainly occurred during the morning with a second, smaller peak of flower opening in the

late morning. In flowers that opened at 9:00 a.m. to 11:00 a.m., anther dehiscence took place approx. 3 hour after the buds opened; in flowers that opened later, dehiscence was delayed.

Project 3: Genomics-assisted selection of *Solanum chilense* introgression lines for enhancing drought resistance in tomato

Generation of backcross populations for *S. lycopersicum* × *S. chilense* interspecific cross and resequencing of parents: Early backcross generations (BC_1F_3, BC_2F_2, BC_2F_3, BC_3F_2 and BC_4F_1) were generated for an interspecific cross Kashi Amrit × (*S. lycopersicum* VF36 × *S. chilense* LA1972). From the previous backcross populations, 152 BC_2F_3 and 63 BC_2F_2 families were produced which constitute populations for BILs development. For development of introgression lines, 58 families of BC_4F_1 and 25 families of BC_3F_1 were produced by backcrossing to cultivar Kashi Amrit as a recurrent parent. This set of 58 BC_4F_1 and 25 BC_3F_1 lines will also be progressed by self-pollination to constitute populations for isolating homozygous ILs. In addition, clones of interspecific hybrid and 120 BC_1F_1 plants were also maintained regularly in tissue culture facility through cuttings.

The parents of interspecific cross VF36 and LA1972 were resequenced by UK partners of the project using illumina Hiseq 2500 platform. The data was shared and is being analysed for SNP discovery.

Project 4: Introgression of begomovirus resistance genes in tomato (*Solanum lycopersicum* L.) using MAS and genomics approach

In the translation program of the project, crossing program for pyramiding *Ty-2* and *Ty-3* in the background of 'Kashi Vishesh' and pyramiding *Ty-2* and *ty-5*/*ty-6* in the background of 'Kashi Aman' was completed to generate the hybrids for backcrossing program. The plants that tested positive for markers linked to *Ty-2*, *Ty-3*, *ty-5* and *ty-6* introgressions were used for crossing.

Seed multiplication of 170 lines of RIL ($_{F8:9}$) population of cross Punjab Chhuhara × H-88-78-1 is completed. The parental lines of this population were exchanged with NIPGR, New Delhi for resequencing. In the discovery program, early filial generation (F_2) was generated from the single F_1 plant of Kashi Vishesh × VRT-88-78-4. Advancement of various backcross generations of interspecific cross Kashi Amrit × [VF-36 x LA1972 (*S. chilense*)] was successfully completed. Genotyping of BC_1F_1 plants was completed for all 120 samples using CAPS markers. Additional marker assays are underway for chromosomes that have not been covered by adequate number of markers.

Project 5: National Innovations in Climate Resilient Agriculture (NICRA)

Identification of tomato genotypes tolerant to high temperature and high soil moisture stress

High temperature stress tolerance in tomato: During summer 2015, 243 tomato lines were tested in field in which 5 lines were found tolerant, 5 moderately tolerant and 2 sensitive. Genotype PR-168, PR-161-L and PR-193-2 performed better under high temperature condition (day maximum temp. > 38°C) on the basis of morphological, physiological and fruit quality traits (Figure 2). Six selected tomato genotypes or their crosses were also assessed under 6 different temperature gradients in TGT for fruit set parameters (Figure 3). Fruit setting percentage varied significantly in all six lines/genotypes, and EC-620421 × Suncherry exhibited higher fruit setting percentage (79.2%) followed by EC-

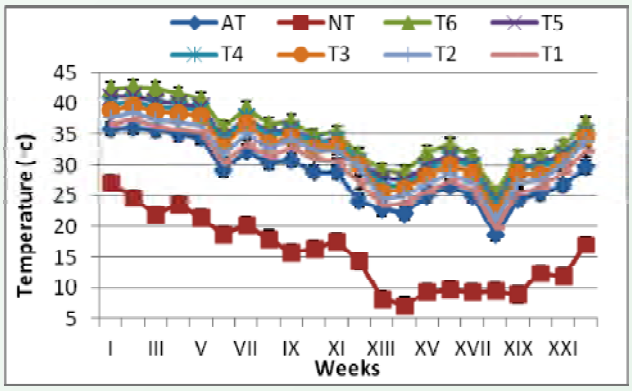


Fig. 2: Average temperature variation under TGT

Fig. 3: Tomato genotypes assessed under TGT with 6 temperature gradients

620438 × EC-538380 (70.6%) at maximum temperature regimes in TGT. Tolerant line such as EC-620421 × Suncherry exhibited only 16.3% reduction in fruit diameter compared to the control, whereas in sensitive genotype *i.e.* Punjab Chhuhara the percentage reduction was 34.2% compared to the ambient temperature.

High moisture (waterlogging) stress tolerance: For waterlogging tolerance, 184 genotypes were evaluated during August to October 2015. Genotype EC-621661-B, IC-521047, M-Local, PDVR-14 and PBC Hybrid-4 (M) have ability to survive for 48h of waterlogging condition. On the other hand, tomato genotype G-1-1 and G-4-4 were found most susceptible, as they could not survive even 48h of waterlogging stress condition.

Re-validation study of 25 genotypes of tomato for waterlogging tolerance: The genotypes Kashi Aman, EC-528422, C-1-1, EC-620354, WIR-13706, EC-620402 and EC-521047 confirmed high tolerance (96 h), while EC-620512, EC-620456, E-4-1, C-9-1, EC-520028, EC-620378, WIR-4360, DARL-66, EC-620422, EC-1161-4-2-1-1 and EC-520049 were moderately tolerant (72 h).

In grafting study, two high yielding varieties of tomato *i.e.* Kashi Aman and Arka Samrat were grafted over earlier identified eggplant rootstocks *viz.*, IC-111056 and IC-354557 (Figure 4). Same tomato cultuvars grafted on eggplant, self-grafted and un-grafted were exposed to 48 h of waterlogging stress.

Fig. 4: Grafted plants ready for transplanting

Fig. 5: Grafted and un-grafted plants expeosed for waterlogging stress

Fig. 6: Grafted tomato cv. Kashi Aman on IC 354557 (R) and un-grafted tomato (L) after 72 h of waterlogging exposure

Tomato grafted on these eggplant rootstocks have not showed any wilting or yellowing, and also maintained higher CCI, chlorophyll fluorescence yields, and optimum enzymatic and non-enzymatic biochemical traits even 48 h after removal from stress. In contrast, the non-grafted plants or self-grafted plants could not sustained 48 h of waterlogging stress, and become dead 4-5 days after removal from the stress (Figure 5).

Biochemical characterization of grafted and un-grafted lines of tomato under water logged condition: One hundred twenty three lines of grafted and un-grafted genotypes of tomato were analyzed for their tolerance to excessive moisture condition. The data were recorded for hydrogen peroxide levels, catalase, ascorbate peroxidase, guaicol peroxidase, superoxide dismutase and proline levels, at different time intervals of waterlogged condition i.e. 24h, 48h and 72h and changes in biochemical parameters at 24h and 48h after recevery. Among un-grafted lines C-1-1, EC-528422, EC-620378, EC-520028, E-5-1 and among grafted lines Arka Samrat on IC-110056 and on IC-354557, Kashi Aman on BR-14, Kashi Aman on Surya showed better tolerance level as compared to their corresponding counterpart (Figure 6).

Enzymatic activities in grafted tomato lines subjected to excess moisture condition for 48 and 120 hours: This study was conducted on Kashi Aman variety which was grafted on IC-354557, Surya, Pant Rituraj and IC-111056 along with control. The grafted plants were subjected to moisture stress for 48 h and 120 h and were screened to find the best root stock that can confer tolerance under excessive moisture stress. The plants were evaluated for their hydrogen peroxide content, catalase, ascorbate peroxidase and guaicol peroxidase level. Both Under 48 hrs and 120 hrs of

moisture stress, Kashi Aman grafted on IC-354557 and IC-111056 were found to be superior as they showed enhanced level of enzymatic activity and low level of hydrogen peroxide content over other roots stocks.

Biochemical screening of six tomato lines under TGT: VRT 101 A × Pusa Ruby, EC-620421 × Suncherry, PBC, 620419 × K. Vishesh, EC-620438 × EC-538380, Suncherry × VRT-1 were screened under six temperature regimes along with control which were evaluated for their total chlorophyll and carotenoids, hydrogen peroxide, catalase, superoxide dismutase, ascorbate peroxidase and glutathione reductase levels. The cross combinations Suncherry × EC-629421 and Suncherry × VRT 101 A showed enhanced level of enzymatic activities coupled with low level of hydrogen peroxide level at all the temperature regimes

Project 6: CRP on hybrid Technology (Tomato)

Hybrid resistant to biotic (tomato leaf curl virus, early blight and RKN) and abiotic (high and low temperature, drought and salinity) stresses: All the genotypes/lines were collected from the IIVR, Varanasi. A total of 70 tomato lines were evaluated to know the presence of *Ty2*, *Ty3* and *Mi* (RKN) genes with P-6-25, To-302 and Mi primers, respectively (Table 3). DNA from young leaves of 70 tomato lines has been isolated by the CTAB method and gel images were photographed after PCR with P-6-25, To-302 and Mi primers (Figure 7a; b). The lines EC-760007, EC-752613, EC-715383, EC-715380, EC-715386, EC-695437, EC-705447, EC-700936, EC-753228 and EC-695044 showed presence of both Ty2 and Ty3 genes and only KT-1 showed the presence of root knot nematode (Mi) gene. These lines will be used as donor parent for development of hybrid in respective traits.

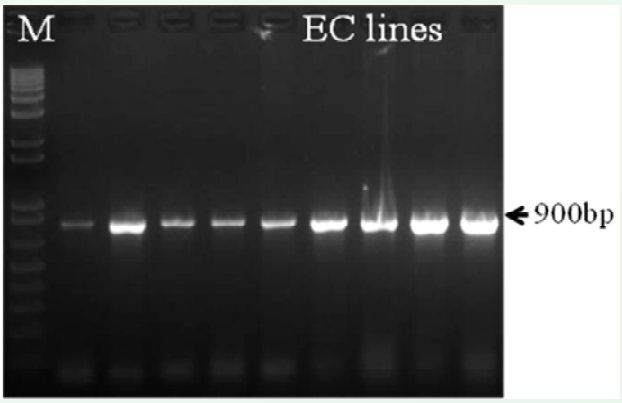


Fig. 7a: PCR gel image of *Ty*-2 gene confirmation in EC lines of tomato with primer To-302. M- 1 Kb DNA ladder, Band size of resistant plant- 900bp

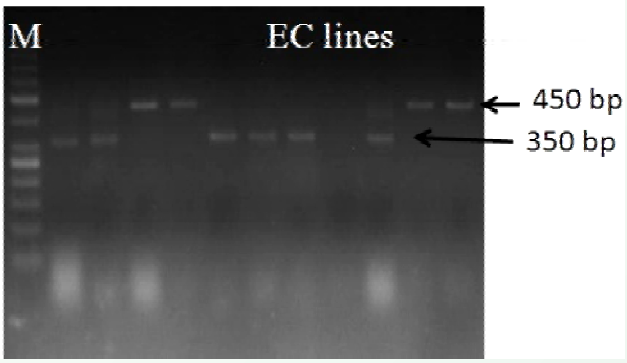


Fig. 7b: PCR gel image of Ty-3 gene confirmation in EC lines of tomato with primer P-5-25. M- 50 bp DNA ladder, Band size of resistant plant- 450 bp Band size of susceptible plant- 350 bp

Table 3: A list of the tomato lines having Ty-2, Ty-3 and RKN gene

EC Lines	*Ty-2 Gene*	*Ty-3 Gene*	*RKN gene*
EC-760007	Present	Present	Absent
EC-753220	Absent	Present	Absent
EC-752613	Present	Present	Absent
EC-715382	Present	Absent	Absent
EC-715384	Present	Present	Absent
EC-715380	Present	Present	Absent
EC-715397	Present	Absent	Absent
EC-715386	Present	Present	Absent
EC-695437	Present	Present	Absent
EC-695043	Present	Absent	Absent
EC-705447	Present	Present	Absent
EC-715377	Heterozygote	Present	Absent
EC-700936	Present	Present	Absent
EC-753228	Present	Present	Absent
EC-759997	Absent	Present	Absent
EC0695044	Present	Present	Absent
EC-705444	Absent	Present	Absent
KT-1	Absent	Absent	Present
Kashi Chayan	Absent	Present	Absent
Kashi Aman	Absent	Present	Absent

Development of F_1s: A total of 11 and 16 F_1s were developed against ToLCV and heat tolerance, respectively.

Nutritional rich hybrid (rich in lycopene, beta carotene, ascorbic acid and acidity): A total of 9 exotic collections (EC), 14 parents and 10 β-carotene tomato lines have been analyzed for the identification of sources for nutrition rich tomatoes for development of F_1s. All thirty three tomato lines were evaluated for nutritional studies, like ascorbic acid, beta carotene, TSS, acidity, lycopene, phenol, total sugar, reducing and non-reducing sugar. Out of 10 ß-carotene lines, only KB-1 showed good source of ß-carotene, ascorbic acid and acidity. Among 14 parent lines, Cheti tomato, Vaibhav, Uttkal Pallavi, Punjab Barkha Bahar-2, Punjab Chhuhara showed good source of lycopene; lines Punjab Barkha Bahar-2, Utkal Pallavi, Cheti Tomato, Vaibhav, Kashi Aman, Punjab Chhuhara showed good

source of β-carotene; lines Cheti Tomato, CLN-1621 showed good source of ascorbic acid; lines Cheti Tomato, Vaibhav, Punjab Chhuhara showed good source of high TSS; lines Kashi Vishesh, Uttkal Pallavi, Cheti Tomato, Punjab Chhuhara, Punjab barkha bahar-2 showed good acidity whereas lines Kashi Chayan, Utkal Kumari, Punjab Barkha Bahar-1 and lines Kashi Chayan, Kashi Aman, Punjab Barkha Bahar-1, Punjab Barkha Bahar-2 were found to be good source of total chlorophyll and total carotenoids, respectively. Out of 14 parental lines, Kashi Aman, Utkal Pallavi, Utkal Raja, Punjab Barkha Bahar-1, Cheti Tomato, Utkal Kumari showed good tolerance to ToLCV due to good accumulation of phenol compared to other parent lines. Among 9 EC lines, EC-695437 and EC-715386 showed good source of lycopene; lines EC-695437 and EC-715386 showed good source of ß-carotene; lines EC-705444 and EC-752613 showed good source of high TSS; lines EC-705444 and EC-715384 showed good acidity; only one line EC-715380 showed the best source of ascorbic acid, whereas lines EC-695437, EC-715384, EC-715386, EC-752613 and line EC-695437 were found to be good source of total chlorophyll and total carotenoids, respectively. In 9 EC lines only EC-705444, EC-695044 showed good accumulation of phenol compared to other EC lines. These lines will be used as donor parent for development of hybrid in respective traits.

Project 7: Network Project on Transgenic Crops (NPTC)

Pyramiding of *AtDREB1A and BcZAT12* transgenes for abiotic stresses: Pyramiding of AtDREB1A and BcZAT12 transgenes were done by crossing both the transgenic lines in a reciprocal manner (Figure 8). The F_1 plants were tested by PCR amplification for both AtDREB1A and BcZAT12 specific primers, and scored according to banding patterns. Progenies having both the transgenes were further used for morphological and physiological characterization for generation advancements. At the same time, both the transgenic lines, AtDREB1A and BcZAT12 are being multiplied for generation advancement programme.

Generation advancement of fruit and shoot borer resistant transgenic brinjal – *Cry1Aa3 gene:* Homozygous T_5 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 T_6 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 (Figure 9) were transplanted in net house. Selfing was performed on fully grown plants for multiplication. Now seeds of mature selfed fruits from all the six lines have been stored. We are waiting for events approval and further for commercialization to start the distribution of seeds of 6 improved lines with *Cry1Ac* gene to farmers for cultivation.

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 T_7 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.

Fig. 8: Generation advancement of pyramided transgenic tomato lines

Fig. 9: Popular varieties of brinjal used for development of transganic brinjal

Project 8: Evaluation of high yielding varieties/ hybrids of cucurbitaceous vegetables for river bed (*diara* land) cultivation and standardization of their agro-techniques

Based on availability of seeds, 48 varieties/ hybrids of 9 cucurbitaceous vegetables were assembled for evaluation. The treatments were formulated to standardize the level of inputs for river bed and methods of pits/trench preparation and other production technologies for yield optimization based on the farmers practices. The crops were sown in the river bed from 5th to 30th November. For one set of experiment, nursery was also raised and transplanted before 15th February. The seeds were soaked in water upto 12 h and after that removed from water. The seeds were kept in the castor leaves as well as germinator for sprouting. The sprouted seeds were sown in the pits. The recommended management practices have been followed for control of the insects. The infection of root knot nematode was observed in muskmelon crop. No any serious disease had been observed. The promising varieties based on yield performance was US-112 in bottle gourd, Kalyanpur Baramasi in bitter gourd, Kashi Madhu in muskmelon, Prasad Komal in longmelon, Sujata in sponge gourd, Watermelon No. 786 in watermelon, Kamini 017, Naraendra Agrim in pumpkin. The transplanting of seedlings was found better for all crops except longmelon and pumpkin. The application of FYM (1 kg) + NPK (25:50:50 g) in the form of urea, DAP and MOP along with liquid fertilizers (19:19:19) @ 3-5 g/l were found to give maximum yield in all crops except sponge gourd. Red pumpkin beetle at cotyledon leaf stage and aphids in the middle of February had been observed on the all cucurbit crops.

Project 9: CRP on Agrobiodiversity

Tomato: Of the 500 accessions received from ICAR-NBPGR, New Delhi, characterization for 26 descriptors for 251 accessions was done in Augmented Block Design using 5 checks i.e. Kashi Aman, Kashi Anupam, Kashi Vishesh, Kashi Hemant and Kashi Amrit. Seeds of the 156 accessions were multiplied and sent to ICAR-NBPGR, New Delhi. Promising genotypes for traits of economic importance were identified and listed below in the table 4. These accessions shall be used in crop improvement program.

Table 4: Promising accessions of tomato for different traits

Traits	Genotypes	Check
Earliness (days to 50% Flowering) (DAT)	EC759278 (20.40), EC0002689 (23.46), EC759263 (23.46), EC759249 (23.46), EC0003103 (24.48)	Kashi Vishesh (35.70)
Fruits/plant (No.)	EC0017169 (162), EC0002694 (150), EC0006594 (150), EC715382 (132), EC759252 (102)	Kashi Vishesh (63)
Fruit weight (g)	EC759251 (130), EC759262 (118.60), EC759276 (114.44), EC759255 (101), EC759264 (92.5)	Kashi Vishesh (64.35)
Yield/Plant (kg)	EC759276 (6.18), EC759252 (4.56), EC759264 (4.44), EC715382 (4.23), EC759244 (4.18)	Kashi Vishesh (2.08)
TSS (°Brix)	EC0006594 (7.2), EC0004958 (7), EC0004639 (7), EC0007317 (7), EC0017169 (6.8)	Kashi Vishesh (4.80)
Pericarp thickness (mm)	EC0007916 (9.2), EC0002640 (9.2), EC759264 (7.1), EC759261 (6), EC759276 (6)	Kashi Vishesh (4.4)

Brinjal: Of the 500 accessions received from ICAR-NBPGR, New Delhi, characterization for 19 descriptors for 495 accessions was done in Augmented Block Design using 5 checks *i.e.* Kashi Taru, Punjab Sadabahar, Kashi Prakash, Naveena, Kashi Uttam and KS-224. Seeds of the same 495 accessions were also multiplied and sent to ICAR-NBPGR, New Delhi. Promising genotypes for traits of economic importance were identified and shall be used in crop improvement program. Trait-wise promising germplasm accessions identified for various market segments are mentioned below in the table 5.

Table 5: Promising accessions of brinjal for different market segments

Traits	Accessions	Check
Light Purple Long		
Earliness (days to 50% Flowering) DAT	IC-0510416 (43.35); EC-0305013 (45.23); IC-0112339 (46.54); IC-0074206 (49.35); EC-0169763 (49.63)	Kashi Taru (46.23)
Fruits/ Plant (No.)	IC-0112331 (31.35); IC-0112339 (28.54); IC-0074206 (28.33); EC-0169763 (26.57); IC-0510416 (21.88)	Kashi Taru (19.66)
Yield/Plant (kg)	EC-0305013 (3.10); IC-0074206 (2.66); EC-0169763 (2.47); IC-0510416 (1.99); IC-0112339 (1.98)	Kashi Taru (2.16)
Purple Black Long		
Earliness (days to 50% Flowering) DAT	EC-0169765 (43.54); IC-0510459 (43.85); IC-0112779 (46.00); IC-0090126 (46.23); IC-0510417 (48.21)	Kashi Taru (46.23)
Fruits/ Plant (No.)	EC-0169765 (39.24); IC-0510459 (38.48); IC-0510417 (36.35); IC-0090036 (35.28); IC-0112779 (28.36)	Kashi Taru (19.66)
Yield/Plant (kg)	IC-0112779 (5.67); IC-0510417 (3.56); IC-0090036 (3.56); EC-0169765 (3.53); IC-0510459 (3.46)	Kashi Taru (2.16)
Green Long		
Earliness (days to 50% Flowering) DAT	IC-0099682 (46.27); IC-0090909 (47.56); IC-0112300 (48.24); IC-0112901 (48.27); IC-0111415 (50.28)	Kashi Taru (46.23)
Fruits/ Plant (No.)	IC-0099682 (39.26); IC-0112300 (35.85); IC-0090909 (35.24); IC-0111415 (31.76); IC-0112901 (31.28)	Kashi Taru (19.66)
Yield/Plant (kg)	IC-0112300 (4.66); IC-0112901 (4.37); IC-0111415 (4.31); IC-0099682 (3.70); IC-0090909 (1.57)	Kashi Taru (2.16)
Light Purple Round		
Earliness (days to 50% Flowering) DAT	EC-0169761-1 (49.64); EC-0169764 (50.45); IC-0090917 (53.63); IC-0099645 (54.36); IC-0112716 (55.48)	Swarnamani 54.23)
Fruits/ Plant (No.)	EC-0169764 (36.26); IC-0112716 (31.45); IC-0112734 (31.26); IC-0090917 (27.28); IC-0099645 (24.43)	Swarnamani (19.86)
Yield/Plant (kg)	EC-0169761-1 (4.56); IC-0099645 (4.27); EC-0169764 (3.62); IC-0112716 (3.17); IC-0112734 (2.65)	Swarnamani (3.67)
Purple Black Round		
Earliness (days to 50% Flowering) DAT	IC-0112814 (51.00); IC-0510419 (51.28); IC-0074239 (51.76); IC-0510435 (52.46); IC-0112344 (54.64)	Swarnamani 54.23)
Fruits/ Plant (No.)	IC-0112814 (37.27); IC-0112344 (31.88); IC-0510419 (28.46); IC-0074239 (27.26); IC-0510435 (24.26)	Swarnamani (19.86)
Yield/Plant (kg)	IC-0112814 (4.09); IC-0510419 (2.84); IC-0510435 (2.45); IC-0074239 (2.45); IC-0112344 (2.39)	Swarnamani (3.67)
Purple Oblong		
Earliness (days to 50% Flowering) DAT	EC-0169761 (42.68); IC-0510414 (45.45); IC-0510453 (46.36); IC-0074224 (46.36); IC-0510447 (46.39)	Swarnamani 54.23)
Fruits/ Plant (No.)	IC-0510447 (39.56); IC-0074224 (38.36); IC-0510414 (35.43); IC-0510453 (35.36); IC-074196 (32.44)	Swarnamani (19.86)
Yield/Plant (kg)	IC-0510447 (3.56); IC-0074224 (3.26); IC-0510414 (3.01); IC-0510453 (3.00); IC-0074196 (2.85)	Swarnamani (3.67)
Purple Black Oblong		
Earliness (days to 50% Flowering) DAT	IC-0074199 (45.23); EC-0169769-A1 (49.36); IC-602631 (50.00); IC-0074224-1 (40.46); IC-0510449 (51.23)	Swarnamani 54.23)
Fruits/ Plant (No.)	IC-0074224-1 (47.28); IC-0074199 (46.74); EC-0169769-A1 (42.25); IC-0510420 (39.35); IC-0510449 (38.78)	Swarnamani (19.86)
Yield/Plant (kg)	IC-0074224-1 (4.01); IC-0074199 (3.97); IC-0510449 (3.26); EC-0169769-A1 (3.18); IC-0510420 (3.14)	Swarnamani (3.67)

Okra

Component I (No. of Okra accession=500): Characterization and regeneration for different agro morphological characters was done in *Kharif*-2015 as per NBPGR descriptor. The data were recorded for 11 quantitative and 10 qualitative traits. Among all, eight accessions did not germinate (IC0253312, IC0257174, IC0257231, IC0467692, IC0467695, IC0467730, IC0557098, IC0043743-B) and 291 accessions could be multiplied. Twelve accessions (IC0588182, IC0588183, IC0588184, IC0588187, IC0588188, IC0588189, IC0588190, IC0588191, IC0588192, IC0588194, IC0140933 and IC0588195) were identified as *Abelmoschus caillei* and one accession i.e. IC0506146 was identified as *Abelmoschus tetraphyllus*. Three accessions *viz*. IC0506172, IC0506206 and IC0588185 were identified as *Abelmoschus moschatus*.

Component II (No. of Okra accession=725): Screening of 725 okra accessions for YVMV and OELCV diseases was done in *Kharif* -2015. One accession (EC305613) did not germinate while, eight genotypes were found free from both YVMV and OELCV diseases. Four accessions viz. IC117125, IC510697, IC510698 and IC510700 were identified as *Abelmoschus caillei* while,

accession IC-117090 was identified having eleven ridges. Accessions IC-117088, IC-117245 and IC-117333 were identified having seven ridges. The details are presented in the table 6.

Table 6: Trait-wise promising accessions identified

Heavy branching and short internode	Early fruiting	Thin fruited	Branching and fruit from lower node	YVMV and ELCV free
IC093724	IC117263	EC102605	IC117005	IC024904-A
IC027875-A	IC117265	EC169459	IC117336	IC117027
IC117314	EC112231	IC014909	IC117339	IC117247
	EC112241			IC117321
	EC169347			IC117336
	EC169350			EC169408
	EC169408			EC169419
				IC033206

Bitter Gourd : During the year total 150 genotypes were received from NBPGR, New Delhi but only 7 genotypes germinated. Potential yield could not be accessed due to lesser number of plants and seed increase was necessary. The details are mentioned in the table 7.

Table 7: Yield related traits of bitter gourd accessions

Genotypes	Fruit Length (cm)	Circumference (cm)	Fruit Wt. (g)	Plant height (cm)
IC44428	11.0	12.5	50.0	268.0
IC44438	20.0	15.0	100.0	265.0
IC588075	18.5	10.0	65.0	235.0
IC212504	18.0	12.0	60.0	270.0
IC255533	16.0	11.5	70.0	272.0
IC85648A	12.0	11.0	35.0	242.0
IC44436	9.0	10.5	25.0	309.0
PDM (C)	13.0	15.0	50.0	244.0
PBIG-2 (c)	15.0	17.0	75.0	127. 3
CD	**13.27**	**9.85**	**9.21**	**7.26**
CV	**6.54**	**3.54**	**6.35**	**3.27**

Project 10: 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)

Maintenance of reference varieties: 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 institutes and SAUs and maintained. All the varieties of these crops were sown in randomized block design (R.B.D.) with 3 replications and maintained. The details of varieties of these crops and their descriptors of morphological traits are presented in table 8.

Table 8: Details of reference varieties and their morphological traits

Crops	No. of reference varieties	No. of morphological traits
Tomato	78	46
Cauliflower	05	28
Cabbage	01	28
Brinjal	86	47
Vegetable Pea	41	21
French bean	25	22
Okra	42	31
Cucumber	24	36
Bitter gourd	25	33
Bottle gourd	31	33
Pumpkin	21	32
Pointed gourd	21	15
Total	**400**	

DUS Testing of vegetable crops: Sixty okra, 101 brinjal, 33 cauliflower, 94 tomato, 11 bottle gourd, 17 bitter gourd, 3 cucumber, 5 pumpkin, 3 cabbage and 2 French bean entries were evaluated under DUS Testing along with reference varieties as given in table 9.

Table 9: DUS testing vegetable crops

Type of variety	New		VCK	FV	Total	Date of Monitoring	Chairman
	1st year	2nd year					
Bottle gourd	-	-	8	3	11	30.04.2015	Dr.A.N.Maurya
Bitter gourd	-	-	15	2	17	18.05.2015	Dr.A.N.Maurya
Cucumber	-	-	3	-	3	18.05.2015	Dr.A.N.Maurya
Pumpkin	-	-	-	5	5	18.05.2015	Dr.A.N.Maurya
Okra	24	21	13	2	60	16.10.2015	Dr. S. K. Pandey
Brinjal	19	53	23	6	101	18.01.2016	Dr. S. K. Pandey
Cauliflower	17	9	6	1	33	08.01.2016	Dr. A. N. Maurya
Cabbage	02	-	01	-	03	13.02.2016	Padam Shri Dr. Brama Singh
French bean	-	-	-	02	02	14.02.2016	Dr. Umesh Srivastava
Tomato	25	25	40	4	94	12.02.2016	Dr. A. N. Maurya
Total	**87**	**108**	**109**	**25**	**329**		

- Twenty (new and extant) varieties of different vegetable crops have been sent for registration through AICRP (VC) to PPV&FR Authority, New Delhi.
- Eighty six brinjal; 78 tomato; 42 okra; one cabbage; 5 cauliflower; 41 vegetable pea; 25 french bean; 31 bottle gourd; 21 pumpkin; 25 bitter gourd; 24 cucumber and 21 pointed gourd varieties were collected and maintenaned as reference varieties of vegetables crops from SAUs and ICAR based Institutes.

Project 11: 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 sanctioned by the Council under NAIF at IIVR, Varanasi from January2016. This ABI unit, in collaboration with IIVR, Indian Society of Vegetable Science and Association for Promotion of Innovations in Vegetables, was instrumental in organizing a "National Symposium on Vegetable Legumes for Soil and Human Health" from 12-14 February 2016 at ICAR-IIVR, Varanasi. In the symposium, a separate session on "Seed Enhancement, Marketing and PPP" was also organized to further the interests of ABI. A number of representatives from private sector participated.

Commercialization of Technologies: The technologies developed by ICAR-IIVR, Varanasi were licensed for commercial production and marketing of the technologies. The commercialised technologies and firms to which they have been licensed is given in table 10. This has helped in generation of resource of Rs. 2,95,000.

Table 10: List of commercialized technologies

Crop	Technology	Firm to which Licensed
Cowpea	Kashi Kanchan	M/S Mali Agritech Pvt Ltd, Nadia, West Bengal
		M/S Haldighati Seed Corporation, Rajsamand, Rajasthan
	Kashi Nidhi	M/S DNA Agri Seed Pvt Ltd., Rangareddy, Telangana
Tomato	Kashi Aman	M/S DNA Agri Seed Pvt Ltd., Rangareddy, Telangana
		M/S Ananya Agri Genetics (India), Rangareddy, Telangana
		M/S/ Suraj Crop Sciences Ltd., Gandhinagar, Gujarat

Fig. 10: Photographs of entrepreneurship development programme

In addition, Rs. 6,93,095 (Rs.Six lakhs ninty three thousand and ninty five only) was received as royalty from technologies commercialized in previous years.

The ABI unit also organized a training programme entitled "Entrepreneurship Development through Value Chain and Seed Production in Vegetables" on 28-29 March 2016 at ICAR-IIVR, Varanasi. Twenty participants from different areas participated in this training programme and got benefitted (Figure10). Some of them expressed interest in initiating their enterprise in the related fields.

Project 12: 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 was sanctioned by the Council under NAIF at IIVR, Varanasi during this year. The unit has ten 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 and ICAR- Central Island Agricultural Research Institute, Port Blair.

The reports from all the ITMUs in domain on management of IP portfolio, commercialization of Technologies, outreach activities, capacity Building in IP Management and training/ workshop/seminar etc. organized was compiled and sent to IPTM unit of the Council on a regular basis. A field day on okra on 9 October 2015 and a solanaceous crops field day on 18 Jan 2016 were organized for showcasing of varieties/ hybrids and promising lines developed by IIVR and for sensitization of probable takers for the technology for promoting the commercialization of IIVR technologies. Participants from private sector seed companies expressed interest in different material generated at IIVR and further interactions with some of them are in process for the purpose. A National Farmers' Fair was organized at the Institute on 30 Jan 2016 in which the ITMUs of ICAR-NRC, Litchi, ICAR-DMR, Solan, ICAR-CPRI, Shimla & ICAR-CISH, Lucknow also exhibited their technologies.

Field day on Solanaceous Vegetables organized at ICAR-IIVR, Varanasi: With a view of an effective collaboration with the private sector in PPP mode and to percolate the technologies of the institute into farmer's field under the guidelines of ICAR , a field day on Solanaceous vegetable crops was organized by the Zonal Technology Management Unit of the Institute on 18th January, 2016 to showcase and commercialise promising germplasm, varieties and hybrids developed by the institute. The program was attended by breeders and marketing strategists from several companies from vegetable seed sector. The delegates visited the farm of the institute and appreciated the varieties and hybrids developed by the institute. The delegates keenly observed the promising germplasm and also expressed their desire to obtain these germplasm lines including sources of resistance and gene pyramided lines (Figure 11). The delegates discussed with the breeders of the institute and provided valuable suggestions on the market demand of tomato, brinjal and chilli. Promising breeding lines in chilli and tomato developed through a blend of conventional and molecular approaches having resistance to biotic stresses, attracted the attention of the visitors.

This program provided an effective and efficient platform for interaction among breeders and experts from private organizations and has helped in better understanding of the market demand. The visitors were assured of the development of new technologies in accordance with the market preference and inputs provided by the visitors Figure 11.

Project 13: Network project on Micronutrients Management in Horticultural Crops for Enhancing Yield and Quality

Status of micronutrients in the soils of Varanasi and adjoining districts: In Bhadohi district a soil survey of 5 villages were made during the year for the analysis of micronutrients are Dih Koiran, Garauli, Jathi, Naktapur and Kurauna. In the village Dih Koiran, the content of Iron ranged from 4.68 to 11.82 mg/kg similarly the manganese content ranged from 12.64 to 21.76 mg/kg. The content of copper and zinc was lower and vary from 0.98 to 4.37 mg/kg and 0.85 to 4.71 mg/kg. In the village Garauli the content of Iron, Manganese, copper and zinc ranged from 7.84 to13.77; 11.38 to 21.91; 1.58 to 3.57 0.77 to 4.74 mg/kg. In the village Naktapur range of micronutrients were 5.65 to 10.54 mg/kg iron, 5.58 to 19.63 mg/kg manganese, 1.05 to 2.27 mg/kg copper and 1.07 to 1.68 mg/kg zinc. While in the Kurauana village the content of micronutrients were higher side. The pH of the Bhadohi district ranged

Fig. 11: Organization of Solanaceous Field Day

from 7.10 to 8.09, EC 0.07 to 0.93 ds/m, organic carbon 0.16 to 0.78 percent, available N 150.53 to 401.41 kg/ha and total N 0.89 to 2.39 percent.

In the Mirzapur district vegetable growing village like Nakkupur, Khunti Rudauli, Arazi Line, Mahraksh, Pahon, Hardara, Taktakpur, Bindapur, Prayagpur, Mavauya, Sonbarsa, Khanpur, Patlukia, Pachraw, Adalpura, Arazi Line (Sultanpur), Parshupur, village were selected for sampling . On basis of data presented in the table the micronutrients were ranged from 5.08 to 19.84 mg/kg iron, 3.78 to 16.40 mg/kg manganese, 0.79 to 3.81 mg/kg copper and 0.26 to 12.89 mg/kg zinc. The pH in the Miarzapur district was ranged between 7.1 to 8.2, EC 0.10 to 0.47 ds/m, organic carbon 0.118 to 0.677 percent, available nitrogen 112.9 to 313.25 kg/ha and total nitrogen 0.868 to 2.412 percent. In the Varanasi a total of 5 villages were selected including the PM opted village Jayapur. The status of micronutrients were 2.90 to 16.28 mg/kg iron, 6.84 to 20.03 mg/kg manganese, 0.55 to 2.84 mg/kg copper and 0.58 to 5.98 mg/kg zinc were ranged. As per pH of the Varanasi district were ranged from 7.5 to 8.5, EC 0.19-0.95 ds/m, organic carbon 0.33 to 0.89 percent, available N 112.9 to 188.16 kg/ha and total N was from 0.05 to 2.28 percent.

Screening of genotypes of tomato (*Solanum lycopersicum*) for higher nutrient acquisition from the soil: An experiment with 9 genotypes of tomato was conducted during the year to see the status of micronutrients acquisition from the soil. The recommended dose of nutrients 60:30:30 mg/kg of NPK along with Zinc (2.5mg/kg), and Borax (2.0 kg ha^{-1}) / pot was given. A total 9 plants were kept as one replication of each genotype and replicated thrice in complete randomized block design. In this way a total of 27 numbers of plants were kept under each treatments. The transplanting in the plots was done on 14th December under polyhouse condition. The observations were recorded on periodic growth intervals (Figure 12 and 13). The genotypes were, G_1 =

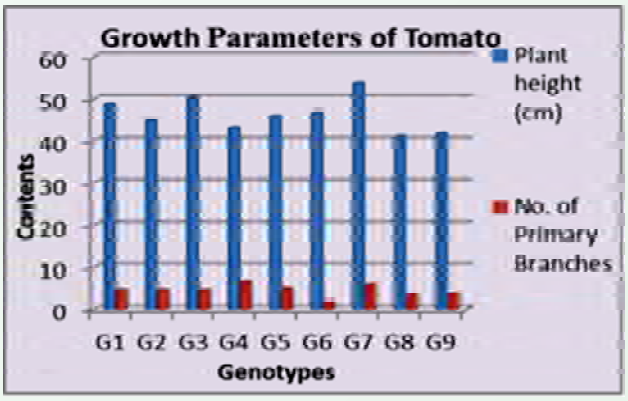


Fig. 12 : Growth parameter of tomato

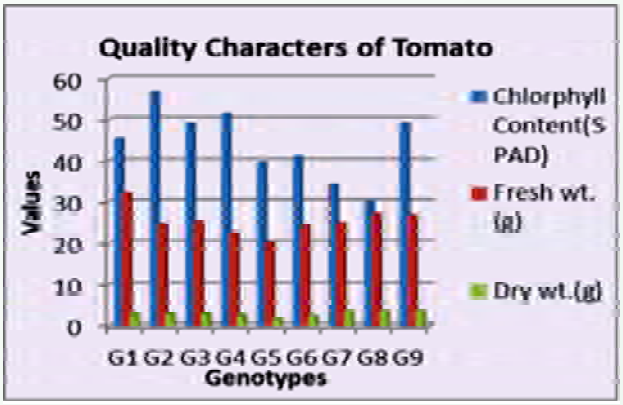


Fig. 13: Quality character of tomato

Punjab barkha-2, G_2 = TLCV-10, G_3 = EC-620446, G_4 = UtkalPalvi, G_5 = DVRT-2, G_6 = Kashi Aman, G_7 = H-88-78-1, G_8 = UtkalKumari, G_9 = CLN-1621. The maximum plant height was noted 53.83 cm in the var. G8, i.e. Utkal Kumari. Similarly the number of primary branches was noted maximum 6.0 in H88-78-1. The chlorophyll content was maximum in TLCV-10 line and the fresh and dry weight of the plants was noted maximum in G7 i.e. H88-78-1.

Effect of soil and foliar application of zinc and boron on growth yield and quality of tomato (*Solanum lycopersicum*) grown in Inceptisols of Varanasi: An experiment was conducted during the year on tomato cv. Kashi Aman with 12 treatment combinations to see pattern of micronutrients acquisition from the soil. The recommended dose of nutrients 60:30:30 mg/kg of NPK along with Zinc (2.5 kg ha^{-1}), and Borax (2.0 kg ha^{-1}) per pot was given. A total 12 plants were kept under each replication and replicated thrice in complete randomized block design. In this way a total of 36 numbers of plants were kept under each treatments. The transplanting in the plots was done on 17th December under polyhouse condition. The observations were recorded on periodic growth intervals. The treatments were T-1- Contol, T-2- NPK + FYM (25t ha^{-1}) + SA of Zinc (2.5 kg ha^{-1}), T-3- NPK + FYM (25t ha^{-1}) + SA of Zinc (5.0 kg ha^{-1}), T-4- NPK + FYM (25t ha^{-1}) + SA of Zinc (7.5 kg ha^{-1}), T-5- NPK + FYM (25t ha^{-1}) + SA of Zinc (10 kg ha^{-1}), T-6- NPK + FYM (25t ha^{-1}) + SA of Borax (1.0 kg ha^{-1}), T-7- NPK + FYM (25t ha^{-1}) + SA of Borax (2.0 kg ha^{-1}), T-8 NPK + FYM (25t ha^{-1}) + SA of Borax (3.0 kg ha^{-1}), T-9- NPK + FYM (25t ha^{-1}) + SA of Zinc (5.0 kg ha^{-1}) and Borax (2.0 kg ha^{-1}), T-10- NPK + FYM (25t ha^{-1}) + FS of Boron (0.2%), T-11- NPK + FYM (25t ha^{-1}) + FS of Micro-mix (T1) 0.2%, T-12- NPK + FYM (25t ha^{-1}) + FS of Micro-mix (T4) 0.2% (SA-Soil application, FS-Foliar spray). The observations on periodic growth intervals were recorded. The maximum chlorophyll was recorded under T-11 while the maximum numbers of branches were under T-12.

Project 14: Network project on Organic Farming in Horticultural Crops

Performance of Amaranths during 2014-15: Figure clearly reflect that the maximum yield of Amaranths leaves was recorded 162.85 q/ha with Vermi 50% +Jeevamrit + Biofert followed by 157.16 q/ha with the application of the treatment 75% Vermi+Biofert. The minimum yield 113.7 q/ha was recorded with T0=Jeevamrit+Panchgavya (Figure 14).

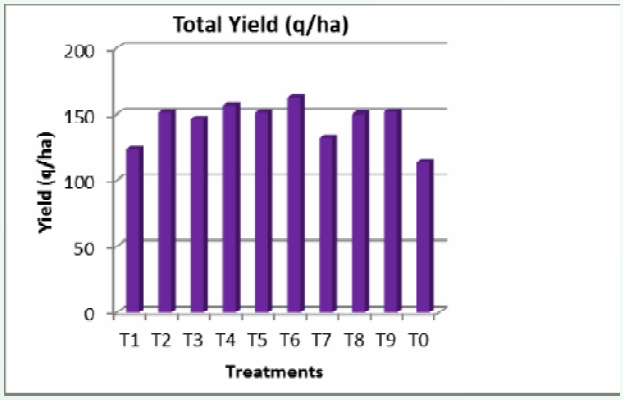


Figure 14: Yield of Amaranths at different cutting

Effect of treatments on quality characters: Maximum ascorbic and plant total nitrogen content was recorded 69.54mg/100g and 1.75% in the treatment 100% through FYM, whereas the maximum dry weight 13.18% was noted in Jeevamrit + Panchgavya (Table 11).

Table 11: Effect of different treatments on quality parameter

Amaranthus 2014-15		Content in leaves			
S.N	Treatments	Ascorbic Acid (mg/100g)	Plant total Nitrogen (%)	Dry wt (%)	Oxalate (%)
1	T1 = 100% through FYM	69.54	1.75	11.04	0.35
2	T2 = 100% through Vermi	50.54	1.47	12.38	0.15
3	T3 = 75% FYM + Biofert	58.90	1.58	11.99	0.59
4	T4 = 75% Vermi + Biofert	58.14	1.73	11.28	0.59
5	T5 = FYM50% + Jeevamrit + Biofert	67.64	1.33	11.48	0.50
6	T6 = Vermi 50% + Jeevamrit + Biofert	52.48	1.45	11.61	0.79
7	T7 = FYM 50% + Panchgavya + Biofert	33.42	1.33	11.44	1.25
8	T8 = Vermi 50% + Panchgavya + Biofert	63.55	1.38	10.98	6.60
9	T9 = Inorganic control	46.33	1.41	11.84	5.28
10	T0 = Jeevamrit + Panchgavya	53.30	1.26	13.18	1.10

Effect of treatments on soil properties: The pH of the soil ranged from 8.05 to 8.47 and the maximum pH was noted in the treatment Vermi 50% + Panchgavya + Biofert. Similarly the EC ranged from 0.129 to 0.225 percent. The soil total nitrogen was noted between 0.224 to 0.492. The Available N in the soil was between 162.07 to238.33 kg/ha. The soil organic carbon content in the soil ranged between 0.251 to 0.380 percent.

Effect of different treatments on palak yield and quality: Significantly maximum palak yield 631.66 q/ha was recorded under the treatment jeevamrit+ panchgavya (Figure 15 and Table 12). However it was observed that the maximum yield was recorded in the second cuttings. The maximum dry weight was ranged from 4.68 to 6.40 percent and the maximum dry was recorded under T2 i. e. 100% through Vermi compost. The oxalate content in the leaves was ranged from 0.048 -0.060. However, the maximum ascorbic acid content 109.547 was noted in T2 i.e. 100% through Vermi compost.

Fig. 15: Yield of palak undervarious treatments

Table 12: Effect of different treatments on palak quality

S. N	Treatments	Dry wt (%)	Oxalate (%)	Ascorbic acid (mg/ 100g)	Total yield (q/ha)
1	T1 = 100% through FYM	5.30	0.057	93.25	505.21
2	T2 = 100% through Vermi	6.40	0.051	109.54	561.44
3	T3 = 75% FYM + Biofert	5.43	0.050	94.64	494.14
4	T4 = 75% Vermi + Biofert	5.43	0.057	92.90	448.57
5	T5 = FYM 50% + Jeevamrit + Biofert	5.52	0.053	98.55	478.81

S. N	Treatments	Dry wt (%)	Oxalate (%)	Ascorbic acid (mg/ 100g)	Total yield (q/ha)
6	T6 = Vermi 50% + Jeevamrit + Biofert	5.79	0.048	98.10	476.48
7	T7 = FYM 50% + Panchgavya + Biofert	5.30	0.048	98.59	503.05
8	T8 = Vermi 50% + Panchgavya + Biofert	4.68	0.057	89.09	559.94
9	T9 = Inorganic Control	5.10	0.060	96.33	351.78
10	T0 = *Jeevamrit* + *Panchgavya*	5.75	0.057	86.32	631.66
CD (P=5%)		0.21	0.002	2.52	16.23

Effect of treatments on yield of Fenugreek: The data shows that the maximum yield of fenugreek was recorded 196.84 q/ha in the treatment T0 i.e. Jeevamrit + Panchgavya. However the minimum yield was noted in 144.96 under inorganic treatments. The maximum dry weight was recorded in the treatment FYM50%+Jeevamrit + biofertilizers *i.e.* 47.35%. The oxalate content was ranged from 0.021 to 0.063 in inorganic control. Similarly the Ascorbic acid content was noted higher in the treatment T4=75%Vermi+Biofert i.e. 39.87 mg/100g (Table 13)

Table 13: Effect of different treatments on quality characters

S. N	Treatments	Dry wt (%)	Oxalate (%)	Ascorbic Acid (mg/ 100g)	Total Yield (q/ha)
1	T1 = 100% through FYM	42.95	0.053	35.36	153.52
2	T2 = 100% through Vermi	44.09	0.059	36.52	161.77
3	T3 = 75%FYM + Biofert	48.48	0.067	36.17	163.68
4	T4 = 75%Vermi + Biofert	46.73	0.057	39.87	177.01
5	T5 = FYM 50% + Jeevamrit + Biofert	47.35	0.070	34.78	165.10
6	T6 = Vermi 50% + Jeevamrit + Biofert	45.91	0.070	36.05	173.93
7	T7 = FYM50% + Panchgavya + Biofert	42.96	0.066	39.52	161.60
8	T8 = Vermi50% + Panchgavya + Biofert	45.33	0.070	33.63	153.02
9	T9 = Inorganic Control	45.26	0.063	38.25	144.96
10	T0 = Jeevamrit + Panchgavya	42.08	0.021	34.78	196.84
	CD(p=5%)				4.25

Project 15: Network project on: new initiatives in protected horticulture

Performance of capsicum hybrids under semi protected conditions: Four capsicum hybrids were selected for cultivation under two semi protected conditions poly house and net house and transplanted on 27th October, 2015 in 4x2.5 m^2 plots. The observations on growth and yield parameters were recorded at periodic growth parameters (Figure 17).

Fig. 17: Different varieties of capsicum under experiment

Fig.16: A view of Fenugreek under various treatments

Under poly house condition, almost all the growth parameters were noted higher as compared to the net house. With regards to the different pruning and training, the two stem trained plants shows better performance as compared to the other. It was surprise to note that the values were decreased with the increase in the number branches.

Yield and yield attributing characters as affected by pruning and growing conditions: It was observed that unlike the growth parameters the yield and yield parameters were better in the polyhouse compared to the net house conditions. However the values were noted higher in two stem training conditions in all most all the characters. The maximum yield per plot was also higher in two stem cuttings compared to other in all most all the hybrids and maximum yield was noted in Orobelle 23.50 kg/plot. The average fruit weight 209 g was noted in Swarna grown under poly house conditions with two stem.

Performance of Cherry tomato under semi protected conditions: Two cherry tomato hybrids namely Roja and Sheeja, red and yellow coloured respectively were sown in the nursery and transplanted after attaining 3 weeks of age and transplanted under net house conditions on 05/11/2015. Growth and yield performance of yellow coloured variety i.e. Sheeja were higher than the Roja. The maximum fruit yield per plant was noted 1.89 kg/plant in yellow colour variety compared to 1.20g in red coloured variety (Figure 18).

Fig.18: Varieties of cherry tomato under experiment

Performance of gynoecious cucumber under low tunnel polyhouse conditions: Two parthenocarpic cucumber varieties namely Pant parthenocarpic Cucumber-2 and Pant Parthenocarpic cucumber -3 were raised in the semi protected conditions. The fruit length and width was noted better in Pant Partheno Cucumber-2. The average fruit weight, number of fruit/hill and length of internode were noted higher in Pant parthenocarpic cucumber -2 (Table 14 & Figure 19).

Table 14: Performance of parthenocarpic cucumber under protected condition

Varieties	Vine length (m)	Fruit length (cm)	Fruit width (cm)	Average Fruit wt. (g)	Number of fruit/hill	Length of internode (cm)
Pant partheno-carpic-2	3.53	17.31	4.28	175.6	21.9	7.85
Pant partheno-carpic-3	3.47	14.95	4.16	142.7	18.7	7.5

Fig.19: Cucumber varieties under low tunnel poly house

Project 16: Efficient water management in horticultural crops under Agri-CRP on water

Work on study of different vegetable based cropping sequences and plant geometry under microirrigation has been initiated for baby corn, amaranth and bitter gourd. The plant geometry of Single, Double, Three, and Four plants at a hill were considered for study.

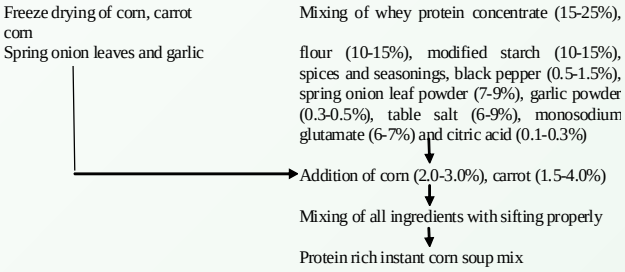
Project 17: A total value chain on commercialization of value added convenience vegetable products

Osmo-freeze drying of corn and spring onion leaf powder: The process for instant protein rich corn soup mix was standardized after osmo-freeze drying of corn, carrot, spring onion leaf powder and garlic as seasonings. Corn was cooked in 5-15% sugar syrup for 5-25 min in steam under pressure at 15 psi. The cooking of corn in 10% sugar syrup for 20 min resulted in charring of corn. The optimum softening of corn was obtained in 5% sugar syrup and cooking at 15 psi for 20 min. Sugar content in corn was reduced from 9.1

– 8.19 mg/100g and a rehydration ratio of 1.72 in boiling water for 2 min.

Spring onion leaves were cut into 0.5 cm size and freeze dried at -92 to -98 °C and at pressure of -0.042 – 0.062 mbar. Freeze dried spring onion leaves was blended in grinder to obtain green spring onion powder.

Formulation of instant protein rich corn soup mix: The formulation of instant protein rich corn soup mix was standardized (Fig. 20) with whey protein concentrate (15-25%), corn flour (10-15%), modified starch (10-15%), spring onion leaf powder (7-9%), dried corn (20-30%), dried carrot flakes (1.5-4.0%), black pepper (0.5-1.5%), citric acid (0.1-0.3%), cumin powder (0.4-0.8%) and garlic powder (0.3-0.5%).



Process for the manufacture of protein rich instant corn soup mix

Sensory score of instant protein rich corn soup mix: Reconstituted soup with the formulation of 21% whey protein concentrate, 14% corn flour, 12% modified starch, 25% dried corn, 3% dried carrot shreds and 8% spring onion leaf powder exhibited good sensory for flavour, consistency, colour and appearance score and overall acceptability score to judges. Overall acceptability score ranged from 7.75-8.0 and 6.6-6.8 during 3 months of storage at 10° and 25°C, respectively.

Physico-chemical properties of instant protein rich corn soup mix: Moisture content in corn soup mix increased (3.28-3.67%) during 3 months of storage at 10°C due to absorption of moisture while moisture content decreased (3.28-3.02%) during storage for 3 months at 25 °C. Loose and packed bulk density increased during storage of corn soup mix at 10 and 25 °C. The values of solubility index and hydroxyl methyl furfural 29.75-33.11 ml and 17.65-21.32 µ mol/ml, respectively increased due to heat induced denaturation which resulted in denaturation of soup mix constituents.

Physico-chemical properties of protein rich *moringa* soup mix:

Moisture content in instant *moringa* soup mix increased from 3.34-4.15% during storage at 10 °C whereas moisture content decreased from 3.34-2.7% after 6 months of storage at 25 °C. Loose bulk density increased from 0.34-0.39 g/cc and 0.34-0.5 g/cc during storage at 10 and 25 °C for 6 months. Hydroxyl methyl content increased from 10.4-15.5 and 10.4-19.7 µmol/L during storage at 10 and 25 °C for 6 months.

Consumer preference of bitter gourd chips based on sensory perception: Consumer preference of bitter gourd chips with 100 respondents was carried at M/s Poorva industries, Allahabad. The respondents were of different age groups of 15-25, 26-35, 36-45 and 46 & above. Maximum respondents had given medium sensory score (5-7). Maximum respondents (80%) had given medium score for colour and appearance, 78% medium score for flavour, 48% medium score for crispness and 72% respondents had given preference in medium score for overall acceptability score. Around 62% respondents have expressed persistence of bitter gourd taste after consumption, which the respondents termed as taste defect.

Project 18: Network project on phytochemicals/ High value compounds

Purification of anthocyanin using polymeric resin: In order to obtain anthocyanins in a purified form, adsorption was carried out with eight different adsorbents like Amberlite XAD-4, Amberlite XAD-7HP, Amberlite XAD-7, Amberlite XAD 16N, Dowex 50WX8, IRC 86 RF, Amberlite XAD-1180N and silica gel. Among

Fig. 20 Dehydrated carrots, sweet corn, ready to use soup mix and moringa soup

these, nonionic acrylic ester adsorbent, namely Amberlite XAD-16N showed the highest adsorption capacity. The resulting anthocyanin solution after purification was free from sugars, which are the major cause for degradation of anthocyanin. No browning was observed.

Metabolite profiling of Black Carrot: After purification detail studies were carried out to identify anthocyanin and other phenolics compounds through LC-MS. Like first year identification, five cyanidin-based anthocyanins were detected as major anthocyanin containing different sugar moieties non-acylated or acylated with acids like sinapic acid, ferulic acid or coumaric acid. The major peak of m/z 919.25026 corresponds to cyanidin-3-O- xylosyl (feruloyl-glucosyl-galactoside) with the confirmatory ions m/z 287.05435. The fragmentation pattern of these five anthocyanins showed the confirmatory ion corresponds to cyanidin aglycone. In addition to this other three delphinidin derivatives were detected in very small amounts with the confirmatory ions m/.z 303.048 for delphinidin aglycones. Two peonidin derivatives were detected in very small amounts with the confirmatory ions m/z 301.070 for peonidin aglycones. Other phenolic compounds identified are kempherol and quiercetin. All the positive identified compounds were within an acceptance criterion of mass accuracy (5 ppm) and more than one confirmatory ion.

***In vitro* antioxidants and antidiabetic potentiality of black carrot:** Black carrot extract showed strong antioxidant activity under in vitro condition measured through DPPH (IC50 =1.76 µg) and TEAC (IC50= 1.65 µg) methods. It also strongly scavenges super oxide under *in vitro* condition (IC50 = 4.4 µg). Under *in vitro* condition purified black carrot extract strongly inhibits both α-amylase (IC50 = 29.71 µg) and α-glucosidase (IC50= 21.66 µg).

Project 19: ICAR Inter-institutional Collaborative Project on "Livelihood and Nutritional Improvement of Tribal Farm Women through Horticulture"

This project work was initiated during Kharif season 2015 after selection of area, location and beneficiaries ie., 100 tribal farmwomen from Bhalukudar, Kekrawah kheri & Satdwari villages of Padrach Gram Panchyat in Sonbhadra district of Uttar Pradesh. Initially, an awareness programme cum workshop was organized in Bhalukudar village of Padrach Gram Panchyat, Sonbhadra during July 2015 in which all the selected tribal farm women had participated. Further, needs were assessed and efforts

were made for livelihood and nutritional improvement of selected tribal farmwomen through horticulture in general and vegetables in particular.

Front line demonstrations of pea (Kashi Udai) were conducted at all the selected 100 tribal farmwomen' field during *Rabi* season 2015-16 in more than 40 acres area after organizing proper training programme/ interface on different aspects of vegetable production for enhancing the knowledge, skills and attitudes of tribal women for adopting the recommended vegetable technologies. The average performance of demonstrated pea variety Kashi Udai at the tribals' field was recorded 37 per cent higher in compared to the other varieties cultivated by them or in nearby area.

In selected tribal region of Sonbhadra, people were not growing much vegetable either on commercial basis or in kitchen garden thereby they used to have less vegetables in their daily diet. Promotion of kitchen garden by providing quality vegetable seeds of tomato (Kashi Visesh); brinjal (Kashi Taru); chilli (Kashi Anmol); okra (Kashi Pragati); bean (Kashi Haritima); cowpea (Kashi Kanchan); bottle gourd (Kashi Ganga); sponge gourd (Kashi Divya) and pumpkin (Kashi Harit) to all 100 selected tribal farmwomen during

Fig. 21: Training of tribal farmwomen on kitchen garden and crop residue management at ICAR-IIVR

Kharif 2015 after proper interface, not only helped them in improving nutritional security by including ample vegetables in their daily diet but also tribal women earned an amount of Rs 1200-1500 by selling excess vegetables in local market. The tribal women were also encouraged for crop residue management by recycled crop residue to organic compost, which can be utilized for enriching soil health of nutria-garden (Figure 21).

Project 20: NHB Project on "Promotion of Vegetables for Nutritional Security in Eastern Uttar Pradesh"

Considering Eastern Uttar Pradesh as vegetable potential area but having less production per unit area, the institute in collaboration with National Horticulture Board, Gurgaon adopted 32 villages from Varanasi, Mirzapur, Chandauli, Gazipur, Jaunpur and Mau districts in Eastern Uttar Pradesh for motivating vegetable growers for adoption of improved production & protection technologies coupled with enhanced seed replacement rate to improve vegetable productivity in this region.

Front line demonstrations of garden pea var. Kashi Udai was conducted in an area of 25 acre at 2200 farmers' field in selected villages of Eastern Uttar Pradesh, which fetched an average yield of 4.7 t/acre during Rabi 2015-16. During Zaid season in 2016 a massive demonstrations of summer vegetables were conducted in 218.69 acre area covering 1810 farmers from selected villages. The different summer vegetables demonstrated were Kashi Ganga in bottle gourd (64.48 acre); Kashi Kanchan & Kashi Unnati in cowpea (53.25 acre); Kashi Kranti in okra (51.71 acre); All Green in palak (3.0 acre); Kashi Harit in pumpkin (21.25 acre) and Kashi Divya in sponge gourd (25.0 acre).

Further, nutritional security was another important initiative which was of prime concern looking after by ICAR-Indian Institute of Vegetable Research for which the institute had empowered rural households in general and women in particular for developing kitchen garden at door steps for dietary security of their family. During different cropping season 1950 kitchen garden packets consisting of small quantity of quality vegetable seeds developed by the institute were distributed among the rural households of the selected locale under this project. Apart, during Rabi 2015, efforts were made to mobilize the farmers from Dhanauta village in Mirzapur for seed production of pea cv Kashi Nandini. Here, one farmer actively participated in seed production programme and successfully produced about 10 qt of pea seeds. During Zaid also he wass engaged in seed production of Kashi Kanchan in cowpea and Kashi Kranti in okra.

During 2015-16, institute has organized 10 training programme/ gosthi for 1075 progressive vegetable growers along with exposure visit of more than 800 farmers to ICAR-IIVR, Varanasi during National Farmers Fair cum Vegetable Showcasing on

30th January 2016 from selected villages under the project. The main objective of these capacity building programmes was to improve the working competence and upgrade the knowledge and develop technical skills as well as to provide an opportunity of experiential learning, problem solving and interaction between experts and farmers.

Project 21: Tribal Sub-Plan (TSP) for Schedule Tribes of Sonbhadra district in Uttar Pradesh

To ensure proportionate flow of plan resources for the development of schedule tribes the strategy of TSP is in force by Government of India since 1979-80. In this context, ICAR-IIVR with a view to ensure livelihood and nutritional security in the tribal populated areas of Sonbhadra district of Uttar Pradesh initiated this project among 1000 tribal households during April 2013. During 2015-16, 06 training programme cum exposure visit were organized at Kota and Padrach Gram Panchyat along with ICAR-IIVR in which more than 650 tribals had participated. Considering the importance of nutritional garden in tribal region 1600 kitchen garden packets of vegetable seeds (tomato, brinjal, sponge gourd, okra, cowpea, dolichos bean and bottle gourd) were provided to 1000 tribal households in selected villages during kharif and zaid season after awareness cum training programme. Besides nutritional security, tribal farmwomen who were mostly involved in developing and maintaining kitchen garden for their family earned upto Rs. 2000 per month from sale of excess vegetables in the local market.

100 demonstrations of pea cv. Kashi Udai, 1000 demonstrations of wheat cv HUW 234, and 450 demonstrations of each urd cv. T-9, pigeon pea cv. Malviya Chamatkar and sesamum (til) cv. Shekhar were conducted in more than 250 ha area of tribal region at Chopan block of Sonbhadra district under TSP showed a significant increase in yield over traditional cultivars. This resulted in building confidence among tribals towards this institute and number of tribals not only producing seeds for replacement but also started sharing their experiences and constraints in crop production during the visit to monitor the demonstrations.

Project 22: ORP on Management of Sucking Pests in Horticultural Crops

Incidence of phytoplasma in brinjal: A Survey of little leaf disease in brinjal was conducted at IIVR farm and nearby areas during *kharif* season. Its incidence was 20.59 %. The leafhopper, a vector, was collected by using yellow sticky traps and got identified as *Hishimonus phycitis* from the Division of Entomology, IARI, Delhi (Figure 22-24).

Fig. 22: Brinjal Little Leaf

Fig. 23 : Yellow Sticky Trap

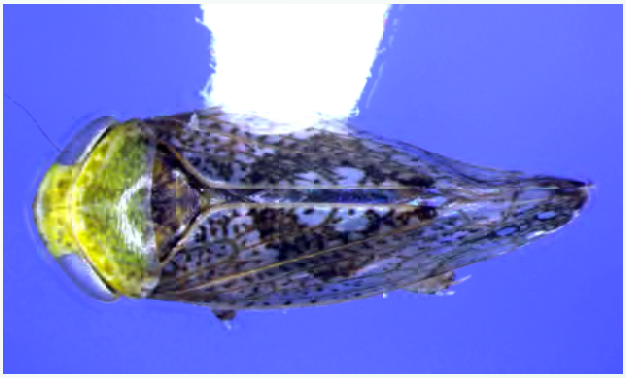


Fig. 24: Leaf Hopper *H. phycitis*

Isolation and characterization of phytoplasma in brinjal: Total nucleic acids were extracted from symptomatic and asymptomatic eggplants. The presence of phytoplasma was confirmed by PCR using universal primers (P1/P7). In Varanasi, eggplant phytoplasma shared maximum sequence identity with 16S rRNA sequence of the eggplant little leaf (EF186820, AF228052, X83431) belong to the 16SrVI clover proliferation group (Figure 25).

Transmission of brinjal phytoplasma through grafting and seed: The pathogenicity test of phytoplasma was determined by grafting into healthy eggplant plants (cv. Punjab Barsati). All the 50 grafted plants showed pale green coloured leaves in the beginning and size of leaves reduced drastically as the disease progressed. All flower buds were malformed to leaf like structure with incubation period of 20-25 days after grafting. Transmission by grafting reached 100% in eggplant graft unions. Results revealed that the phytoplasma was not seed borne in nature as seeds collected from diseased plants did not produce symptoms even up to 120 days after emergence. However, germination of seed from diseased fruits was lower (70%) than seeds from healthy fruits (90.0%).

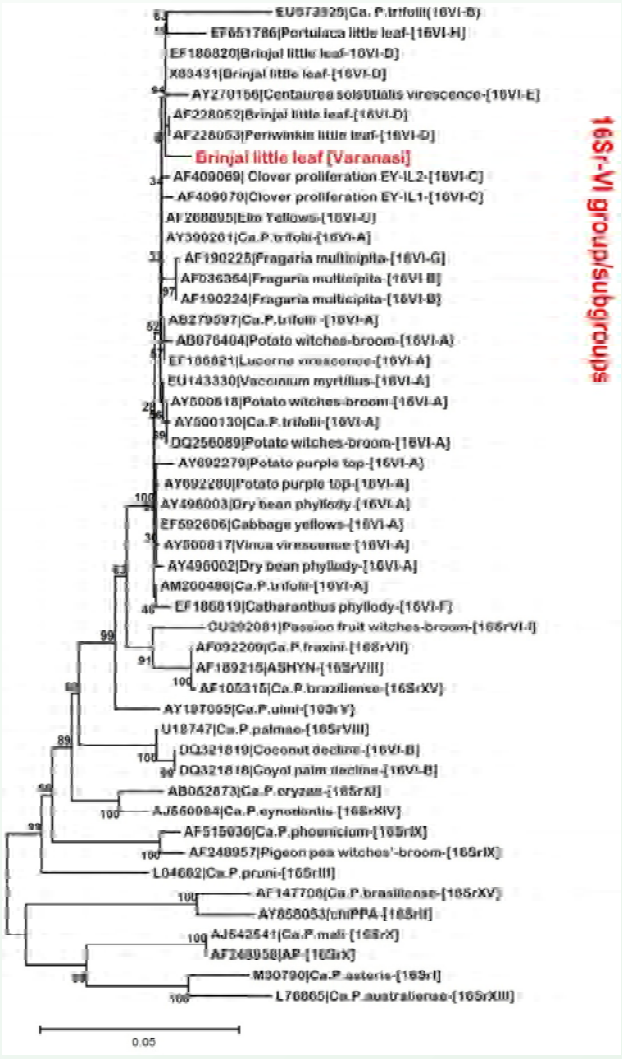
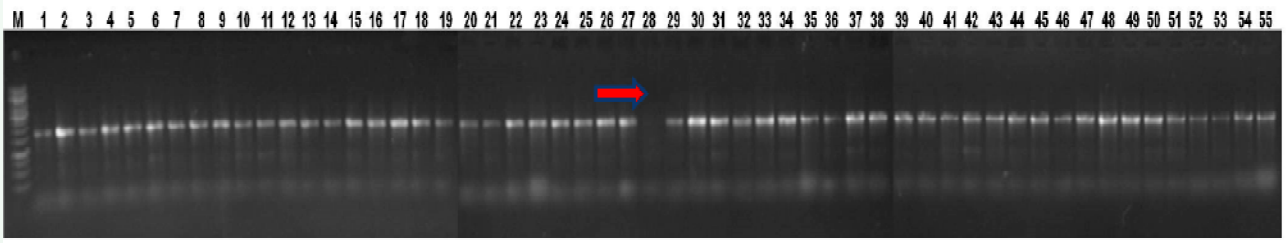


Fig. 25: Phylogenetic tree based on nucleiotide sequences of 16S rRNA gene from brinjal little leaf phytoplasma with other phytoplasma strains using Neighbor-joining algorithm. Horizontal distances are proportional to sequence distances, vertical distances are arbitrary. The trees are unrooted. A bootstrap analysis with 1000 replicates was performed

Identification of resistance sources to little leaf disease: Fifty five brinjal varieties/lines and 17 wild *Solanum* spp were screened against little leaf (Phytoplasma) under natural open field conditions during *Kharif* season. The incidence was recorded at weekly interval. Among, 55 brinjal varieties/lines screened, variety "Uttra" was completely immune to the disease and Pusa Ankur as resistant with 6.5 % incidence and other 12 varieties/lines viz., KKM 01, Azad Brinjal 4, CHBR 1, Rajendra Brinjal 9, BH 2, CHBR 2, Utkal Madhuri, Bhagyamati, Shobha, Arka Nidhi, CH 215 and Arka Keshav as moderately resistant. Remaining 37 and 4 varieties/lines were susceptible and highly susceptible, respectively. All the 17 wild Solanum lines were free from little leaf disease. During peak incidence of the disease,

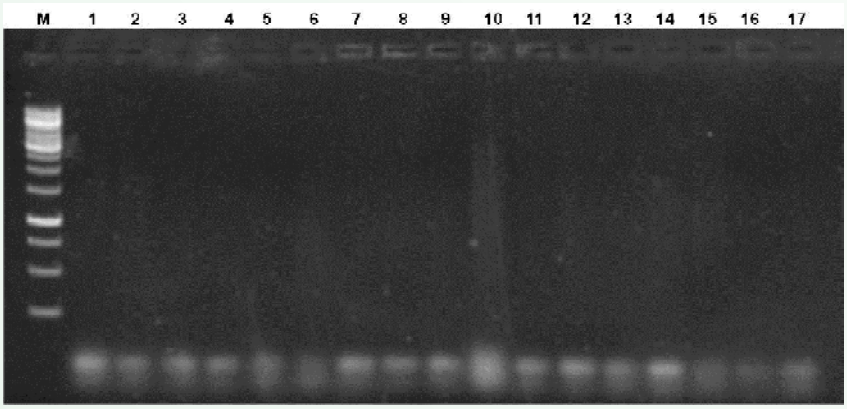
a.



M – 1kb marker; 1-55 – Brinjal Varieties

Marker 1 kb	1. P. Barasati	2. KKM 01	3. Kashi Prakash	4. Ivbl 22	5. Ajad Brinjal 3	6. Ajad Brinjal 1
7. Ajad Brinjal2	8. Ajad Brinjal4	9. PR 5	10. CHBR 1	11. R. Brinjal 9	12. Pusa Ankur	13. JB 9
14. Jb8	15. A. Neelkanth	16. Co2	17. A.Kranti	18. Jb 69	19. IBH 3	20. B h 2
21. Dbl 24	22. CHBR 2	23. Aruna	24. UttakalTarini	25. B r 14	26. Pusa Shymel	27. RS 356
28. **Uttra**	29. UtkalMadhuri	30. Bhagyamati	31. Pusa Uphar	32. Jb 6	33. Ks 339	34. B. Devariya
35. ABSR 2	36. RCMBL 02	37. Shobha	38. Adm 190	39. Pant Rituraj	40. RM Jaint	41. DBR 8
42. Dbr 31	43. Arka Nidhi	44. J. Brinjal	45. Ch 215	46. SLW	47. P.sadabahar	48. GULABI
49. S. Pratibha	50. Jb 67	51. A.Keshav	52. Co 11	53. Jb 2	54. PP Long	55. RCMBL 04-04

b.



M – 1kb Marker	1. *Solanum torvum*	2. *S. incanum*	3. ADM-117 *S. gilo*	4. ADM-183-*S. kashianum*	5. EC 790351 *S.laciniatum*
6. EC 790352 *S.sisymbifolium*	7. EC 790353 *S.aethiopicum*	8. EC 790354 *S.macrocarpum*	9. EC 790358 *S.anguivi*	10. EC 790360 *S.aethiopicum*	11. EC 790361 *S. aethiopicum*
12. EC 790363, *S. viarum*	13. Ysr 2015	14. EC 790365 *S.xathocarpum*	15. EC 790349 S. *sundatum*	16. EC 790359, *S.anguivi*	17. EC 790357 *S.aethiopicum*

Fig. 26: Amplification of 16S rRNA gene of little leaf phytoplasma infecting a. 55 brinjal varieties/lines and b. 17 wild *Solanum* spp.

symptomatic and asymptomatic samples of 55 brinjal varieties/lines and 17 wild *Solanum* spp. were collected for total nucleic acid extraction. The presence of phytoplasma in all the 55 brinjal varieties/lines was confirmed positive by PCR amplification of 16S rDNA region by using universal primers except in Uttra and 17 wild *Solanum* spp ((Figure 26 a & b).

Fig. 27: Uninfested Variety Uttra

Fig. 28: Field view of Uttra variety

Estimation of peroxidase, polyphenol oxidase and total phenol activity in the phytoplasm infected brinjal varieties/lines: Peroxidase, polyphenol oxidase and total phenol activity were estimated from healthy and phytoplasma infected leaf samples of 55 brinjal varieties/lines. In all the varieties/genotypes, the these biochemicals were significantly higher in the healthy plants than the phytoplasma infected plants (Figures 27 and 28). The maximum peroxidase activity in terms of of change in absorbance (g/min) was recorded in PR-5, Ajad Brinjal and Shobha with 1.8666, 1.838 and 1.8293g/min, respectively. The highest polyphenoloxidase activity in terms of change in absorbance (g/min) of 0.9450, 0.9277 and 0.9183 was observed in Azad Kranti, SLW and Pusa Syamal respectively. The maximum phenol content of 785.12, 655, 554, 515 and 512 (mg/100g) was recorded in JB-9, DBR-31, JB-2, BH2 and Aruna, respectively.

Transmission of *Okra enation leaf curl virus (OELCuV)* through grafting, vector and seed

Seed transmission: Mature seeds were collected from infected and healthy plants. The seeds were treated with 2% (v/v) sodium hypochlorite for 2 min and rinsed with water. Three sets of 25 seeds each from healthy and infected plants were sown in earthen pots, seperately (soil, sand, compost 2:1:2 w/w), kept in a glasshouse for 1 month and monitored for appearance of symptoms. The seedling grown from infected and healthy plant seeds were free from symptoms and without virus (confirmed by ELISA and PCR).

Grafting transmission: Naturally infected Okra plants were used for grafting. Twenty non-symptomatic okra plants were used as root stocks. Wedge grafting was carried out with scions from infected plant of the same variety (Azad Bhendi 1). The graft transmission efficiency was >90% with incubation period of 25-30 days for symptom expression.

Vector transmission: The relationship of OELCuV and its vector whitefly, *Bemisia tabaci* showed the transmission efficiency of 100% on okra plant (*cv.* Azad Bhendi 1). A minimum of two whiteflies per plants was effective for disease transmission (10%) showing disease symptoms after 10-12 days incubation period.

Acquisition Acess Period (AAP) and Inoculation Acess Period (IAP): Minimum AAP for vector was 1hr, prolonging the AAP from 1hr to 24 hr, increased the transmission efficiency from 20 to 100%. The minimum IAP was 30 minutes. The disease transmissibility increased with the increase in IAP from 30 minutes to 24 hr resulted in higher transmission frequencies up to 100%. The plants inoculated with non-viruliferous whiteflies did not show any symptoms.

Effect of age of seedling: The young seedling age up to 15 days were highly vulnerable to the virus as compared to 20, 25 and 30 days old plants.

Toxicity of neonicotinoids to different population of whitefly *B. tabaci*: Toxicity of imidacloprid 17.8 SL and thiamtehoxam 25 WG was established by leaf dip bioassay method against different population of whitefly collected from different sources. A susceptible whitefly population was reared on brinjal plants for 7-8 generation under insect proof net house and used as refernce for comparison of resistance levels in the field population. Whitefly from cucumber plants in open fields showed 30.50 and 26.72 fold resistance to imidacloprid and thiamethoxam with LC_{50} value of 0.00549 and 0.00481, respectively. The whitefly from Parsupur Village showed high level of resistance to thiamethoxam with 134.80 fold resistance as compared to imidacloprid with 5.88 fold resistance. The whitefly from nethouse or polyhouse showed 9.77 and 66.55 fold resistance to imidacloprid and thiamethoxam with LC_{50} value of 0.00176 and 0.01198, respectively.

Relative resistance of whitefly to neonicotinoid insecticides: The toxicity of imidacloprid 17.8 SL and thiamethoxam 25 WG evaluated was used to ascertain the shift in the susceptibility of whitefly to these insecticides over a period of five years (2010-2015). There was significant increase in the LC_{50} values of imidacloprid and thiamethoaxm from 7.60 to 54.90 and 8.60 to 48.10. The values of relative resistance worked out in the laboratory revealed that during last five years (2010-2015), the whitefly, *B. tabaci* in Varanasi area has developed 7.22 and 5.99 fold resistance to imidacloprid and thiamethoxam, respectively.

Detection of metabolic basis of insecticide resistance mechanism in whitefly *B. tabaci:* Activity of cytochrome P450 based monooxygenase and glutathione S- transferase involved in the metabolic basis of resistance mechanisms were analysed in whitefly collected from treated and untreated vegetable host plants. High level of cytochrome P450 based monooxygenase was observed in whiteflies from the insecticide treated plants indicating detoxification of insecticides and imparting resistance in the whitefly to these insecticides. A significant variation was also observed in the activity of monooxygenase in whiteflies collected from the different host plants. In contrast the glutathione S-transferase level was high in the whiteflies collected from untreated plants as compared to the whiteflies collected from the treated plants.

Susceptibility of whitefly *B. tabaci* to and newer insecticides: Two populations of whitefly (open field

& laboratory susceptible population) were evaluated for their susceptibility to flupyridifurone 200 SL, cyantraniliprole 10 OD, spiromesifen 22.9 SC, sulfoxaflor 24 SC, flonicamid 50 WG and spirotetramate 150 OD and neonicotionoid insecticides, imidacloprid 17.8 SL, imidacloprid 30.5 SC, thiamethoxam 25 WG, acetamiprid 20 SP, thiacloprid, OP insecticides, quinalphos 25 EC and chlorpyriphos 20 EC, synthetic pyrethroids, cypermethrin 25 EC by leaf dip bioassay method. The whitefly collected from field was less susceptible to neonicotinoid and conventional insecticides with lower mortality compared to laboratory population. Flupyridifurone, cyantraniliprole, sulfoxaflor, flonicamid and spirotetramat were effective against field collected whitefly with higher mortality of 78.89, 87.92, 96.30,100 and 100%, respectively as compared to neonicotinoid and conventional insecticides (Figure 29).

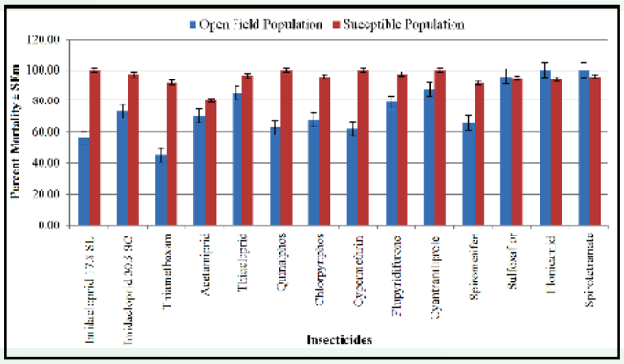


Fig. 29: Effect of neonicotinoid and newer insecticides against different populations of whitefly

Baseline toxicity of insecticides to okra leafhopper *Amrasca biguttula biguttula*: Toxicity of neonicotinoid and OP insecticides was evaluated against okra leaf hopper by whole petiole leaf dip bioassay method. The imidacloprid 17.8 SL was most toxic and quinolphos was least toxic. Based on LC_{50} values, the descending order of toxicity of insecticides was imidacloprid 17.8 SL> imidacloprid 30.5 SC> imidacloprid 70 WG> thiamethoxam > dimethoate > acetamiprid > chorpyriphos > quinalphos. High level of tolerance was observed to neonicotinoid insecticides thiamethoxam, acetamiprid and OP insecticides dimethoate, chlorpyriphos and quinalphos with LC_{50} values of 99.33, 167.20, 152.1, 1043.30 and 1013 ppm, respectively.

Relative resistance of okra leafhopper *A. biguttula biguttula* to neonicotinoid insecticides: The relative resistance worked out for okra leafhopper to neonicotinoid insecticides indicates development of resistance in *A. biguttula biguttula* to imidacloprid, thiamethoxam and dimethoate with 1.85, 8.63 and 1.0 fold resistance, respectively. Over a period of two years (2013-2015) there was significant increase in the LC_{50} values of imidacloprid 17.8 SL, imidacloprid 70 WG, thiamethoaxm and dimethoate from 6.53 to 12.10, 60.10 to 71.90, 11.50 to 99.33 and 151.80 to 152.1, respectively.

Bionomics and host-mediated interaction(s) of mealybugs and its potential natural enemies: Among two mealy bug species, *Phenacoccus solenopsis* and *Centrococcus insolitus* noted infesting major vegetables during March to December, 2015, *P. solenopsis* was dominant infesting several vegetable crop brinjal, capsicum and okra. It was observed almost thorough out the year on one or other vegetable crops available in the region except during peak summer season (May – June). In brinjal, this mealy bug existed from March to April, in okra from August – September, in capsicum during March - April. During peak summer (May-June) its incidence was restricted to weeds particularly *Parthenium hysterophorus* and *Vernonia* sp. associated with many vegetables. In brinjal, another mealy bug species *C. insolitus* was also recorded during September - December.

Potential natural enemies of Mealy bugs: *Aenasius arizonensis* as nymphal endoparasitoid of *Phenacoccus solenopsis* was recorded. Besides, polyphagous predators like green lace wing, *Chrysoperla zastrowi sillemi* and lady bird beetle, *Coccinella septempunctata* and *Menochiles sexmaculatus* were also found feeding on this soft-bodied invasive pest.

Host mediated interactions: Tritrophic interaction (Host plant – *P. solenopsis* – parasitoid) was observed during the recovery of the parasitoids from different hosts. The highest parasitization was obtained from okra (35.25%) followed by capsicum (28.07%) and the lowest from eggplant (13.56%) (Figure 30).

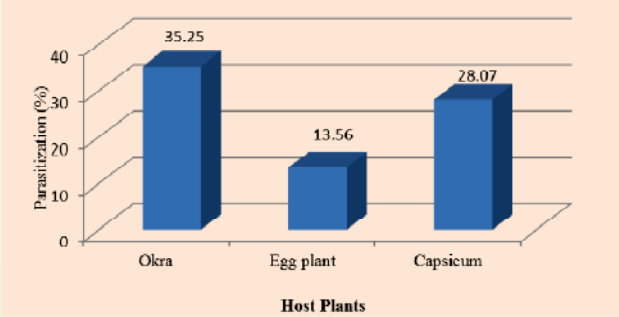


Fig. 30: Host preference of *A. arizonensis* parasitoid of *P. solenopsis* on different vegetables

Laboratory evaluation of *Isaria farinosa* on mealy bug, *Phenococcus solenopsis*: Among different conidial concentrations of *I. farinosa* isolate, the conidial suspension at 1×10^8 conidia/ml caused maximum of 78.92 and 81.14% mortality of 3rd instar mealybug after

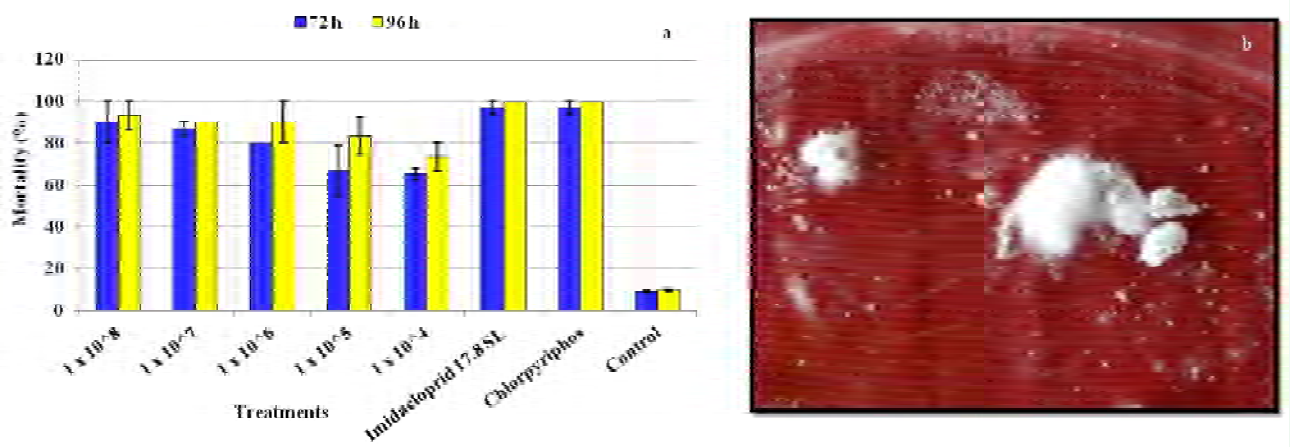


Fig. 31: a. Efficacy of *Isaria farinosa* on mealy bug **b. Infection of mealy bug with *I. farinosa***

72h and 96h, respectively, which were comparable to Imidacloprid 17.8 SL and chlorpyriphos 30 EC causing 83.85 and 90% mortality (Figure 31 a & b).

Project 23: NICRA Project on Real Time Pest Dynamics in Tomato Crop

Real time pest surveillance was undertaken in tomato crop at IIVR main centre and ten fixed farmer fields covering Varanasi and Mirzapur districts during Kharif and Rabi season. Real time data on insect pest and disease incidence was recorded for 19 weeks (from 37 to 2rd standard weeks) and 15 weeks (45 to 6th standard weeks) for Kharif and Rabi seasons, respectively under protected and unprotected conditions at IIVR main center. 14 weeks (from 45th to 5th standard weeks) pest observations were recorded in fixed farmers field. Daily weather parameters were also recorded. The data so collected at main centre were uploaded to the NICRA client software and the uploading of farmers field and weather data is under progress.

***Kharif* Season:** Tospovirus disease in the Varanasi region was a major disease during *kharif* season at main centre. In the main field, its incidence was severe in both protected and unprotected conditions with 15.05 and 19.05%. The Tospovirus incidence started increasing from 43rd SMW onwards with a higher infection during 3rd standard week in both protected and unprotected plots. The unusual severe incidence of Tospo virus may be due to long dry spell and high temperatures (>35 °C) from 37 standard weeks onwards. The viral diseases like leaf curl (10.84%) and mosaic (6.31%) incidence were also observed which was slightly lesser in protected condition than that of unprotected condition where they registered 14.84 and 8.42%, respectively. The average incidence of early blight was 9.42% in unprotected condition and 6.44% protected condition. The peak infestation (14%) of disease was recorded during 45 standard weeks. Similarly, the bacterial spot incidence was also higher (18%) during same SMW. The overall incidence of bacterial spot was relatively low (5.76%) in protected as compared to unprotected conditions (10.5%). The unprecedented rainfall (4 mm) and higher humidity (95%) during 44th standard weeks might have contributed in the higher incidence of early blight and bacterial spot diseases. Among insect pests, aphid (3.23/spot) and whitefly (2.67/spot) were major sucking in protected fields, whereas in unprotected fields the average number was slightly higher with 4.65/spot and 3.63/spot, respectively (Figure 32 & 33).

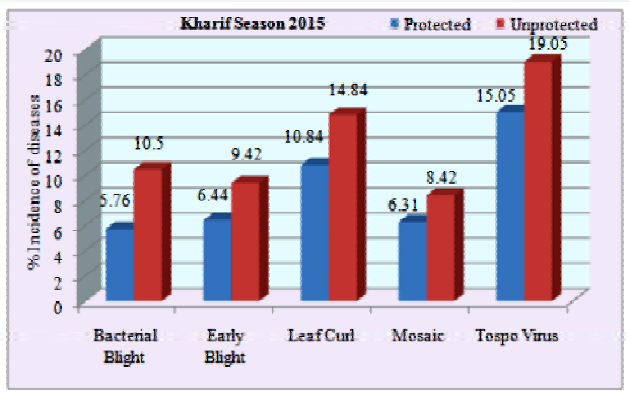


Fig. 32: Incidence of tomato diseases during *Kharif* season

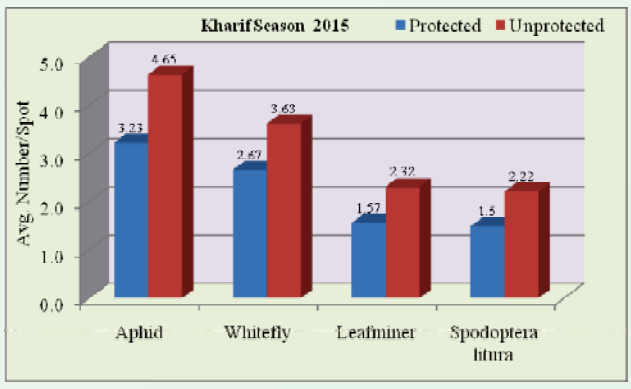


Fig. 33 : Incidence of major insect pests of tomato during *Kharif* season

***Rabi* Season:** The incidence of Tospo virus was observed in both the protected and unprotected fields with 10.26 and 19.06%, respectively. Occurrence of the viral disease was recorded from the initial stage of the crop, 46 standards onwards. Variation in the incidence of disease was observed in the protected field due to application of insecticides for the management of insect vector. There was a significant increase in the Tospovirus infestation ranging between 12-38% in unprotected plots. This may be due to favorable weather conditions like temperature and high RH (76-98%) during the cropping season. The incidence of leaf curl and mosaic diseases was almost same as that of *kharif*, in both protected (9.2 and 6.8%) and unprotected (15.2 and 7.12%) conditions. Early blight disease was observed under field condition in protected and unprotected conditions, with incidence of 12.75 % and 17.29 %, respectively. Bacterial spot incidence in main field was negligible as compared to *kharif* season. The infestation of aphids was similar to that of *kharif* season with 3.17/spot and 3.82/spot in protected and unprotected fields. In case of whitefly population was relatively on higher in unprotected field (2.74/spot) as compared to protected field (1.93/spot), indicating higher incidences of leaf curl, mosaic and tospo virus (Figure 34-42). The incidence of leaf miner was comparatively high during *Rabi* season.

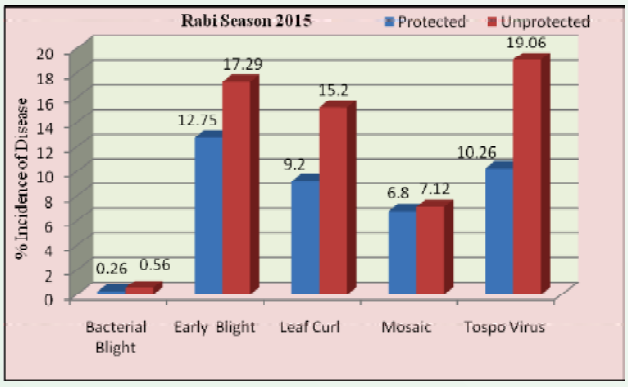


Fig. 34: Incidence of tomato diseases during *Rabi* season

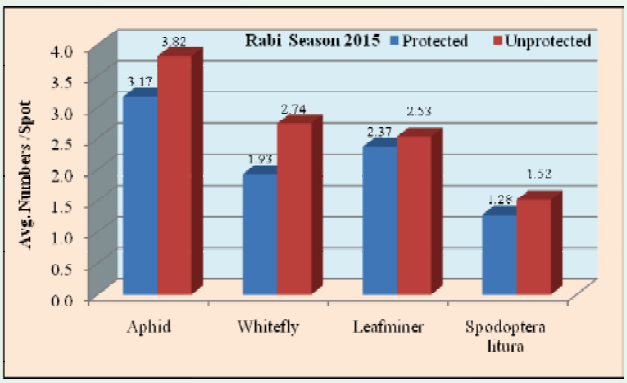


Fig. 35 : Incidence of major insect pests of tomato during *Rabi* season

Fig. 36: *Tospovirus* infected plant

Fig. 37: Necrosis on young shoots and leaf

Fig. 38: Necrosis on flower buds

Fig. 39: Necrosis on stem and petiole

Fig. 40: Island symptom on leaf

Fig. 41: Field view of Tospovirus infected tomato plants

Fig. 42: Visit of Research Fellow from NCIPM

Pheromone trap catches of *Helicoverpa armigera* and *Spodoptera litura*: Sex pheromone traps were installed to monitor the incidence of *H. armigera* and *S.litura* at IIVR farm. There was a large fluctuation in the trap catches with high number of catches for *S. litura* compared to *H. armigera*. Maximum trap catches of *S. litura* (99/trap) was recorded during 15-17 and 21 standard weeks, followed by 68/trap in 42 standard week. The trap catches clearly indicates the peak incidence of *S. litura* during April-May and October month. Similar, trend was also observed in the case of *H. armigera* with two peaks, one during 15 and second in 39 standard week with maximum trap catch of 29 and 35/trap, respectively (Figure 43).

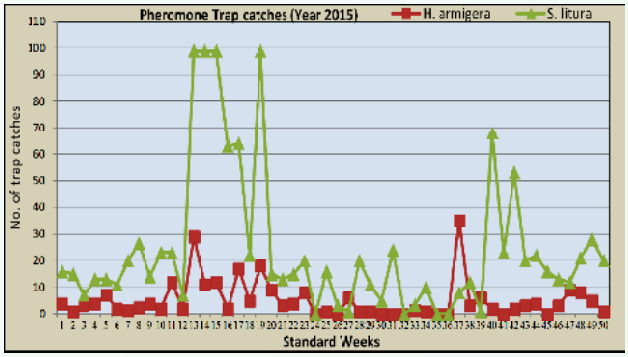


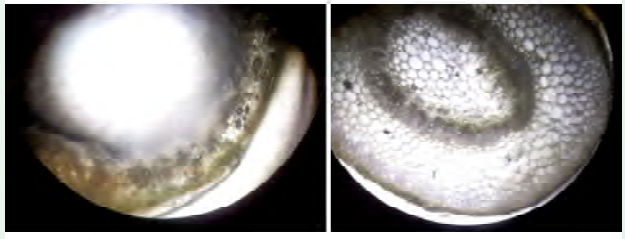
Fig. 43: Pheromone trap catches

Project 24: CRP on Insect Borers

Dynamics of borer species, damage symptoms/severity and natural enemies

Incidence of *Leucinodes orbonalis* in brinjal in nursery: Serious incidence of *L. orbonalis* was noted during August-September in nursery, causing maximum of 37.16% seedling damage during September 1st week. The gravid female showed preference for egg laying mostly towards the junction of apical leaves with seedling stem thickness of 1.78±0.13 mm. On damaged stem, larvae fed the cells from pith (parenchyma) and vascular bundles leaving only the epidermal and hypodermal cells. The neonate larvae after entering stem, move downwards towards basal portion of the plant which gradually become thicker, perhaps to supplement the food requirements of late instar larvae. Most of the affected plants (97.5%) harbored single larva as against only 2.5% seedlings with >1 larvae.

Affected nursery | Affected seedling



Histology: Damaged stem | Healthy stem

Species composition and successive incidence of okra shoot and fruit borer: Two spotted boll worm species *Earias vittella* and *E. insulna* are known pests, causing serious damage in *Kharif* okra. To elucidate its composition and frequency of occurrence, larvae collected periodically from infested shoots and fruits were reared till adult emergence and the species differentiated by the wing colour. Both the species coexisted during cropping season (Figure 44) However, *E. vittella* was dominant during vegetative and early reproductive phase of the crop (>85% *E. vittella* & <10% *E. insulana*), thereafter *E. insulana* gradually increased and the former species declined in later crop phase. During the end of cropping season (October last week), the composition of *E. insulana* was the highest (72.75%) as against 27.25% of *E. vittella*.

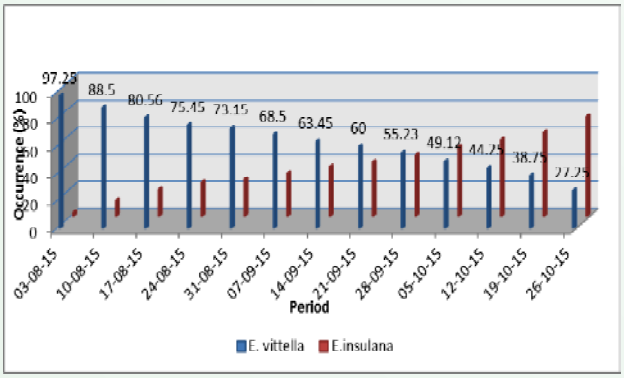


Fig. 44: Species composition of okra shoot and fruit borer

Seasonal incidence of *Earias* spp. and its parasitoids: In summer okra, infestation started from April last week as shoot borer (0.82%) and gradually increased to a maximum of 36.73% as shoot and fruit borer damage during Jul 1st week. In *Kharif* okra, the highest fruit damage noted during the Sept 3rd week (54.68%) followed by October 1st week (49.23%) (Figure 45). The cumulative parasitism of two braconid parasitoids, *Chelonus blackburni* an egg-larval parasitoid and *Agathis* sp., a larval endo-parasitoid were more in *Kharif* okra (August-October) with maximum of 30% parasitization during September 1st week than that of summer okra with maximum of 14.3% parasitization during Jun 2nd week (Figure 46).

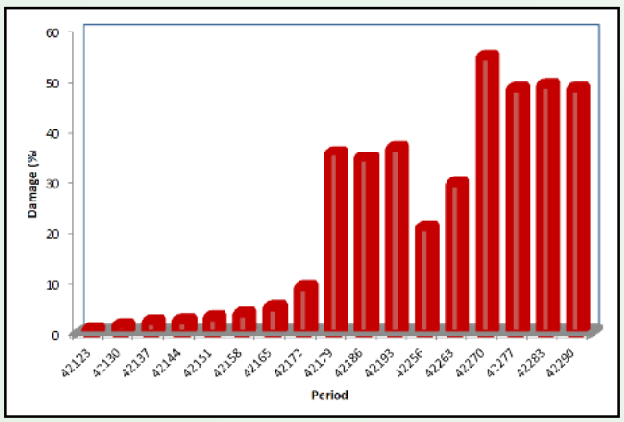


Fig. 45: Seasonal incidence of *Earias* spp.

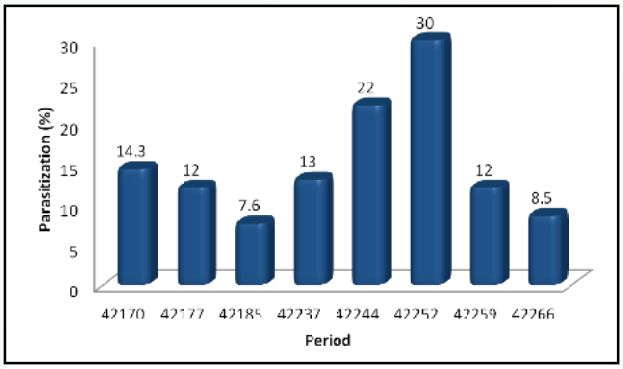


Fig. 46: Seasonal incidence of endoparasitoids of *Earias* spp.

Record of Hollyhock as an alternate host of *E. vittella*: The ornamental plant hollyhocks grown/available during November to March were severely damaged showing appearance of 'dead-heart' of central shoot. Black excreta was often visible as peeping out of a nodal portion of the plant (Figure 47 a & b). On an average 25.57% plants were affected during December last week. Shoot damage was 5.75% at the beginning of a cropping season (November last week) with a peak

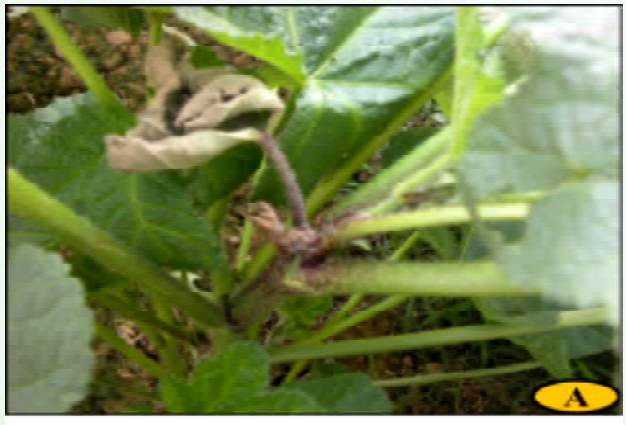
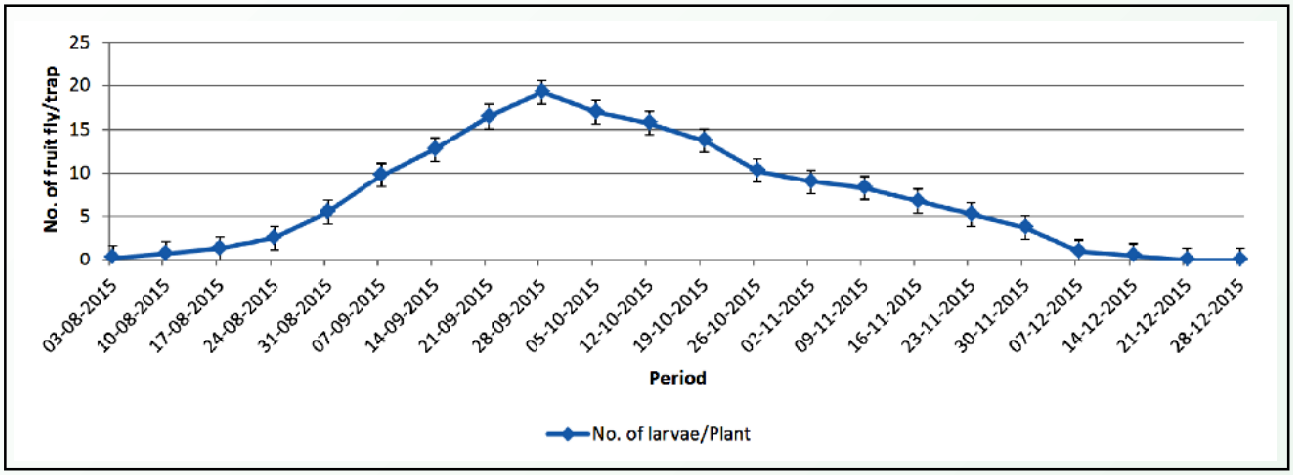


Fig. 47a: Dead heart in hollyhock

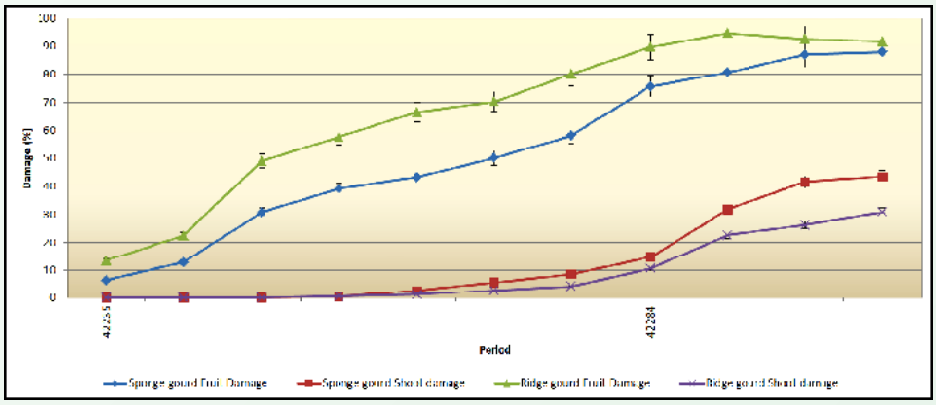
Fig. 47b: larva and its excreta peeping out from central shoot



during January 3rd week (32.54%). Thereafter, it declined during Feburary 2nd week (4.46%). These three successive malvaceous crop (summer okra–*Kharif* okra–hollyhock) provides a year round host availability for this pest. A single larva was able to kill the entire plant of hollyhock.

Incidence of cucumber moth, *Diaphania indica* on bitter gourd in the farmers' field: It is a sporadic pest of bitter gourd. Caterpillars scrap the chlorophyll portion of the leaves by webbing them together and also bore into fruits. Its incidence started from the August 1st week exhibiting peak during September last week (19.25 larvae/plant), thereafter it declined gradually, with no incidence from the December 2nd week onwards.

Incidence of new emerging melon weevil in gourd crops: This weevil was observed to infest sponge gourd and ridge gourd. Adult Infestation on fruits resulted in oozing out of whitish secretions, later it turned to brown gummy encrustation on the fruits. Adults emerge from the dry fruits after making small emergence hole. This weevil also bores into the vines resulting in the gradual drying of vines bearing tender fruits, flowers and flower buds. In sponge and ridge gourds, fruit damage started from August 3rd week and gradually increased with maximum of 87.93 and 91.67% fruit damage, respectively, during October last week. The highest vine damage in sponge (43.51%) and ridge gourd (30.87%) were noted during October last week when both the crops were at physiological maturity. The maximum fruit damage was recorded on ridge gourd (91.67%) and highest shoot damage on sponge gourd (43.51%). Its incidence was nil from November onwards coinciding with onset of winter.



Seasonal incidence of *Trathala flavo-orbitalis*, an endoparasitoid of *Leucinodes orbinalis*: The incidence of *Trathala* a larval-endoparasitoid was noted from 31st SMW (August 1st week) with highest parasitization (18.59%) during 41st SMW (October 2nd week) onwards and continued till 12th SMW (March 3rd week). Its activity reduced during December–January coinciding with severe winter (Figure 48). It pupates outside the host insect as whitish silken cocoon. The pupal periods last for 4-7 days.

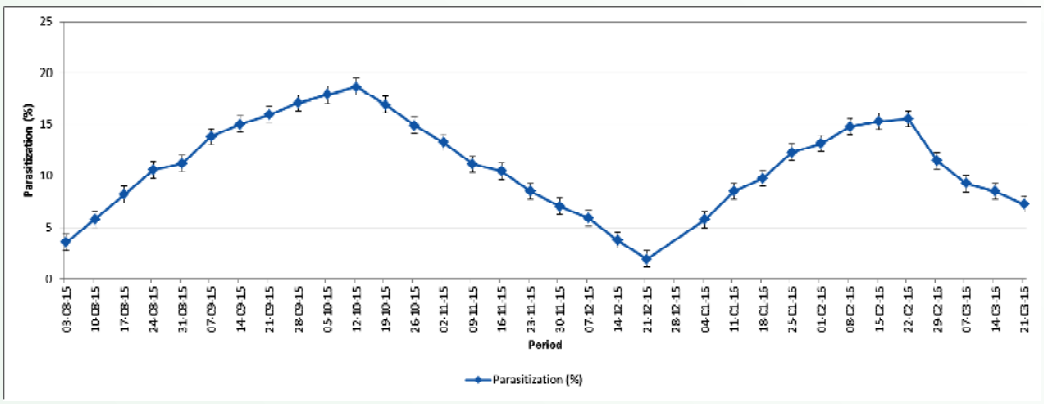


Fig. 48: Seasonal incidence of *Trathala flavo-orbitalis*

II. Identification of effective bipestcides and newer molecules against borer pests

Laboratory evaluation of *Isaria farinosa* against BFSB: One ml of entomopathogenic fungal suspension @ 1×10^8, 1×10^7, 1×10^6, 1×10^5, 1×10^4 conidia/ml along with check treatment and control, containing 0.02% Tween 20 was sprayed using Potter's tower (at 340 g cm^2 pressure) in a petri dish containing ten 3rd instar larvae, replicated thrice and incubated at 28±1 °C. The mortality was recorded at 48, 72 and 96 hrs after treatment and corrected mortality worked out. The data after arcsine-transformation were subjected to one-way ANOVA. The *I. farinosa* @1 × 10^8 conidia ml^{-1} was most toxic, causing 49.31% mortality after 48h which was 84.95 and 23.78% higher than cypermethrin and chlorpyriphos, respectively (Table 15).

Bioefficacy of entomopathogens and botanicals against melon weevil: Amongst different biopesticides, neem oil 1% registered the lowest median lethal time (64.94 h). Among three entomopathogenic fungi, *L. lecanii* was most effective (LT_{50}-87.84 h) followed by *M. anisopliae* IIVR strain (LT_{50}-101.08 h). When these EPF combined seperately with neem oil at 1:1 ratio (half recommended dose), *L. lecanii* + neem oil showed compatibility and synergistic action against melon weevil as evidenced by lowest LT_{50} value 63.78 h. However, *M. anisopliae* and *B. bassiana* showed moderate activity. *B. thuringiensis* and *B. subtilis*-2 were ineffective (Table 16).

Table 15: Effects of different inoculum concentrations of *Isaria farinosa* on percent mortality of *L. orbonalis* larvae

Treatments	Mortality (%) after								
	48h			72h			96h		
T1. $1X10^8$ conidia/ml	49.31[a]	±	0.83	50.76[a]	±	0.00	53.76[a]	±	1.73
T2. $1X10^7$ conidia/ml	34.66[b]	±	2.66	46.44[a]	±	2.49	51.14[a]	±	6.98
T3. $1X10^6$ conidia/ml	33.21[b]	±	0.00	45.00[a]	±	3.33	47.90[a]	±	3.34
T4. $1X10^5$ conidia/ml	33.00[b]	±	3.65	45.00[a]	±	3.33	46.46[a]	±	4.18
T5. $1X10^4$ conidia/ml	31.48[b]	±	2.80	41.16[a]	±	0.96	45.00[a]	±	3.33
T6.Cypermethrin 25EC (0.0125%)	26.56[b]	±	0.00	39.23[a]	±	0.00	45.00[a]	±	3.33
T7.Chlorpyriphos 20 EC (2 ml/l)	33.00[b]	±	3.65	51.14[a]	±	6.98	62.00[a]	±	14.88
SEm ±	2.47			3.59			7.28		
CD (P<0.05)	8.54			12.42			25.18		

The means within columns followed by the same small letter do not differ significantly (P<0.05), The value is Arcsine-transformed with standard deviation

Table 16: Efficacy of entomopathogens alone and with neem oil (1:1) against melon weevil

Biopesticides	Heterogenity		Regression Equation	LT_{50} (hr)	Fiducial Limit
	df	χ^2			
M. anisopliae IIVR strain	7	3.155	Y= 3.878X – 2.774	101.08	111.31 – 91.80
B. bassiana IIVR strain	8	8.064	Y= 4.102X – 3.700	132.05	148.30 – 117.58
Lecanicillium lecanii	6	9.563	Y= 5.720X – 6.112	87.84	94.36 – 81.76
Neem oil (1%)	6	8.952	Y= 2.444X + 0.569	64.94	77.35 – 54.53
M. anisopliae IIVR strain + Neem oil	7	3.157	Y= 4.949X – 5.133	111.55	125.51 – 99.14
B. bassiana IIVR strain + Neem oil	6	3.033	8.043X – 11.342	107.60	116.11 – 99.71
L. lecanii + Neem oil	6	3.736	3.308X – 0.969	63.78	76.30 – 53.31

Table 17: Effect of different entomopathogens alone and their 1:1 combination with neem oil against okra shoot and fruit borer

Sl. No	Treatments	Av. shoot damage (%)			Av. fruit damage (%)			NEs/plant	
		Before	After*	PPOC	Before	After*	PPOC	Spider	LBB
T1	*B. bassiana* IIVR strain 5g	40.78	28.51	46.84	37.86	26.68	44.93	2.89	1.11
T2	*Bt* 2.5 g	46.96	23.25	56.65	37.55	23.79	50.90	2.77	1.09
T3	*M. anisopliae* IIVR strain 5g	48.48	30.98	42.22	42.64	30.67	36.70	3.04	1.23
T4	*L. lecanii* 5 g	35.92	29.77	44.49	40.29	25.81	46.73	3.11	1.29
T5	*B. subtilis* 2.5 g	40.37	33.49	37.55	38.54	29.40	39.32	2.69	1.16
T6	Neem oil 1%	41.04	29.35	45.27	39.41	34.28	29.25	1.87	0.93
T7	T1 + T6 (1:1 Ratio)	44.44	28.85	46.20	41.26	27.30	43.65	2.46	1.21
T8	T2 + T6 (1:1 Ratio)	35.86	38.78	27.69	41.95	36.65	24.36	2.53	1.09
T9	T3 + T6 (1:1 Ratio)	32.05	25.49	52.47	37.28	25.74	46.87	2.41	1.32
T10	T4 + T6 (1:1 Ratio)	47.65	25.48	52.49	37.76	27.28	43.69	2.66	1.24
T11	T5 + T6 (1:1 Ratio)	39.49	38.81	27.63	39.97	32.51	32.90	2.73	0.98
T12	Cypermethrin 0.75 ml/l	46.09	21.35	60.19	38.50	24.85	48.71	0.84	0.39
T13	Untreated control	44.61	53.63	--	38.54	48.45	--	3.14	1.43
	CD (5%)	1.89	1.41	--	1.04	1.78	--	0.17	0.09

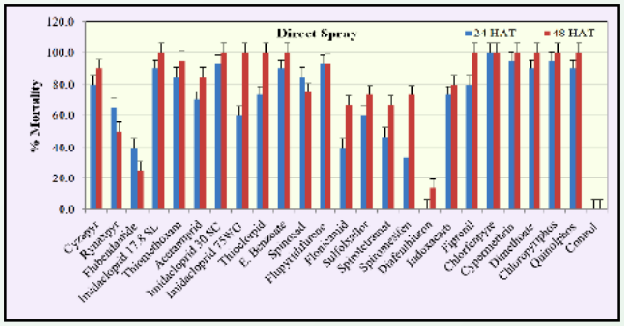
PPOC: Percent protection over control; Round of spray: 3 at 10 days interval; NEs: natural enemies; * Pooled average of each of five observations (1,3,5,7,10 days) after three sprays

Field evaluation of entomopathogens and botanicals against okra shoot & fruit borer: Among *B. bassiana* IIVR strain, *M. anisopliae* IIVR strain, *L. lecanii*, *B. thuringiensis* var Kurstaki, *B. subtilis*-2 IIVR strain and neem oil alone and in combination with neem oil at 1:1 ratio, *Bt* 2.5 g/l registered the lowest shoot (56.64%) and fruit damage (50.90%) followed by *M.anisopliae* IIVR strain 2.5 g/l + 0.5% Neem oil with 52.47 and 46.87% shoot and fruit damage, respectively. The maximum spider population (3.04/plant) was recorded in *M. anisopliae* IIVR strain @ 5 g/l and lady bird beetle population (1.32/ plant) in *M. anisopliae* IIVR strain 2.5 g/l + Neem oil (0.5%) (Table 17).

Laboratory evaluation of certain insecticides to sponge gourd weevil: 24 insecticides of different groups were tested at recommended dose, following direct spray as well as film residue methods. All insecticides were effective against weevil in direct spray method except diafenthiuron and flubendamide. Variation in the mortality was observed in film residue method. Only CNI and OP compounds were effective.

III. Insecticide Resistance Management (IRM)

Baseline toxicity of diamide insecticides against BSFB: Susceptibility of 3rd instar larvae of *L. orbonalis* was evaluated against diamide insecticides by fruit dip and direct spray bioassay methods. Cyantraniliprole was most toxic with very low LC_{50} values of 0.35 and 1.3 ppm at 48 HAT when tested by fruit dip and direct spray methods, respectively. In fruit dip assays the toxin requirement was less as compared to direct spray method. The descending order of toxicity of diamide insecticides was cyantraniliprole> chorantraniliprole> flubendiamide (Table 18 & Figure 49).



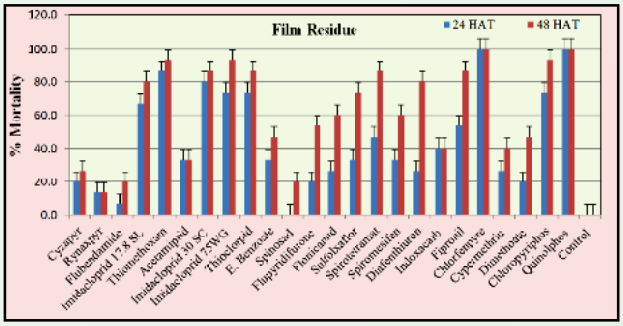


Table 18: Dose mortality response of *L. orbonalis* to diamide insecticides

Insecticides	HAT	df	χ2	Slope± SE	% LC_{50}	95 % FL	% LC_{90}	95 % FL
Fruit Dip Bioassay Method								
Cyantraniliprole	24	4	5.55	1.37 ± 0.040	0.000084	0.000069- 0.000100	0.00072	0.00050-0.00102
	48	4	1.31	0.941± 0.061	0.000035	0.000026-0.000046	0.00080	0.000344-0.00186
Chlorantraniliprole	24	3	0.66	1.27 ± 0.046	0.000291	0.000236-0.00036	0.00292	0.000692-0.01240
	48	3	2.13	0.95 ± 0.062	0.000139	0.000105-0.00018	0.00321	0.000551-0.01871
Flubendamide	24	5	6.40	1.13 ± 0.045	0.001731	0.00141-0.00212	0.00234	0.01338-0.04114
	48	5	4.93	1.12 ±0.045	0.001037	0.000844-0.00127	0.01432	0.08801-0.023303
Direct Spray Bioassay Method								
Cyantraniliprole	24	4	5.14	1.10 ± 0.048	0.000172	0.000138-0.000213	0.00247	0.00098-0.00616
	48	4	3.73	1.02 ± 0.054	0.000130	0.000102-0.000166	0.002337	0.000981-0.005567
Chlorantraniliprole	24	5	2.16	0.90 ± 0.055	0.000986	0.000768-0.00126	0.0025475	0.00720-0.090117
	48	5	1.88	1.16 ± 0.049	0.000372	0.000297-0.000464	0.004665	0.00367-0.00597
Flubendamide	24	4	4.12	1.05± 0.050	0.00640	0.00508-0.00805	0.10578	0.033972-0.32941
	48	4	2.53	1.18±0.046	0.004625	0.003748-0.00571	0.05635	0.031063-0.10225

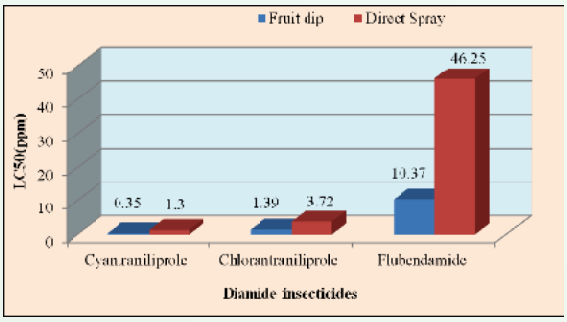


Fig. 49: Effect of bioassay methods on LC_{50} value of diamide insecticides against *L. orbonalis*

Shift in susceptibility and relative resistance of *L. orbonalis* to different diamide insecticides: The toxicity of diamide insecticides was used to ascertain shift in the susceptibility of *L. orbonalis* over a period of time (2013-2015). There was an increase in the LC_{50} values of cyantraniliprole, chlorantraniliprole and flubendiamide from 0.62 to 0.85; 1.8 to 2.91 and 11.2 to 17.31, respectively. The BSFB has developed 1.37, 1.61 and 1.54 fold resistance to cyantraniliprole, chlorantraniliprole and flubendiamide, respectively (Figure 50 & Table 19).

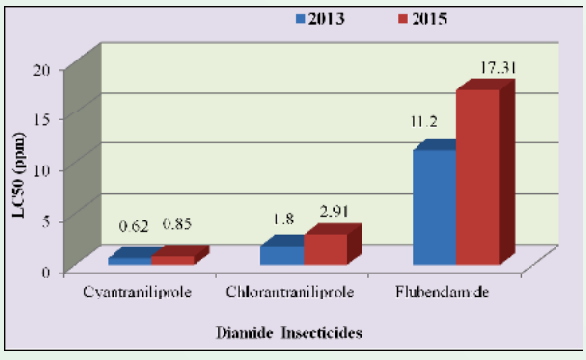


Fig. 50: Shift in LC_{50} value of different diamide insecticides against *L. orbonalis*

Table 19 : Relative resistance of *L. orbonalis* to diamide insecticides

Diamide Insecticides	LC_{50} value (ppm) worked out during		Relative Resistance
	2013*	2015	
Cyantraniliprole	0.62	0.85	1.37
Chlorantraniliprole	1.8	2.91	1.61
Flubendamide	11.2	17.31	1.54

Relative Resistance = LC_{50} value in 2015/LC_{50} value in 2013; *IIVR, Annual Report 2013-14 and Kodandaram *et al.*, 2015

Laboratory efficacy of diamides insecticides against BSFB, *L. orbonalis:* Cyantraniliprole 10 OD at three doses along with other two diamide insecticides at recommended doses were evaluated against 2nd and 3rd instar larvae by fruit dip and direct spray assays. Cyantraniliprole @ 90 g a.i./ha was most effective to 2nd and 3rd instar larvae with 98.33 and 85.39 % mortality in fruit dip method and 86.67 and 100% mortality, respectively in direct spray method, However, it was comparable with other doses of cyantraniliprole and other diamides.

Efficacy of diamide insecticides and development of resistance in *L. orbonalis*: A field efficacy of diamide insecticides was evaluated against BSFB during *kharif* season in brinjal (cv. Kashi Taru). Cyantraniliprole was most effective with 97.58 and 78.30 % reduction in shoot and fruit damage, respectively followed by Spinosad. Highest marketable fruit yield was obtained in cyantraniliprole and spinosad treatment. The Native PAGE analysis of larvae indicated less / no expression of total esterase enzyme in flubendiamide (T3), and spinosad (T5), indicating comperatively less/no development of resistance thereby showing the effectiveness. However, in cyantraniliprole treatment enzyme expression was little higher than the above two treatments (Table 20).

Table 20: Field bioefficacay of diamaide insecticides on BSFB and yield in brinjal

Treatment Details	Dose (ml/l)	Shoot Damage (%)		Fruit Damage (%)		Yield (q/ha)	
		Avg	PPOC	Avg.	PPOC	Avg.	PIOC
Cyantraniliprole 10 OD	1.8	1.12	97.58	9.73	78.30	251.87	179.43
Chlorantraniliprole 18.5 SC	0.4	1.56	96.63	12.88	71.27	195.76	117.18
Flubendamide 40 SC	0.5	3.21	93.06	32.09	28.41	166.16	84.34
E. Benzoate 25 WG.	0.3	4.12	91.08	23.48	47.63	126.70	40.57
Spinosad 2.5 SC	1.5	2.56	94.45	11.90	73.45	199.32	121.13
Dimethoate 30 EC	2	17.32	62.49	42.22	5.82	104.83	16.30
Cypermethrin 25 EC	0.5	52.55	-13.80	40.20	10.33	100.85	-11.89
Control		46.18		44.83		90.14	
CD(P=**0.05**)		2.61		2.17		-	

DOT: 10.8.2015; Plot size: 3.5x 3.8 m; Round of applicaton: 5 at 15 days interval starting from initiation of infestation.

To know esterase enzyme pattern in *L. orbonalis*, larvae were collected from different plots treated with insecticides. The Native PAGE analysis of *L. orbonalis* larvae indicated less /no expression of esterase enzyme in cyantraniliprole (T1), flubendiamide (T3), and spinosad (T5) indicating the effectiveness of treatments (Figure 51).

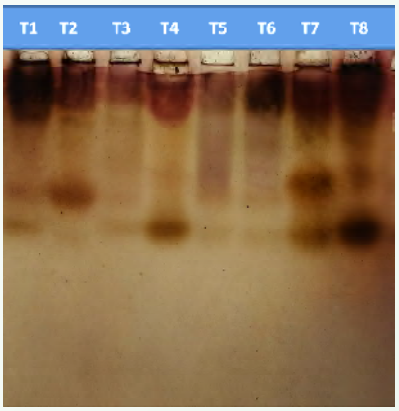


Fig. 51: Native PAGE analysis of BSFB

Project 25: Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops

Maintenance of *Fusarium* isolates collected during 2009-2012 and analyzing diversity of *Fusarium* through virulence factor: Listed cultures of Fusarium species were maintained in the PDA slants, sterile water, Whatman filter paper strip and silica gel.

S.No.	Name of the isolate	Species	Host	Location
1.	FOL-3	FOL	Tomato	Kelabela,Varanasi, Uttar Pradesh
2.	FOL-4	FOL	Tomato	Kaneri ,Varanasi, Uttar Pradesh
3.	FOL-14	FOL	Tomato	KVK, Guwahati, Assam
4.	FOL-22	*F. solani*	Tomato	Asamlengey, Sikkim
5.	FS-9	*F. solani*	Chilli	Gulbarga, Karnataka
6.	FS-75	*F. solani*	Chilli	Wadala, Solapur, Maharashtra
7.	FS-81	*F. oxysporum*	Chilli	Bhubaneshwar, Orissa
8.	FS-90	*F. solani*	Chilli	New Delhi
9.	Fus-Co-2	*F. solani*	Tomato	Coimbatore, Tamil Nadu
10.	Fus-Co-3	FOL	Tomato	Coimbatore, Tamil Nadu
11.	Fus-Mi-3	*F. solani*	Tomato	Basaratpur, Mirzapur, Uttar Pradesh
12.	Fus-Vns-1	FOL	Tomato	Araziline, Varanasi, Uttar Pradesh
13.	Fus-vns-2	FOL	Tomato	Khanav, Varanasi, Uttar Pradesh
14.	Fus-Vns-3	FOL	Tomato	Korauta bajar, Varanasi, Uttar Pradesh
15.	FWC-1	*F. solani*	Chilli	IIVR-A5-Block, Varanasi, Uttar Pradesh
16.	FWC-26	*F. solani*	Chilli	Moth-1, Hissar, Haryana
17.	FWC-27	*F. solani*	Chilli	Sanghai -2, Karnal, Haryana
18.	FWC-86	*F. oxysporum*	Chilli	Chandouli, Samastipur, Bihar
19.	FWC-111	*F. oxysporum*	Chilli	Kararia Farm-2, Bhopal, Madhya Pradesh
20.	FWC-113	*F. solani*	Chilli	Bhopal bypass, Bhopal, Madhya Pradesh
21.	FWC-118	*F. solani*	Chilli	NAU campus, Navsari, Gujrat
22.	FWC-124	*F. solani*	Chilli	RanchiRlycolony, Ranchi, Jharkhand
23.	FWT-1	*F. solani*	Tomato	Darad-2, Karnal , Haryana
24.	FWT-3	FOL	Tomato	Budhana-2, Hissar, Haryana
25.	FWT-5	FOL	Tomato	Bawetalab, Jammu, J & K
26.	FWT-8	FOL	Tomato	Udheyvala, Jammu, J & K
27.	FWT-15	FOL	Tomato	Rajpura, Patiala, Patiala
28.	FWT-20	FOL	Tomato	Patran, Patiala
29.	FWC-20	*F. oxysporum*	Chilli	Dadupur-2, Karnal , Haryana
30.	FWT-56	FOL	Tomato	Khanpur ,Samastipur, Bihar

S.No.	Name of the isolate	Species	Host	Location
31.	FWT-60	FOL	Tomato	Baheri-2, Samastipur, Bihar
32.	FWT-67	FOL	Tomato	Bishunpur-2, Raipur, Chattisgarh
33.	FWT-71	FOL	Tomato	Raipur ,Chattisgarh
34.	FWT-74	FOL	Tomato	Haisel, Ranchi, Jharkhand
35.	FWT-77	FOL	Tomato	Khakhra-2, Ranchi, Jharkhand
36.	FWT-82	*F. solani*	Tomato	Gorakhpur, Uttar Pradesh
37.	FWT-85	FOL	Tomato	Bhopal, MadhyaPradesh
38.	FWT-89	FOL	Tomato	Jabalpur, Madhya Pradesh
39.	FWT-93	*F. solani*	Tomato	Chikadera, Anand, Gujrat

Study on identification and distribution of races among the FOL isolates infecting tomato in India: Twenty isolates of FOL (FOL-3, FOL-4, FUS-CO3, FUS VNS 1, FUS VNS 2, FOL 14, FWT 77, FWT 5, FWT 15, FUS VNS3, FWT 8, FWT 56, FWT 60, FWT 67, FWT 71, FWT 74, FWT 20, FWT 89, FWT 85 and FWT 3) were subjected to the PCR amplification using universal primer pair, uni-f – 5′ uni-r – 5′ specific to *Fusarium oxysporum f.sp. lycopersici* and *F. o. radicis-lycopersici* based on the polygalacturonase gene. Among them only 15 isolates were showed amplification to a size of ~670bp which confirms the presence of polygalacturonase gene in these isolates and remaining three isolates failed to produce amplification (Figure 52). Another set of primer pair, sp13-f – 5′ sp13-r – 5′ specific to race 1 and 3 of FOL isolates had amplified 17 isolates to an amplification size of 445bp and remaining three isolates (FWT 67, FWT 85 and FWT 3) failed to amplify (Figure 53). Third set of primer pair sp23-f – 5′; sp23-r – 5′ specific to race 2 and 3 of FOL failed to amplify (518bp) in any of the FOL isolates which indicated that fifteen of these isolates (FUS-CO3 (Coimbatore, TN), FUS VNS 1 (Varanasi, UP), FUS VNS 2 (Varanasi, UP), FOL 14 (Guwahati, Assam), FWT 77 (Ranchi, Jharkhand), FWT 5 (Jammu, J & K), FWT 15 (Patiala, Punjab), FUS VNS 3(Varanasi, UP), FWT 8 (Jammu, J & K), FWT 56 (Samastipur, Bihar), FWT 60 (Samastipur, Bihar), FWT 71 (Raipur, Chattisgarh), FWT 74 (Ranchi, Jharkhand), FWT 20 (Patiala, Punjab) and FWT 89 (Jabalpur, Madhya Pradesh) belonged to race 1 and the two isolates (FOL-3 and FOL-4) failed to amplify in uni-f/r primer pair but amplified with sp13-f/r indicating that they are the variant from the other FOL isolates. Thus FOL race 1 is predominantly infecting race on tomato in India causing wilt disease.

For the race identification among FOL isolates, inoculations on tomato differential lines were initiated to validate the molecular based identification. Twenty FOL tomato isolates were inoculated on the cv. Bonny Best, a susceptible line to all the 3 races of the pathogen and found that all the isolates were able to cause the wilt disease on tomato plants with different grades of

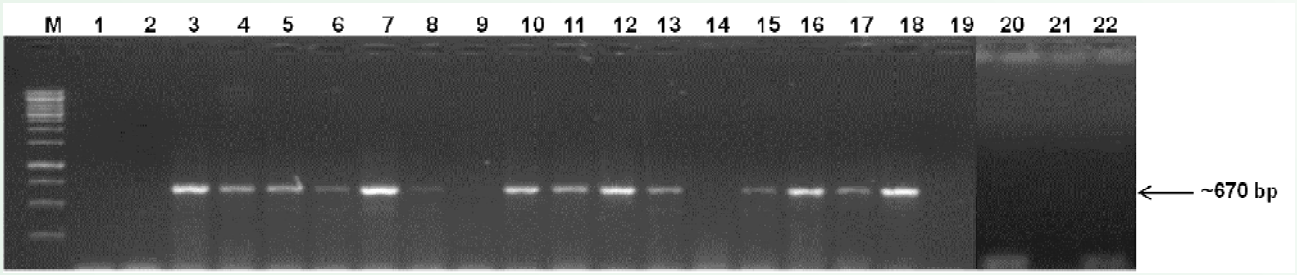


Fig. 52: PCR amplification of polygalacturonase gene using universal primer pair (uni-f/r) specific to *FOL*

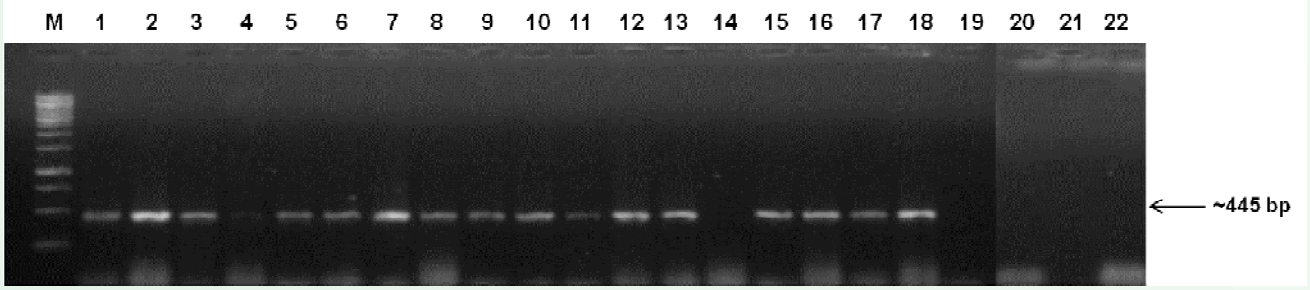


Fig. 53: PCR amplification primer pair (sp13-f/r) specific to race 1 and race 3 of FOL

Fig. 54: Pathogenecity of FOL isolates causing wilt disease in India upon artificial inoculation under greenhouse conditions on tomato *cv.* Bonny Best

disease severity as shown in (Figure 54). Hence this shows that all the isolates were pathogenic. Also identification of race with differential lines viz., UC82-L-Resistance to race 1; MH1-Resistance to Race 1 and Race 2; I3R1-resistance to Race 3 imported from AVRDC, Taiwan is under progress.

Host Resistance: To popularize the grafting technique for raising *Fusarium* wilt, bacterial wilt and nematode resistant seedlings using resistant root stock (brinjal - EG219) obtained from AVRDC, Taiwan with tomato leaf curl virus resistance scion of IIVR tomato cv. Kashi Amman, grafted plants were planted in field and the plants were well established under field conditions (Figure 55). Hence these grafted plants harbor multiple disease and nematode resistance. Same plants inoculated with FOL isolates under net house conditions are under progress (Figure 56). Grafted seedlings will be supplied to the KVK's of ICAR – IIVR for the evaluation in the next season.

Fig. 55: Establishment of grafted tomato plants (*cv.* Kashi Amman) on brinjal root stock (EG219) under filed conditions

Fig. 56: Screening of grafted tomato plants (*cv.* Kashi Amman) on brinjal root stock (EG219) under screen house conditions upon artificial inoculation

Evaluation of biocontrol agents, botanicals and chemicals against wilt diseases of tomato under field conditions: Talc based formulation of *Trichoderma* isolates (Phyto 1-15), two fungicides and botanicals (Datura & Garlic extracts) were evaluated against *Fusarium* wilt of chilli and tomato under field conditions (Figure 57 a & b). In tomato, all the *Trichoderma* isolates showed significant reduction of wilt incidence of 96% (Carbendazim + Mancozeb), 88% (Phyto 6), 86% (Carbendazim) and 71% (Phyto-4 and Phyto-9) compared to untreated control plots (33.1%). Increase in yield was observed by 66% (Carbendazim + Mancozeb) and 61% (Phyto-14 and Phyto-10) with corresponding yield recorded were 162.7 Q/ha and 158 Q/ha and 157.7 Q/ha respectively whereas control recorded 98Q/ha.

a. Tomato

b. Chilli

Fig. 57: Evaluation of bio-formulations, botanicals and chemicals against *Fusarium* wilt of tomato and chilli under field conditions

Table 21: Evaluation of biocontrol agents, botanicals and chemicals against wilt diseases of tomato under field conditions

S. No.	Treatment	Tomato wilt incidence (%)	Yield (Q/ha)
1	Phtyo-1	12.2 (20.39)	119.5
2	Phyto-2	18.2 (25.22)	113.2
3	Phyto-3	12.6 (20.76)	117.7
4	Phyto-4	9.3 (17.74)	155.0
5	Phyto-5	17.3 (24.54)	110.7
6	Phyto-6	3.9 (11.14)	146.7
7	Phyto-7	13.9 (21.84)	155.3
8	Phyto-8	14.3 (22.19)	144.9
9	Phyto-9	9.5 (17.9)	104.8
10	Phyto-10	18.2 (25.23)	157.7
11	Phyto-11	11.2 (19.53)	145.3
12	Phyto-12	17.1 (24.38)	112.3
13	Phyto-13	15.8 (23.34)	115.7
14	Phyto-14	12.4 (20.59)	158.0
15	Phyto-15	17.4 (24.63)	111.3
16	Carbendazim + Mancozeb	1.3 (3.84)	162.7
17	Carbendazim	4.6 (12.01)	146.7
18	Datura extract	16.8 (24.19)	118.0
19	Garlic extract	19.3 (26.07)	109.3
20	Control	33.1 (35.11)	98.0
	CD 5%	3.92	18.05
	CV	17.04	8.39

Project 26: Synthesis and validation and sustainable and adaptable IPM technologies for cucurbitaceous vegetables

IPM technology was synthesized and validated in bitter gourd fields of selected farmers in the villages Mahagaon, Varanasi and Basratpur, Mirzapur for the management of insect pests and diseases is as followed seed treatment with *Trichoderma* @ 5g/kg of seed; spraying of neem @ 5 ml/l against red pumpkin beetle; installation of cue lure traps @ 10/acre (wooden plywood blocks saturated with Ethanol : Cuelure : Insecticide (DDVP) in 8:2:1 ratio for 48 hrs) for fruit flies; raking of soil; need based application of insecticides like malathion @ 2 ml/l or deltamethrin @ 0.75 ml/l or *Bt* @ 2 g/l against cucumber moth, *Diapahnia indica* in bitter gourd, need based application of systemic fungicides metalaxyl+mancozeb against powdery and downy mildews. In bitter gourd, the IPM adopted fields suffered lowest fruit fly damage (8.39%) compared to non-IPM fields (18.25%) (farmers' practices). Same trend was also observed in case of cucumber moth and Hadda beetle infestations. Only

10.45 *D.indica* larvae per plant were recorded in IPM plots and the corresponding value for non-IPM plot was 21.33 per plant. The minimum hadda beetle population (2.89/ plant) was recorded in IPM plot than the non-IPM fields (6.75/ plant). Natural enemies' population (lady bird beetle, spiders) were highest in IPM plots compared to farmers' practices and untreated control. In IPM plot, disease incidence (downy mildew, viral disease) was less compared to non-IPM plot. Also crop duration was more in IPM plots than non-IPM plots giving higher B:C ratio (1:2.58) in IPM practices than to the non-IPM practices (1:1.78).

Table 22: Occurrence of downy mildew in bitter gourd (per cent disease index)

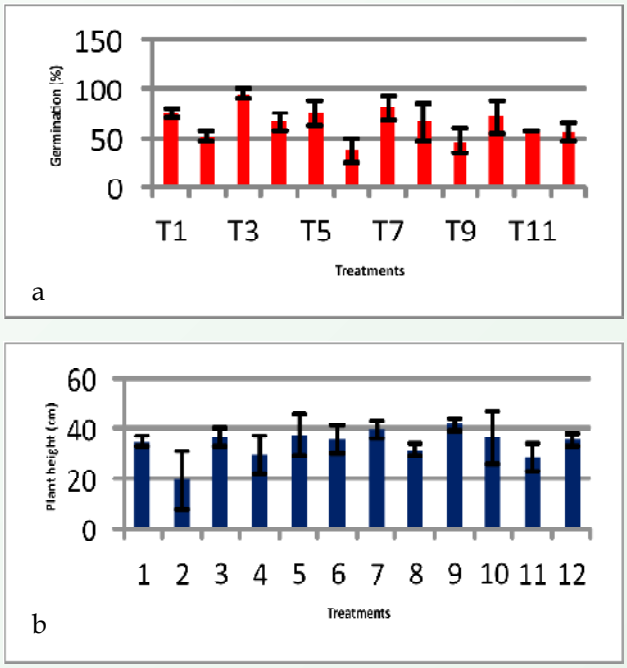
Period	IPM	Non-IPM	Per cent reduction over Non-IPM
September, 2015	12.4	45.7	72.87
October, 2015	16.6	54.3	69.43
November, 2015	8.3	30.4	72.70
December, 2015	3.2	18.1	82.32

Nematological studies also revealed that the regions are mostly infected with root knot nematode (RKN). The populations of *Meloidogyne incognita, Rotylenchulus reniformis* and *Tylenchorhynchus* spp. were recorded at 2.5, 1.5 and 1.5 J_2/g of soil and root knot nematode gall index was (2.6) in cucurbitaceous vegetables. There were not much differences between the field practiced by farmers and IPM field.

Project 27: Development and validation of effective formulation(s) of plant growth promoting rhizobacteria (PGPR) having multicide mechanisms for pest management in vegetables

Evaluation of beneficial microorganisms against *Sclerotium rolfsii* and *Fusarium oxysporum* f.sp. *lycopersici* under pot conditions under glasshouse and field conditions

On the basis of in vitro tests, 08 bacterial isolates (CRB-8, CRB-7, CRB-3, CRB-9, CRB-4, TRB-4, TRB-17, TRB-7) were selected and talc based formulations were developed. These bacterial isolates were tested against *Sclerotium rolfsii* and *Fusarium oxysporum* f.sp. *lycopersici* under pot conditions. The treatment of carbendazim recorded highest germination (95.23%) followed by CRB-7 (80.95%) when the plants were inoculated with the pathogen, *Scleroium rolfsii*. As regards to plant height, the treatments of CRB-9 (T9-41.46 cm) and CRB-7 (T7-39.76 cm) performed better than chemical treatment where the plant attained the minimum height (Figure 58 & 59).



Date of sowing: 22-8-15; Pot diameter: 16cm; No. of treatments: 12; Replication 3; Design: CRD; Crop: Tomato (*cv.* Kashi Amrit); Seed treatment: 5g talc based formulation/kg seeds

Fig. 58a: Influence of bacterial isolates on germination. b. plant height

Evaluation of selected bacterial isolates against *Fusarium* sp. under pot conditions

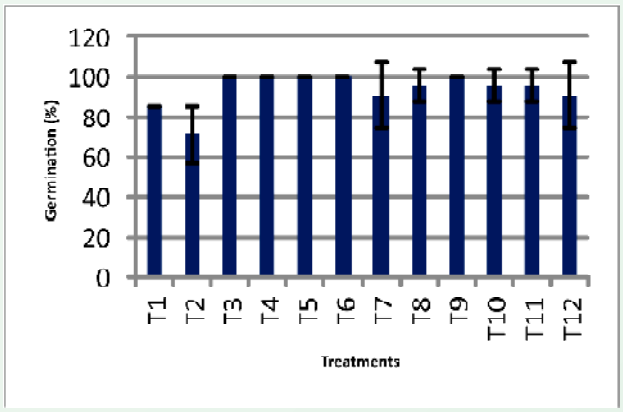


Fig. 59a: Influence of bacterial isolates on germination

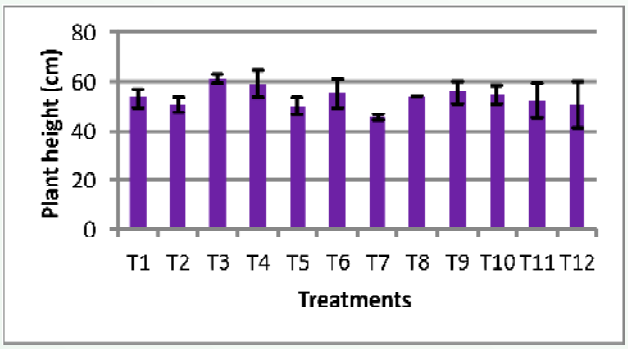


Fig. 59b: plant height

In case of *F.oxysporum f.sp. lycopersici,* chemical control followed by CRB-3 which recorded 100% germination. The treatments T3 (61 cm) and T4 (59 cm) recorded highest plant height.

Evaluation of selected bacterial isolates and their consortia against *Sclerotium rolfsii* and *Fusarium oxysporum* f.sp. *lycopersici* in tomato under field conditions (Fig. 60).

Fig. 60: Field evaluation of bacterial isolates

Table 23: Details of the treatments evaluated under field conditions

Tr. No.	Treatment details
T1	Untreated Control
T2	Chemical control (Carbendazim-0.25g/l)
T3	Check (BS2) @5g/kg seeds+seedling root dip 1% +drenching @1%
T4	CRB 18 @5g/kg seeds+seedling root dip 1% +drenching @1%
T5	CRB3 @5g/kg seeds+seedling root dip 1% +drenching @1%
T6	CRB 7 @5g/kg seeds+seedling root dip 1% +drenching @1%
T7	CRB 4@5g/kg seeds+seedling root dip 1% +drenching @1%
T8	CRB 9@5g/kg seeds+seedling root dip 1% +drenching @1%
T9	TRB 7@5g/kg seeds+seedling root dip 1% +drenching @1%
T10	TRB 4@5g/kg seeds+seedling root dip 1% +drenching @1%
T11	TRB 17@5g/kg seeds+seedling root dip 1% +drenching @1%
T12	Consortia 1 (CRB 3 +CRB 7 +CRB 18 +CRB 4 +CRB 9) @5g/kg seeds+seedling root dip 1% +drenching @1%
T13	Consortia 2 (TRB 4 +TRB 7 +TRB 17) @5g/kg seeds+seedling root dip 1% +drenching @1%
T14	Consortia 3 (TRB 4 +TRB 7 +TRB 17 +CRB 3 +CRB 18 +CRB 7 +CRB 4 +CRB 9) @5g/kg seeds+seedling root dip 1% +drenching @1%
T15	Consortia 4 (CRB 3 +CRB 4) @5g/kg seeds+seedling root dip 1% +drenching @1%
T16	Consortia 5 (TRB 7 +TRB 17) @5g/kg seeds+seedling root dip 1% +drenching @1%

Note: Drenching was done one month after transplanting

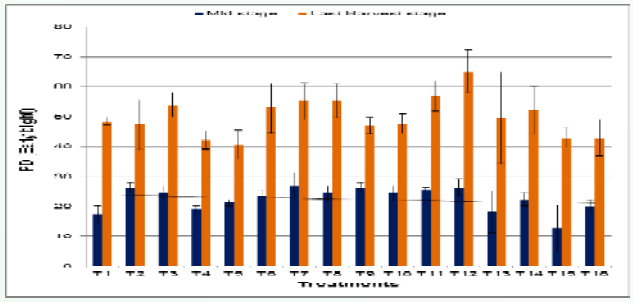


Fig. 61: Incidence of early blight disease in tomato

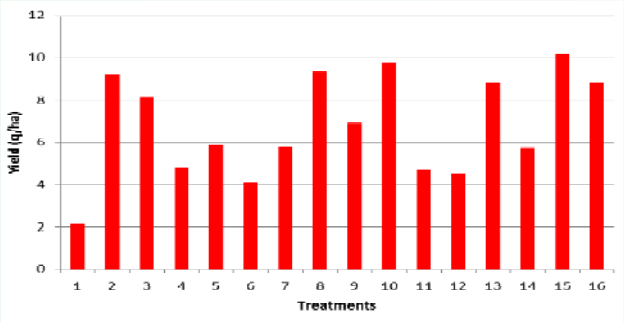


Fig. 62: Effect of bacterial isolates on yield

The treatments T15-CRB3 and CRB4 (10.13 q/ha) followed by T10-TRB4 (9.73 q/ha) T8-CRB-9 (9.33 q/ha) and T2-carbendazim (9.20 q/ha) recorded highest yield (Table 23, Figure 61 and 62). The Treatment T15 also recoded least incidence of early blight disease as compared to other treatments. However, there was no incidence of collar rot and fusarial wilt diseases during the cropping season.

Bio-efficacy of different PGPR isolates screened *in-vitro* against Root Knot Nematode *Meloidogyne incognita:* Different PGPR isolates were tested (Table 24) against root knot nematode, *M. incognita* in *in-vitro* condition at 24 h exposure period. The observation has recorded on mortality under stereoscopic microscope (40 X). The mortality ranged from 0.0% to 83.3%. Among all isolates, isolate CRB7 showed highest percentage (%) of mortality at 83.3% followed by CRB9 at 75.3, CRB2 74.5% over control.

Table 24: Effect of different PGPR isolates tested against root knot nematode, *M. incognita* in *in-vitro*

S. No	Isolates name	% Mortality (24h)	S No.	Isolates name	% Mortality (24h)	S. No.	Isolates name	% Mortality (24h)	S. No	Isolates name	% Mortality (24h)
1	TRB 1	8.2	16	TRB 11	1.7	31	CRB19	5.0	46	CRB8	16.0
2	TRB 2	0.0	17	TRB 12	0.0	32	CRB7	85.2	47	CRB11	10.0
3	TRB 3	0.5	18	TRB 13	1.3	33	CRB9	75.5	48	CRB12	20.7
4	TRB 4	32.5	19	TRB 14	5.7	34	CRB4	0.0	49	CRB13	15.3
5	TRB 5	1.2	20	TRB 15	2.3	35	CRB2	83.3	50	CRB15	12.0
6	TRB 6	5.3	21	TRB 16	4.0	36	CRB5	0.0	51	CRB16	19.0
7	TRB 7	8.7	22	TRB 17	8.7	37	CRB1	73.5	52	CRB17	5.7
8	TRB 8	5.7	23	TRB 18	7.3	38	CRB22	74.5	53	CRB18	4.3
9	TRB 9	0.5	24	TRB 19	0.0	39	CRB25	55.1	54	CRB20	18.0
10	TRB10	11.6	25	TRB 20	3.7	40	CRB14	45.3	55	CRB21	23.3
11	*B.p	15.7	26	TRB 21	2.7	41	CRB10	35.6	56	CRB23	17.0
12	*B. l	18.4	27	TRB 22	4.0	42	CRB6	55.8	57	CRB24	1.7
13	BS-2	12.6	28	TRB 23	4.7	43	TRB7	10.2	58	CRB26	2.3
14	CRB3	5.3	29	TRB 24	5.7	44	TRB4	55.6	59	Control	0.0
15	CRB18	15.0	30	TRB 25	8.3	45	CRB3	6.0			
CD at *0.05P*											7.7
SEd											2.7
Note- * *B.l - Bacillus licheniformis; B.p - B. pumilus*											

Bio-efficacy of different PGPR isolates screened against Root knot nematode, *Meloidogyne incognita* infecting tomato, under pot condition: Different bio-control agents were tested their bio-efficacy potential against root knot nematode, *M. incognita* under pot condition in tomato *var* Kashi Aman. Bio-agents were tested at 0.5% and 1% and their combination (Table 25). The results exhibited that irrespective of treatments, there was reduction in the number of galls, soil population and reproductive factor when compared to inoculated control. Among the treatments, application of Neem cake @ 40 g/m^2 was reduced soil population @ 73%, gall index at 1 and Rf 0.2 which was on par with carbofuran treatment @ 1 kg a.i/ha gall index 1, soil population 71% and Rf 0.2. However, combined application of Neem cake + CRB2+CRB7+ CRB9 @ 0.5% showed more efficacy in controlling *Meloidogyne incognita* causing reduction of 80% of soil population with 0.2 reproductive factor and gall index 1 and it was at par with the treatment, nematicide+ CRB2+CRB7+CRB9 @ 0.5%. Application of bio-agents individually or their combination considerably influenced on plant growth parameters with respect to plant height, root length and yield (Table 26, Figure 63). The results revealed that application of neem cake + Bio-consortium treatment enhanced the plant height at 52%, root length at 63cm and yield 43% with compared to inoculated control in tomato. However, there was no significant difference between the treatments.

Table 25: Bio-efficacy of different PGPR screened against Root knot nematode, *Meloidogyne incognita* infecting tomato, under pot condition.

Treatments	Gall Index (0-10)	Soil population	% Reduction over control	Repro-ductive factor (Rf)
T1-Healthy control	0	0.0(0.7)	100	0
T2-Inoculated control	6	495.0(22.0)	0.0	1.8
T3-Fym alone	5	468.0(22.0)	5.0	1.4
T4-Neem cake	1	132.0(11.0)	73.0	0.2
T5-Carbofuran	1	145.0(12.0)	71.0	0.2
T6-CRB2 @0.5%	4	438.0(21.0)	11.0	1.2
T7-CRB2@1%	3	462.0(21.0)	7.0	1
T8-CRB7 @0.5%	4	452.0(21.0)	9.0	1.2
T9-CRB7 @1%	3	432.0(21.0)	13.0	1
T10-CRB9@0.5%	3	317.0(18.0)	36.0	1
T11-CRB9 @1%	2	265.0(16.0)	46.0	0.4
T12-CRB2+CRB4 +CRB9@0.5%	2	250.0(16.0)	49.0	0.4
T13-CRB2+CRB4+ CRB9@1%	1	117.0(11.0)	76.0	0.2
T14-Neem cake + Bio-consortium @0.5%	1	97.0(9.9)	80.0	0.2
T15- Nematicide+ Bioconsortium @ 0.5%	1	110.0(10.0)	78.0	0.2
CD *at 0.05P*		5.20		
SEm±		1.83		

Note-Data presented in parentheses ( ) are square root transformed value ; Pot size 12" Dia, Variety-Kashi aman; Neem cake @40g/m2, carbofuran @1kg a.i/ha; Rf-Reproduction factor

Table 26: Bio-efficacy of different PGPR screened against Root knot nematode, *Meloidogyne incognita* infecting tomato, under pot condition.

Treatments	Plant height (cm)	% increase over control	Root length (cm)	Yield (kg/pot)	% increase over control
T1 Healthy control	76.7(8.8)	21.1	47.0(6.9)	0.6	8.0
T2 Inoculated control	63.0(8.0)	0.0	29.0(5.4)	0.3	0.0
T3 FYM alone	67.0(8.2)	5.3	34.0(5.8)	0.6	8.0
T4 Neem cake	85.0(9.2)	34.0	53.0(7.3)	1.6	37.0
T5 Carbofuran	66.0(8.2)	4.21	51.0(7.2)	1.5	34.0
T6 CRB2 @0.5%	65.0(8.1)	2.6	34.0(5.9)	0.5	6.0
T7 CRB2@1%	68.0(8.3)	6.8	36.0(6.0)	0.6	7.0
T8 CRB7 @0.5%	69.0(8.3)	8.9	33.0(5.8)	0.6	7.0
T9 CRB7 @1%	73.0(8.6)	15.0	38.0(6.2)	0.6	7.0
T10 CRB9@0.5%	72.0(8.5)	14.0	41.0(6.4)	0.7	11.0
T11 CRB9 @1%	80.0(9.0)	26.0	48.0(6.9)	1.2	26.0
T12 CRB2+CRB4+ CRB9 @0.5%	68.0(8.3)	6.8	38.0(6.2)	1.2	26.0
T13 CRB2+CRB4+ CRB9 @1%	91.0(9.5)	43.0	57.0(7.6)	1.7	40.0
T14 Neem cake + Bioconsortium @0.5%	96.0(9.8)	52.0	63.0(7.9)	1.8	43.0
T15 Nematicide + Bioconsortium @0.5%	92.0(9.6)	46.0	54.0(7.4)	1.7	40.0
CD at *005P*	1.20		1.03	0.35	
SEm±	0.42		0.36	0.12	

Note-Data presented in parentheses () are square root transformed value; Pot size 12"Dia, Variety-Kashi aman; Neem cake @40g/m2, carbofuranFuradon @ 1kg a.i/ha; Bio-consortium-CRB2+CRB4+CRB9.

Fig. 63: Management of *M. incognita* in tomato through bio-control agents

Evaluation of different PGPR formulation against *Lipaphis erysimi* infesting cabbage: Amongst them, TRB-2, TRB-23, TRB-16 and CRB-11 @5 g/l found promising as they caused 59.35, 56.02, 52.69 and 52.28 % mortality after 4 days (Table 27). However, isolate from tomato rhizosphere TRB 2 maintained significant superiority over all the tested formulations and closely followed by TRB-23. The isolate CRB-11 was on par on one side with TRB-11 and on the other side with TRB-1 and TRB-6 and closely followed by CRB-1, CRB-2 and CRB-8. These isolates will be further evaluated individually and in the consortia mode under field condition.

Table 27: Efficacy of different PGPR against *Lipaphis erysimi*

Bacteria	Mortality (%) over control		
	48 hr	72 hr	96 hr
CRB-1	3.33	37.26	49.50
CRB-2	22.8	45.60	49.50
CRB-3	10.71	29.62	40.00
CRB-4	14.29	18.51	55.98
CRB-5	25.58	36.14	30.04
CRB-6	17.24	28.92	38.38
CRB-7	10.71	14.81	28.00
CRB-8	17.24	37.26	49.50
CRB-9	10.71	25.92	34.24
CRB-10	17.24	34.48	43.94
CRB-11	17.24	37.26	52.28
CRB-12	20.02	40.04	43.94
CRB-13	28.36	42.82	41.16
CRB-18	14.29	25.92	47.99
CRB-22	25.58	40.04	46.72
CRB-24	17.24	34.48	41.16
TRB-2	37.72	41.66	59.35
TRB-14	17.74	34.91	42.70
TRB-15	14.41	41.66	45.70
TRB-16	14.41	41.66	52.69
TRB-20	14.41	38.24	39.37
TRB-23	21.07	41.66	56.02
D27S Tel	22.22	30.56	36.11
D27SR4	33.33	36.11	41.67
PSB-3	33.33	38.89	44.44
B-2	16.67	44.44	41.67
TRB-3	5.56	30.56	41.67
TRB-1	22.22	36.11	50.56
TRB-7	11.11	36.11	47.22
TRB-6	13.89	36.11	50
TRB-4	27.78	33.33	41.67
SEM ±	1.39	0.81	0.91
CD (P=0.05)	3.43	1.87	2.23

Table 28: Analysis of Substrate utilization pattern in selected PGPR

Isolate	Substrate utilization
TRB-7	Citrate, Lysine, Ornithine, Urease, Malonate (5)
CRB-4	Lysine, Ornithine, Urease, Nitrate reduction, Sod. Gluconate, Glycerol, Mannitol, Xylitol, ONPG, Esculin hydrolysis, D-Arabinse, Citrate, Malonate (13)
CRB-7	Lysine, Ornithine, Urease, Nitrate reduction, Inulin, Glycerol, Xylitol, ONPG, Esculin hydrolysis, D-Arabinose, Citrate, Malonate (12)
CRB-9	Lysine, Ornithine, Urease, Nitrate reduction, Inulin, Glycerol, Salicin, Inositol, Srbitol, Mannitol, Esculin hydrolysis, D-Arabinse, Citrate, Malonate (14)
CRB-18	Lysine, Ornithine, Phenylalanine Deamination, Nitrate reduction, Inulin, Glycerol, Salicin, Inositol, Srbitol, Mannitol, Melizitose, Esculin hydrolysis, D-Arabinse, Citrate, Malonate (15)
TRB-4	Lysine, Ornithine, Urease, Inulin, Glycerol, Salicin, Srbitol, Mannitol, α-methyl-D-glucoside, cellobiose, Xylitol, Esculin hydrolysis, D-Arabinose, Malonate, Sorbose (15)
CRB-3	Lysine, Ornithine, Urease, Glycerol, Salicin, Mannitol, cellobiose, Xylitol, Esculin hydrolysis, D-Arabinose, Citrate, Sorbose (12)
CRB-8	Ornithine, Urease, Glycerol, Salicin, Inositol, Srbitol, Mannitol, cellobiose, Xylitol, Esculin hydrolysis, D-Arabinose, Citrate, Malonate, Sorbose (14)

Substrate utilization by promising bacterial isolates

The isolates TRB-4 and CRB-18 utilized maximum of 15 substrates followed by CRB-8 (14) and CRB9 (14), CRB-4 (13), CRB-3 and CRB-7 (12) indicating their maximum adaptability/survival in the environment (Table 28).

Enzyme activity: TRB-16, TRB-4 and TRB-13 were promising in Carboxy methyl cellulase enzyme activity (Table 29).

Table 29: Analysis of Carboxy methyl cellulase (CM case)

S. No.	Bacterial isolates	OD @ 545nm
1.	TRB3	0.03
2.	TRB4	0.05
3.	TRB6	0.02
4.	TRB9	0.03
5.	TRB13	0.05
6.	TRB16	0.06
7.	TRB17	0.02
8.	TRB18	0.02
9.	TRB22	0.03
10.	TRB25	0.02

All India Coordinated Research Project (Vegetable Crop)

ALL INDIA COORDINATED RESEARCH PROJECT ON VEGETABLE CROPS (AICRP-VC)

During the year 2015-16, 1437 trials were conducted at 36 regular centres and 28 voluntary centres of AICRP on Vegetable Crops.

The following recommendations under Crop improvement, Crop production and Crop protection were made during 33rd Group Meeting of AICRP (VC) held at ICAR-IIVR, Varanasi from 21-24 May, 2015.

Crop Improvement

Table 1: Variety identified for release and notification

Crops	Name of entry	Actual Name	Source	Rec. Zone
Long melon	2011/ LGMVAR-3	VRSLM-16	IIVR-RRS, Sargatia	IV (Punjab, U.P., Bihar and Jharkhand)

Table 2: Hybrid identified for release and notification

Crop	F_1 Hybrid	Original name	Source	Rec. Zone
Brinjal (Round)	2012/ BRRHYB-3	Nishant	Advanta	IV (Punjab, U.P., Bihar and Jharkhand)

Table -3: Resistant Variety identified for release and notification

Crop	Entry	Original Name	Source	Rec. Zone
Tomato	2011/ ToBW-2	IIHR-H-240	IIHR, Bangalore	VIII (Karnataka, Tamil Nadu, Kerala and Pudducherry)

Vegetable Production

Integrated Nutrient Management

- At Junagarh, under IPNM trial in bottle gourd (cv. Pusa Naveen), the maximum fruit yield (180.86 q/ha) with C:B ratio (3.09) was recorded with application of poultry manure @ 2.5 t/ha + Half rec. NPK through inorganic fertilizers. Hence, it is recommended as IPNM practice for bottle gourd under Junagarh condition.
- At Junagarh, on the basis of pooled data in cowpea cv. Gujarat Cowpea-4, it is concluded that the maximum mean green pod yield of 117.98 q/ha and C:B ratio 4.45 was obtained when crop was nourished with FYM @ 10 t/ha + Half rec. NPK through inorganic fertilizers. Hence, it recommended for cultivation of cowpea under Junagarh condition.
- At Bhubaneswar, under IPNM trial in bitter gourd, pooled data revealed that combined application of lime @ 1t/ha +sulphur @25 kg/ha + Mo 25 ppm resulted in maximum pod yield (81.63 q/ha) with higher C:B ratio (2.2). Hence, it is recommended for cultivation of bitter gourd under Bhubaneshwar condition.

Micronutrient studies

- At Bhubaneshwar, pooled data analysis revealed that application of mixture of all micronutrient (Boric acid-100 pm + Zn-100 ppm + Mo + 100 ppm + Cu-100 ppm + Mo 100 ppm) except boron in bitter gourd recorded highest fruit yield of 164.14 q/ha with C:B ratio of 5.9. Hence, the above micronutrient combination is recommended for cultivation of bitter gourd under Bhubaneswar condition.

Organic vegetable production

- Experiment conducted at Vellanikkara revealed that application of FYM@ 20 t/ha recorded maximum leaf yield of Amaranths. Sole application of FYM (20 tonnes/ha) also registered maximum pod yield (113.9 q/ha with C:B ratio 1.9) in okra. Hence, it is recommended for organic cultivation of amaranth and okra under Vellanikkara condition.
- Organic farming trial at Vellanikkara in tomato and cowpea cropping pattern, the maximum yield in tomato and in cowpea was recorded (201.7 q/ha along with C:B ratio 2.3 in tomato and C:B ratio 1.8 in cowpea) with application of FYM 20 tones/ha along with use of AMF + *Pseudomonas* + *Trichoderma* + *Azotobactor* (each @ 5 kg/ha). Hence, above treatment combination is recommended for organic production of tomato and cowpea under Vellanikkara condition of agroclimatic zone – VIII.
- At Jorhat, under organic farming trial in amaranth, the maximum leaf yield (63.17 q/ha) was recorded with vermi-compost (equivalent 100 kg

N/ha) along with soil application of PSB and *Azosprillum* each 5 kg/ha. However, the maximum C:B ratio of 2.52 was obtained with recommended dose of NPK. Hence, it is recommended for organic cultivation of amaranth under Jorhat condition of agroclimatic zone – II.

- At Jorhat in spinach the maximum green leaf production of 29.74 q/ha was recorded with application of FYM equivalent of 100 kg N, but C:B ratio of 22.3 was registered under recommended NPK practice. Hence, it is recommended for organic cultivation of spinach under Jorhat condition of agroclimatic zone – II.
- At Kalyanpur, organic farming trial on cowpea was conducted during *Zaid* season reveals that the maximum pod yield (69.68 q/ha) with C:B (1.97) was registered with the application of vermicompost 5 tones/ha +VAM + *Pseudomonas* + *Trichoderma* + *Azotbactor*. Hence, this treatment is recommended for organic cultivation of cowpea under Kalyanpur condition of agroclimatic zone – IV.

Drip irrigation

- At IIHR, the maximum tomato yield of 1004 q/ha along with C:B ratio 6.1 was recorded under drip irrigation at 0.9 PE with black-silver polythene mulch. Hence, it is recommended for hybrid tomato cultivation under IIHR condition agroclimatic zone – VIII.

Cropping system research

- Under vegetable based cropping system at Coimbatore, the maximum crop yield and C:B ratio of 6.63 was obtained with cropping sequence- Brinjal (442 q/ha), multiplier onion (171. 7 q/ha) and ash gourd (416.4 ha). Hence, this cropping sequence is recommended for Coimbatore condition of agroclimatic zone – VIII.

Weed management

- Weed management study at Dharwad and Coimbatore concluded that in cowpea the maximum yield of 78.03 q/ha with C:B ratio of 1.23 at Dharwad, and 201.5 q/ha and C:B ratio 2.31 at Coimbatore was recorded with black polythene mulching. Hence, black polythene as mulch is recommended for the control of weeds and realization of maximum green pod yield in cowpea under Dharwad and Coimbatore condition of agroclimatic zone – VIII.

Low tunnel production for cucurbits

- Three years study under low tunnel at Hisar revealed that maximum marketable fruit yield (316.6 q/ha) with C:B ratio (3.80) in bottle gourd cv. Pusa Naveen was observed when crop was sown on 15th December under low tunnel. Similarly, in bitter gourd (cv. Pusa Do Mousami) also the maximum marketable yield (90.9 q/ha) and C:B ratio (1.30) was obtained with 15th December sowing. Hence, under low tunnel, sowing on 15th December has been recommended for profitable production of bottle gourd and bitter gourd in low tunnel under Hisar conditions of agroclimatic zone – VI.

Seed production

- Based on three year data, soaking of bottle gourd seeds with 500 ppm GA_3 for 48 hours was found best with respect to germination, mean germination time, seedling length, seedling dry weight, vigour index-I and vigour index-II at Bhubaneswar condition of agroclimatic zone – V.
- Seeds of knol-khol cv. White Vienna coated with carbendazim @ 2g/kg seed + imidacloprid @ 2ml/kg seed + micronutrient mixture @ 20g/kg seed were found significantly superior to all other treatments in improving the seed germination, shoot length, dry matter production, vigour index-I and vigour index-II at Srinagar codition of agroclimatic zone – I.

Plant Protection

Integrated Disease Management

- For the management of early blight disease in tomato, three foliar sprays of dimethomorph (0.1%) + mancozeb (0.2%) at 15 days interval at the onset of disease was found to be effective treatment with 51 % and 73.7% reduction in disease severity and B:C ratio of 1.38 and 2.43 on tomato cv. Anagha and S-22 at Vellanikara condition of agroclimatic zone – VIII and Parbhani condition of agroclimatic zone – VII, respectively.

- For the integrated management of yellow vein mosaic disease of okra at Raipur condition of agroclimatic zone – V, growing border crop of maize followed by four sprays of insecticides 30 days after sowing, which includes first spray of acephate 75% SP @ 1.5 gm/l + neem oil 0.15% @ 2.0 ml/l followed by imidacloprid 17.8% SL @ 0.5 ml/l + neem oil 0.15% @ 2.0 ml/l followed by imidacloprid 17.8 SL @ 7.5 ml/15 l + neem oil 0.15% @ 2.0 ml/l followed by triazophos 40% EC @ 1.0 ml/l+ neem oil 0.15% EC @ 2.0 ml/l (at 10 days interval) found to be very effective in the reduction of YVMV incidence (43.3%) and increasing yield (39.3 q/ha) as against control (25.8 q/ha) in okra cultivar Parbhani Kranti.
- For the management of foliar disease (Cercospora and Rust) of cowpea, two foliar sprays of difenconazole (0.05%) at 10 days interval was effective for the management of cercospora leaf spot of cowpea variety Utkal Manika (90.8% disease reduction over control) with a BC ratio of 3.15 under Bhubaneshwar conditions of agroclimatic zone – V.
- Application of Seed Pro (IIHR) as seed treatment @ 4g/kg, soil application @10g/m^2, soil drenching @ 5% in tomato cv. Patharkutchi exhibited highest plant vigour (2260.39) with reduced disease incidence (9.39%) as against control (26.12%) . However, significantly lowest disease incidence was observed in fenamidone + mancozeb (4.74%). Therefore, Seed Pro can be used in seedling growth promotion and seedling disease management in sustainable disease management in tomato under Kalyani conditions of agroclimatic zone – II.

Insect Pest Management (Entomology & Namotology)

- In okra, four foliar application of thiamethoxam 25 WG @ 0.35g/l or imidacloprid 70 WG @ 0.07 g/l at 25, 35 45 and 55 DAS found to be highly effective against jassids (76.14 & 70.57% reduction, respectively) and whitefly (88.56 & 84.80% reduction, respectively) with highest yield of 95 q/ha and CB ratio 1:16 at Sabour conditions of agroclimatic zone – IV.
- In okra, seed treatment with *Pseudomonas fluorescens* 1% W.P. 2 x 10^8 cfu @ 20g/kg seed and application of 5 tons of FYM enriched with 2.5 kg of each *Paecilomyces lilacinus* (2 x 10^6 cfu/g) + *Pseudomonas fluorescens* (2 x 10^8 cfu/g) was found effective with 64.80 and 77.4% reduction in population of *M. incognita* and 17.54% and 49.7% increase in marketable yield, respectively at IIHR, Bengaluru condition of agroclimatic zone – VIII and IIVR, Varanasi of agroclimatic zone – IV.

Breeder Seed Production

Through breeder seed production programme conducted under the AICRP (VC) during the year 2014-15 (as indent for 2015-2016), 7070.415 kg breeder seed have been produced against 6893.750 kg indent for 108 varieties in 31 vegetable crops by 22 coordinating centres. During the year 2015-16, an indent of 10825.940 kg breeder seeds for 121 varieties in 31 vegetable crops have been received from the Deputy Commissioner (Seed) DAC, GOI, New Delhi and the same have been allotted to 22 coordinating centres for undertaking the production. Final production details are awaited.

Krishi Vigyan Kendras

ICAR- KRISHI VIGYAN KENDRA, BHADOHI

Training Programme: KVK-Bhadohi conducted 75 numbers of 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 1812 number of beneficiaries including 1254 male and 558 number of female participants (Table-1)

Front Line Demonstration on agricultural Discipline: A total of 580 numbers of front line demonstrations (FLDs) in agricultural discipline were conducted in 55.55 ha area in order to establish the production potential of improved technologies at the farmers' fields (Table-2).

Table 1: Training programmes organized during 2015-16

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	69	1254	440	1694
Rural youths	04	-	71	71
Extension functionaries	02	-	47	47
Total	**75**	**1254**	**558**	**1812**

Table 2: Front Line Demonstration (FLD) on crops/enterprises

Crop	Thematic area	Technology demonstrated	Variety	No. of farmers	Area (ha)	Yield (q/ha)				% Increase in yield
						Demo			Check	
						High	Low	Average		
Pigeon pea	Varietal Evaluation	Improved Variety, Timely sowing	NA-2	41	5.0	15.11	8.70	11.40	6.21	83.57
Chickpea	Varietal Evaluation	Improved Variety, Timely sowing	JAKI-9218	16	0.9	15.50	9.40	11.36	9.10	24.83
Field pea	Varietal Evaluation	Improved Variety, Timely sowing	HUDP-15	208	16.125	14.31	10.22	12.73	11.52	10.50
Paddy	Varietal Evaluation	Improved Variety in Usar	CSR-36	26	5.075	61.30	46.20	53.10	43.80	21.23
Paddy	Pest Management	Management of rice root weevil	MTU-7029	14	1.25	74.2	58.8	68.2	46.6	46.35
Wheat	Varietal Evaluation	Improved Variety in Usar, Timely sowing	KRL-210	14	2.0	26.13	19.50	21.07	16.48	27.85
Wheat	Varietal Evaluation	Improved Variety in Usar, Timely sowing	KRL-213	18	3.0	29.76	20.80	23.80	16.48	44.41
Wheat	Weed management	Application of herbicide	PBW 343	13	5.0	34.8	24.4	29.6	19.5	51.79
Cowpea	Varietal Evaluation	Improved Variety	Kashi Kanchan	33	2.0	102.6	86.2	93.7	72.8	28.71
Chilli	Varietal Evaluation	Improved Variety	Kashi Anmol	50	2.5	155.6	124.7	142.3	118.2	20.39
Vegetable pea	Varietal Evaluation	Improved Variety	Kashi Uday	43	2.5	128.7	102.6	118.3	105.2	12.45
Kharif onion	Varietal Evaluation	Improved Variety	AFDR	32	1.0	207.6	112.1	165.3	-	-
Sponsored FLDs under NEP, New Delhi										
Scented rice	Varietal Evaluation	Improved Variety, Timely sowing	P-2511	16	2.5	60.50	44.80	55.20	35.40	55.90
Scented rice	Varietal Evaluation	Improved Variety, Timely sowing	P-1612	06	1.0	61.40	43.80	54.40	35.40	53.67
Wheat	Varietal Evaluation	Improved Variety, Timely sowing	HD-2967	08	1.2	36.57	27.90	32.40	22.62	43.23

Crop	Thematic Area	Technology demonstrated	Variety	No. of Farmers	Area (ha)	Yield (q/ha)				% Increase in yield
						Demo			Check	
						High	Low	Average		
Wheat	Varietal evaluation	Improved variety, timely sowing	HD-3086	07	1.2	37.12	26.30	31.65	21.80	45.18
Wheat	Varietal evaluation	Improved variety, timely sowing	HD-3059	04	0.4	32.32	24.50	30.15	20.20	49.25
Arhar Ageti	Varietal evaluation	Improved variety, timely sowing	P-992	20	1.75	16.40	4.80	12.35	7.51	64.67
Lentil	Varietal evaluation	Improved variety, timely sowing	L-4076	04	0.15	11.30	4.90	8.50	4.80	77.08
Mustard	Varietal evaluation	Improved variety, timely sowing	Pusa Tarak	07	1.0	20.65	16.80	18.75	16.30	14.90
Grand Total				**580**	**55.55**					

Front Line Demonstration on livestock and poultry science discipline: A total of 12 numbers of front line demonstrations (FLDs) on improved fodder in 0.71 ha area and 238 numbers of FLDs were conducted in 486 units of livestock and poultry in order to establish the production potential of improved technologies in the farmers' fields (Table-3)

Technology Assessment and Refinement: A total of 8 numbers of technology assessment on agriculture and allied disciplines in order to identify the location specificity of technologies under various farming systems in participatory mode conducted during the period 2015-16.

- **Assessment of high yielding tomato variety against leaf curl virus:** For high yielding tomato variety, an OFT was conducted at three farmers fields to assess the infestation of tomato leaf curl virus in cultivar Kashi Vishesh, Kashi Aman and Kashi Sharad with local check (Kajla). On the basis of symptoms appeared, it was found that (Kashi Aman) was least affected (5.30%) by tomato leaf curl virus followed by T2 (Kashi Vishesh) 28.55% infection, and yield was also higher (312.16 q/ha) in Kashi Aman.

Table 3: Front Line Demonstration on livestock and poultry

Category	Thematic area	Name of the technology demonstrated	No. of farmers	No. of Units (Animal/ Poultry/ Birds, etc)
Cattle/ Buffalo	Diseases management	Deworming (levamizole + oxyclozanide + Silymarin to be fed @ 1ml/ 5kg body wt. of animal)	92	142
		Ectoparasite control Deltamethrin to be diluted @2.5 ml in one litre of water and sprayed on body.	42	63
		3rd Generation Cephalosporin class + Tazobactum antimicrobial therapy @ 7.5mg/Kg body wt. for a period of 5 days.	20	20 (11buffalo and 09 crossbred cattle)
	Nutrition management	Mineral mixture supplementation @30g/day/ animal + germinated gram @100g/ day/ animal for improving the conception percent for a period of 6 weeks	27	27 (11 buffalo : 16 cattle)
Sheep & Goat	Diseases management	Deworming (levamizole + oxyclozanide + Silymarin to be fed @ 1ml/ 5kg body wt. of animal)	51	84
Dairy animals	Fodder management	Improved forage cereal (Oat) during Rabi- 2015-16	06	0.21 ha
Dairy animals		Improved fodder (Vardan)	06	0.50 ha
Poultry	Dual purpose breed (Egg and meat production)	Improved germplasm (Grampriya/ Vanraja)	06	25 nos./ farmer (unit)

- **Assessment of different techniques to obtain potential yield of guava during winter season:** An OFT was conducted to assess the technique for getting maximum yield and better quality guava fruit during winter season. The trial was conducted with three treatments i.e., no practice (T1), pruning in April-May (T2) and spray of 10% urea solution at flowering stage in April –May (T3) on about 8 years old guava plant. The maximum yield (167.0 q/ha) and good quality guava fruit was found in T2 followed by T3 (130.6 q/ha)
- **Little leaf disease management in brinjal:** Effect of seedling treatment, hand removal and destruction of infested plants along with need based foliar sprays of bactericide and insecticide was assessed to manage the little leaf disease in brinjal. Seedling treatment with streptomycin sulphate + tetracycline hydrochloride @ 150 ppm for 20-30 minute and installation of yellow sticky traps @ 15 per ha. and foliar application of streptomycin sulphate + tetracycline hydrochloride @ 150 ppm and imidaclopid @ 0.3 ml/l reduced the disease incidence from 46.27 (farmers' practice) to 18.95 percent.
- **Yellow vein mosaic disease management in okra:** The effect of seed treatment, rouging of infested plants, installation of yellow sticky traps and foliar sprays of biological, botanicals and chemicals was assessed to manage the yellow vein mosaic disease in okra. Seed treatment with imidaclorpid @ 3 gm/kg + installation of yellow sticky trap @ 15/ha + roguing of infested plants + foliar sprays of barium chloride @ 1000 ppm at 25 DAS + imidaclorpid @ 0.3 ml/l at 35 DAS and thiomethoxon @ 0.3 gm/l at 45 DAS reduced the disease incidence from 60.07 to 50.68 per cent and increased the net return from Rs. 67706/ha to Rs. Rs. 99220/ha.
- **Assessment of nutritional garden at household level:** For nutritional security, an OFT was conducted at five farmers field in 180 m^2 area to ensure the nutrition from vegetables round the year in a farm family. Different types of vegetables namely cowpea (5.0 kg), leafy vegetables (16.0 kg), cucurbitaceous vegetables (155.0 kg), okra (3.0 kg), ginger (1.5 kg), elephant footyam (3.5 kg), papaya (56.4 kg), tuber crop (3.75 kg) were obtained during kharif season. The average produce per family including 06 members was obtained 48.83 kg. Similarly, solanaceous vegetables (24.48 kg), leafy vegetables (87.64 kg), leguminous crops (9.4 kg), root crops (34.5 kg), cob (26.8 cob), bulb crops (4.5 kg), and spice (1.98 kg) were obtained during *rabi* season in 250 m^2 area. The average produce per family including 06 members was obtained 36.86 kg. As a result farmers get variety of vegetables for their family during *kharif* and *rabi* season whereas only few in control group.
- **Management of mastitis incidence by supplementation of Vitamin E and Se in crossbred cows:** Supplementation of Vitamin E @ 1000 IU and Se @ 3mg for a period of 3 months (2 months during pre-calving and one month of post- calving period) cows revealed a decrease incidence of sub-clinical mastitis (6.25%) and no such incidences of clinical form of mastitis among crossbreed dairy cattle. Such supplementation strategies needs to be practiced among the dairy animal in order to curb down the somatic cells counts in milk, and thereby decrease the chance of mastitis.
- **Supplementation of metho-chelated minerals in the ration for improvement in milk yield potential among the buffalo:** Supplementation of metho-chelated minerals fed @ 10, 15 and 20g in the ration of dairy buffaloes revealed an increase percentage of milk production to a tune of 12.73, 16.02 and 18.46, respectively. In addition, the residual effect of mineral supplementation had also recorded for a period of 2 weeks even after the completion of the trial period. The net return from increase of milk yield was recorded to a tune of Rs. 5892.54/ week/ animal when fed @ 20g/day/ animal. An expenditure amount of Rs. 1.30 incurred for 10g of mineral mixture supplemented in the ration of buffalo.
- **Supplementation of probiotics in the ration for improvement in milk yield potential among the crossbred cattle**: Supplementation of probiotics (*Lactobacillus acidophilus*-22500 million CFU, *Saccharomces cerivisiae* Sc-47 – 150000 million CFU, *S. boulardi* 25000 million CFU, *Propioni bacterium* freudenrecichii 25000 million CFU and sea weed extract 50g/fed @ 10, 15 and 20g in the ration of crossbred cattle revealed an average increase of percentage of milk production to a tune of 14.52, 16.23 and 20.37. In addition, the residual effect of mineral supplementation had also

recorded for a period of 2 weeks even after the completion of the trial period. The net return from increase of milk yield was recorded to a tune of Rs. 3640/ week/animal when fed @ 20g/day/animal. An expenditure amount of Rs. 1.80 incurred for 10g of probiotic supplemented in the ration of crossbred cattle.

Extension programmes: Extension programme were conducted to disseminate and popularize improved agricultural technology for the benefit of the stakeholders of the farming community & Fig. 1 (Table 4 & 5)

Figure 1: Visit of Hon'ble MP at KVK Bhadohi

Table 4: Extension activities conducted by the KVK Bhadohi

Activities	No. of programmes	No. of farmers	No. of Extension Personnel	Total
Advisory services	200	190	10	200
Diagnostic visits	128	369	-	369
Field day	10	247	10	257
Kisan ghosthi	05	472	20	492
Kisan mela	02	1101	32	1133
Exhibition	05	1810	31	1841
Scientists' visit to farmers field	128	369	-	369
Method demonstrations	04	160	-	160
Celebration of important days	01	250	05	255
Special day celebration (Jai Kisan Jai Vigyan Diwas)	03	135	07	142
Exposure visits	02	416	-	416
Others (Lecturer delivered as resource person)	36	2462	52	2514
Total	**524**	**7981**	**167**	**8148**

Table 5: Details of other extension programmes

Particulars	Number
Extension literature	05
News paper coverage	65
Popular articles	08
Radio talks	09
TV talks	12
Animal health camps (Number of animals treated)	3 (109)

ICAR- KRISHI VIGYAN KENDRA, DEORIA

Training programmes: To improve economy of farmers, 105 training courses were conducted in which 2292 farmers and farm women participated. Income generations for rural youths / school dropouts 20 vocational training were organized on and off campus in which 418 rural youths had participated. Five training courses were organized for extension functionaries of the district in which 115 extension functionaries were participated. (Table 6 & Fig. 2)

Figure 2: Off-campus training programme for women

Front Line Demonstration: KVK, Deoria demonstrated 33 technologies on the 451 selected farmers field and covering 82.95 ha. area. The details are follows. (Table 7&8).

On Farm Trials (OFTs) - On the basis of problem diagnosed 8 OFT (Pest and Disease Management, Integrated Nutrient Management, Integrated Crop Management, Drudgery Reduction and Kitchen Gardening) were conducted on 70 farmers field for assessment/refinement of technology.

- OFT on intercropping with pigeon pea and maize was conducted at five farmer's field. The intercropping system of pigeon pea and maize

Table 6: Training programmes

Sl. No.	Training	No of courses	No. of participants
1	Practicing farmers	105	2292
2	Rural youths/ school dropouts	20	418
3	Extension functionaries	5	115
	Total	130	2825

Table 7: Front Line Demonstration

Crop	Thematic area	Technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)				% Increase in yield
					Demo			Check	
					High	Low	Average		
Mustard	Varietal evaluation	Introduction of HYV (Satabdi)	41	14	22.60	16.13	20.73	14.42	43.75
	Varietal evaluation	Introduction of HYV (PusaTarak)	2	0.2	21.34	19.62	20.48	14.42	42.02
Pigeonpea	Resource conservation	Sowing on raised bed (Pusa Bahar)	12	3.7	16.20	11.50	14.90	11.02	35.20
Chickpea	Varietal evaluation	Introduction of HYV (RSG 973)	46	16.8	18.20	11.25	14.13	9.78	44.47
	Integrated pest management	IPM technology	10	1	17.2	12.3	14.75	13.1	12.6
Lentil	Varietal evaluation	Introduction of HYV (HUL 57)	55	18.2	16.20	7.8	10.46	7.89	32.57
Paddy	Resource conservation	Direct seeded rice	12	4.8	36.2	26.5	30.07	31.2	5.1
Scented rice	Varietal evaluation	Indroduction of scented variety (PS - 2511)	06	02	38.8	27.5	32.7	28.2	15
	Varietal evaluation	Introduction of scented Hybrid (PRH 10)	03	0.4	40.6	32.6	34.6	32.1	7.4
	Varietal evaluation	Introduction of scented variety (P - 1612)	04	0.8	32.8	24.5	28.7	28.5	0.7
	Varietal evaluation	Introduction of scented variety (Kala Namak)	02	0.4	22.5	17.6	20.0	19.5	2.5
Wheat timely sown	Varietal evaluation	Introduction of HYV (HD 2967)	01	0.4			51.60	41.72	23.68
	Varietal evaluation	Introduction of HYV (HD 3059)	06	2	46.20	38.50	42.40	37.20	13
Wheat late sown	Resource conservation	Sowing by zero till method (PBW 550)	13	5.0	40.25	38.50	39.57	35.70	10.84
Bottlegourd	Integrated pest management	IPM technology	05	0.5	129	101	115	105	9.52
Cowpea	Varietal evaluation	Introduction of HYV (Kashi Kanchan)	15	01	134.20	109.30	118.1	102.50	15.20
	Integrated disease management	Seed treatment with Bio-control agent Trichoderma @ 5 g/kg seed + use of Trichoderma in field @ 5kg/ha	23	1.0	131	115	123	115	6.96
	Integrated disease management (Kharif)	Seed treatment with Bio-control agent Trichoderma @ 5 gm/kg seed + use of trichoderma in field @ 5kg/ha	18	1.0	140	124	132	116	13.8

Crop	Thematic Area	Technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)				% Increase in yield
					Demo			Check	
					High	Low	Average		
Frenchbean	Varietal evaluation	Introduction of HYV (Kashi Param)	06	0.4	124	106.30	112.50	79.30	41.87
Brinjal	Varietal evaluation	Introduction of HYV (Kashi Uttam)	32	02	493.70	426.60	467.80	387.60	27.37
	Integrated pest management	Regular clipping of infested twings and fruits + use of pheromone trap@ 100 traps/ ha + spray of Ranyxpyr @ 150 ml/acre	20	1.0	308	282	295	251	17.5
Vegetable pea	Varietal evaluation	Introduction of HYV (Kashi Mukti)	08	0.5	103.60	88.20	92.80	76.60	21.15
	Varietal evaluation	Introduction of HYV (Kashi Uday)	08	0.5	107.8	84.00	96.20	76.60	25.59
Okra	Varietal evaluation	Introduction of HYV (Kashi Pragati)	39	02	149.30	117.80	136.60	107.20	27.40
Onion	Varietal evaluation	Introduction of HYV (ADR) in Kharif 2015	28	0.7	272.60	229.5	240.5	_	_
	Nutrient management	Application of Sulfer @ 22 kg /ha	18	1.25	294.30	246.5	268.5	240	11.88
Potato	Varietal evaluation	Introduction of HYV (K. Arun)	14	0.10	408.5	366.6	379.1	338	12.16
	Varietal evaluation	Introduction of HYV (K. Pukhraj)		0.08	427.3	382.40	398.5	338.0	17.90
	Varietal evaluation	Introduction of HYV (K. Khyati)		0.10	422.4	376.8	394.6	338.0	16.75
	Varietal evaluation	Introduction of HYV (K. Jyoti)		0.08	415.5	380.1	390.3	338.0	15.47
	Varietal evaluation	Introduction of HYV (K. Sindhuri)		0.04	385.5	342.3	360.8	338.0	6.74
Cowpea (F)	Varietal evolution	Introduction of HYV (BL 2)	04	1.0	472	431	458.2	438.5	4.49
Total			451	82.95					

Table 8: FLD on Pusa Zero Energy Cool Chamber for preservation of fruits & vegetables unit of Zero Energy Cool Chamber at farmer field

Sl. No.	Name of Fruits & Vegetables	Shelf life in Zero Energy Cool Chamber (in days)	Shelf life in open condition (in days)
1	Banana	12	5
2	Lemon	14	7
3	Guava	9	3
4	Tomato	8	3
5	Spinach	3	1
6	Brinjal	8	3
7	Bottle gourd	9	4
8	Okra	5	2
9	Cowpea	5	2
10	French bean	8	4
11	Pea	8	4

had realized a net return of Rs. 97250/ha as compared to the pigeon pea mono-crop cultivation with net returns of Rs. 68640 /ha. Another trial on intercropping with sugarcane + cowpea was conducted at ten farmer's field. A net return of Rs. 118590/ha was obtained with intercropping of sugar cane + cow pea, whereas the sugarcane as mono-crop cultivation gave net returns of Rs. 87230 /ha.

- Weed management trial in zero till sowing of wheat was assessed at six farmers field. The results indicate that the use of pendimethaline @ 1 kg.a.i/ha as pre-emergence gave 5.15 per cent

increase in yield over application of 2-4 D sodium salt @ 625 gm/ha as post-emergence (Fig. 3).

Fig. 3: OFT on Zero Tillage Wheat

- OFT on bottle gourd was conducted at six farmer's field during *zaid* 2015 to control the fruit fly. Treatment combination of pheromone traps @ 50/ha + spray of 1500 ppm neem oil @ 4 ml/ liter water + spray of imidacloprid @ 0.5 ml/liter water + spray of deltamethrin @ 2 ml/liter reduced fruit damage by fruit fly from 19 to 13 and yield was increased by 13.03%.
- Chilli is an important vegetable crop and high incidence of leaf curl disease resulting in poor yield. Kashi Anmol variety of chilli assessed (on 15 numbers farmers field) with seed treatment with imidacloprid @ 5g/kg seeds + dipping seedlings with imidacloprid @ 0.3ml/lit along with spray of thiomethaxam @ 0.3 g/lit reduced the percentage of disease incidence from 30 to 12 and yield was increased by 23.36%.
- OFT was conducted at 8 number farmer's field to find out appropriate micro nutrient management practice to enhance the tomato productivity as well as quality. The assessed or refined practice of spray of boron @ 0.1% solution at flowering fruiting was found better with 4.16% and 12.3% increase in yield and quality, respectively.
- Trial of nutritional kitchen garden was organized at 15 farmers/ farm women fields to assess production of vegetables in *kharif*, *rabi*, *zaid* season and availability of vegetable (g/day), requirement of vegetable (g/day) and gap (g/day). Results reveal that from a model nutritional kitchen garden of 100 sq m^2 area, 1448 g/day vegetables can be harvested which would fulfill 98.93% of the vegetables requirement of 5 members (1500 g/day) @ 300 g/day/member and gap 16 g/day. Average productions of trials were noted 356.3 kg (240 day) for consumption of five families.
- OFT (10 no.) on drudgery reduction in harvesting of zero tillage of wheat by the farm women. Wheat harvesting is a major problem and is done mostly by the farm women. Harvesting of crop is to be done timely and carefully as the matured grains, otherwise the mature grains shatter from the panicle. Farm women cannot harvest wheat by fast working tools or machines, therefore, the demonstration of improved sickle for drudgery reduction was given to the farm women. The results indicated that use of *Naveen Darati* increased working efficiency by 14.28 % during harvesting of wheat.

Extension activities: For horizontal spread of scientific technology, 5 field days were organized on different crops at farmers field in which 93 farmers / farm women were participated. 489 diagnostic visits were made by KVK scientist (Fig. 4), 4 kisan gosthi was organized in which 268 farmers were participated. Nine SHGs were also formed and the group organized different training programmes for income generation in which 127 women members were benefited, 250 members of 25 kisan club get regular knowledge and skill improvement training from the KVK scientists during above mentioned period. Besides, 54 news were covered in different local news papers. Also five lectures delivered by scientist of KVK as a resource person and 2436 farmers were benefited. In addition to these, KVK also organized Pre-kharifKisansammelan (511 beneficiaries), Pre-*rabi* Kisan sammelan (506 beneficiaries) and Jai Javan- Jai Kisan Stall Week, Soil Health Day, etc.

Fig. 4: Field Visit

ICAR-KRISHI VIGYAN KENDRA, KUSHINAGAR

Training programmes : Krishi Vigyan Kendra, Kushinagar organized 117 need based on and off–campus training programmes under human resource development comprising diverse aspects of production technologies of cereals, oil seeds, pulses, vegetables, livestock, soil health management, value addition, household food security, rural craft and women empowerment benefitting a total of 2787 participants comprising 645 female and 2142 male farmers, rural youth and extension functionaries (Table 9)

Frontline demonstration : Front line demonstration were conducted in 83.30 ha area at 638 farmers field on paddy, wheat, mustard, maize, lentil, field pea, cowpea, cauliflower, sugarcane, onion, mushroom, maize- sheller, dairy milk production and nutritional garden (Table 10).

Table 9: Training programmes organized by KVK, Kushinagar

Clientele	No. of courses	Male	Female	Total participants
Farmers & farm women	105	1870	558	2428
Rural youths	8	157	35	192
Extension functionaries	2	19	26	45
Sponsored training	1	96	5	101
Vocational training	1	-	21	21
Total	**117**	**2142**	**645**	**2787**

Fig. 5: FLD on Toria variety: PT 303

Table 10: Frontline Demonstration at KVK, Kushinagar

Sl. No	Crop	Technology demonstrated	Area (ha)	No. of Farmers	Yield (q/ha)		% increase in yield
					Demo	Local	
1	Paddy	Line transplanting HYV BPT 5204	4	12	23.8	17.15	38.77
2	Paddy	Improved variety MTU 7029	2	6	26.4	17.35	52.16
3	Paddy	Line sowing HYV BPT 5204	2	7	20.35	16.25	25.23
4	Wheat	Line sowing DBW -17	5.0	14	23.75	20.05	18.45
5	Wheat	Line sowing HUW -234	5.8	23	25.55	21.05	17.61
6	Wheat	Zero tillage HUW -234	2.5	05	26.12	21.5	17.69
7	Wheat	Line sowing variety HD - 2967	0.4	1	32.32	21.95	32.1
8	Wheat	Zero tillage (HD-2967)	1.0	1	31.5	21.2	32.7
9	Wheat	Zero tillage (HD-2733	2.0	2	27.3	19.0	30.40
10	Wheat	Zero tillage (PBW-550)	0.4	1	22.8	18.5	18.86
11	Lentil	HUL- 57	0.5	5	16.75	9.80	41.49
12	Mustard	Line sowing - Shatabdi	20	114	12.45	8.75	42.28
13	Field pea	Line sowing –Vikas	16	189	8.45	7.10	19
14	Maize	DKC-9081	1.5	4	58.5	39.2	32.9
15	Maize	Line sowing PhuleRajarshi	3.5	15	37.45	30.25	23.8
16	Cowpea	Kashi Kanchan	1.5	09	85.2	67.2	21.13
17	Onion	HYV AFDR	1.0	07	223.45	170.5	20.56
18	Cauliflower	HYV Sabour Agrim	5.0	53	229.5	202.5	33.33
19	Dairy	Use of Mineral mixture and dewormer to increase milk production	20 units	19	105.25 l milk/day	83.75 l milk/day	25.67
20	Dairy	Use of leguminous green fodder (Barseem) to increase milk production	35 units	31	200.75 l milk/day	172.05 l milk/day	16.70
21	Nutritional garden	Balance diet through nutritional garden	18	18 (150 m^2)	309	211	46.45
22	Mushroom	Mushroom production	4	13	-	-	-
23	Maize/ Drudgery reduction	Use of maize sheller (manual)	2.704	21	-	-	-
	Total		76.60	604			

TECHNOLOGY ASSESSMENT AND REFINEMENT

Intensification and diversification of irrigated rice-wheat cropping system to overcome low economic return: KVK, Kushinagar assessed the technology of intensified diversification of irrigated rice-wheat cropping system at 5 farmers field. Cropping intensity of district Kushinagar *i.e.* 155.2 % is low due to large area under sugarcane as sole crop. In case of rice – wheat system, cropping intensity is 200%. During Kharif season rice var. P-2511 gave 40.25 q/ha in 125 days in comparison to farmers practice *i.e.* BPT-5204 gave 22.75 q/ha in 147 days due to dry spell and scattered rainfall and saved 20 days of cropping period so that in *rabi* season advantageous farmers take early/ timely sown toria. Toria var. PT-303 yield observed to be 7.45 q/ha and 6.25 q/ha for Uttara, respectively in comparison to farmers practice *i.e.* wheat var. HUW-234 gave yield 20.15 q/ha due to late sowing after delayed harvesting of paddy and preparation of land. During *zaid* season farmers sowed vegetables crop cowpea variety Kashi Kanchan after harvesting of toria. The cropping intensity increased to 300% (Paddy var. P-2511, Toria var. PT-303/ Uttara, cowpea var. Kashi Kanchan) in comparison to farmers practice i.e. 200 % (Paddy var. BPT-5204, Wheat var. HUW-234 followed by fallow land (Fig 6).

Fig. 6: OFT Kharif 2015 on Paddy (PS 2511)

Performance of paddy transplanter in transplanted rice

KVK, Kushinagar conducted the on farm trial on performance of paddy transplanter in transplanted rice. It was found that transplanting of paddy by paddy transplanter in un-puddled condition gave highest yield of 46.68q/ha with B:C ratio of 2.81 over manual transplanting 31.65 q /ha with B:C ratio 1.45). A cost saving of Rs. 3345/ ha in transplanting under puddled conditions and Rs.7285/ha over farmers practice was observed by transplanting rice under unpuddled conditions using paddy transplanter.

Fig. 7: Paddy transplanted by transplanter

Performance of paddy drum seeder on farmer's field : KVK, Kushinagar conducted the OFT to assess the effect of paddy drum seeder at farmer field. Result showed that use of paddy drum seeder for direct seeding of rice (NPK 120:60:40 and application of post emergence herbicide bispyribac sodium 75g/ha.) gave the highest yield i.e. 46.08 q/ha with B:C ratio 3.00 followed by direct seeding of rice (NPK 120:60:40 and manual weeding) i.e. 43.75 q/ha with B:C ratio 2.14 in comparison to manual transplanting i.e.31.75 q/h with B:C ratio 1.31/ha. Use of paddy drum seeder reduced the cost of cultivation Rs. 12, 250/ha below farmers practice.

Effect of age of seedling on rice yield in System of Rice Intensification (SRI) : KVK, Kushinagar conducted the OFT to assess the effect of age of seedling on rice yield in SRI at farmer's field. Result indicate that transplanting of 12 days old seedling gave the highest yield *i.e.* 45.05 q/ha with B:C ratio 2.04 followed by transplanting of 10 days old seedling *i.e.* 44.75q/ha with B:C ratio of 2.04 as compared to manually transplanting of 18 days old seedlings with a yield of 32.45 q/ha and B:C ratio 1.39. Cultivation of rice with SRI method saved labour, irrigation and time, besides giving higher yield. This technology is suitable and feasible for marginal farmers.

Effect of Zero-tillage and mulching with rice straw on wheat yield and soil health : KVK, Kushinagar conducted OFT to assess the effect of Zero-tillage and mulching on wheat (HD 2967) yield. Results indicate that Zero-tillage and mulching with paddy straw gave the highest yield i.e. 42.13 q/ha with a B:C ratio 3.34 followed by Zero-tillage sown wheat *i.e.* 37.33q/ha with B:C ratio 3.04 in comparison to farmers practice *i.e.*

32.10 q/ha with B:C ratio 1.98. It was also observed that Zero-tillage wheat with mulching reduced the cost of cultivation by Rs. 5450.00/ha and increased 23.8 per cent yield over farmer's practices (Fig. 8).

Fig. 8: Zero tillage in Wheat

Use of dewormer for control of endoparasites: On-farm trial conducted on use of dewormer (Albendazole) in 10 calves as a treatment over 10 newly born calves; as control farmers practice's devoid of dewormer. In treatment Istdose- 15 ml Albendazole was given at 10 days, IInd-15 ml after 30 days, IIIrd-20 ml after 60 days, and IVth-dose 30 ml after 90 days. No mortality was observed in calves given dewormer. 20% mortality was observed in calves not given dewormer. Results indicate that the use of dewormer plays a key role in control of calves mortality. Hence the recommendation for farmers is to use Albendazole as a dewormer at age of 10, 30, 60 and 90 days to control endo-parasites in calves and check their mortality.

Availability of fruits and vegetables throughout the year: Systematic nutritional garden executed under OFT in *zaid* – 2015, *kharif* – 2015 and *rabi* – 2015-16 at 3 villages to analyze the impact of year round production gave higher yield of vegetables *i.e.* 992 kg while the farmer practice gave the yield of vegetables 751 kg from a area 150 m^2. The net profit from the nutritional garden was Rs. 9480 as the average selling rate of vegetable was Rs. 15/kg.

Highlights of the year: Krishi Vigyan Kendra organized a pre-*kharif kisan sammelan* which was inaugurated by the Shri Kalraj Mishra, Honorable Union Minister, Government of India, Ministry of Micro, Small and Medium Enterprises and Member of Parliament, Deoria on the 6th of July 2015 at the Kisan PG Degree College campus, Banaraha in presence of various dignitaries including scientific resource persons, media persons and over 1200 farmers of the district to ensure that the farming community is to be updated of the recent advancements in agriculture and gain maximum benefit from limited resources.

A Scientist – Farmer Interface was organized by the KVK on "Advanced technology for banana production" on the 19th February, 2016 and inaugurated by Dr. B. Singh, Director, ICAR-IIVR in presence of fellow scientific dignitaries from ICAR-NRC on Banana, Tiruchirapalli, media persons and 150 farmers from different blocks (banana growers) of the district. The farmers were enriched with the innovative ways of minimizing losses and maximizing yields from the experiences shared by the dignitaries in the technical session.

Krishi Vigyan Kendra organized kisan sammelan to inaugurate the *Pradhan Mantri Fasal Bima Yojana* on the 28th of March, 2016 in the district Kushinagar at the village Puraina Katya by the Honorable Shri Kalraj Mishra, Union Minister, Ministry of Micro, Small and Medium Enterprises, Government of India and Member of Parliament, Deoria in presence of various dignitaries, media persons and over seven hundred farmers of the district to ensure that the farming community is aware of the latest updates about the scheme and can avail maximum benefit from it.

Extension Activities: To expedite the process of transfer of technology programme the KVK, organized 5 kisan gosthi which was participated by 1822 farmers. Seven field days were organized covering 357 farmers for demonstration of technologies two kisan mela & kisan sammelan was organized covering 2285 farmers and five kisan mela was attended by the kvk personnel's for awareness creation benefitting a total of 6090 farmers. KVK participated in eight agriculture exhibitions to disseminate the latest agricultural technologies. A total of 478 scientific visits to farmer's field visits covering 1815 farmer plots and 150 diagnostic visits were made by the kvk, scientist for the benefit of more or less 2000 farmers. Kisan diwas organized for 100 farmers was a success. One soil health campaign was undertaken to the benefit of 65 farmers. 55 lectures were delivered as resource person benefitting more than 8375 farmers of Kushinagar and adjoining districts, 4961 farmers visited KVK during 2015-16.

A total of 150 farmers participated in one scientist – farmer's interaction at KVK 7 soil testing campaigns covering 157 farmers were also organized to aware the farmers about soil health. Important day celebration i.e. World Soil Day benefitted a 100 farmers and Jai Kisan Jai Vigyan Week boasted of 388 farmers organised by the KVK. 3 Swachh Bharat Abhiyan were organized to aware 255 farmers. In addition, technologies were popularised through 8 TV talk, 60 news items, 1 leaflet, 2 popular articles and 5 extension folders. 1500 soil and 2500 water analysis were conducted successfully with a total revenue generation of Rs. 1250.

Seeds and planting materials: In addition to above, followings are the details of seed, planting material, bio-products and fishery production and their net worth (Table-11).

Table 11: Seeds and planting materials

Produce	Quintal/Number	Value Rs.
Seed (q)	2528.46	1314305.2
Planting material (No.)	34253	122816
Bio-Products (kg)	550	3300
Fishery production (kg)	267.32	32330.20
Total		14,72,751.40

Institutional Activities

TRAINING PROGRAMME AND OTHER ACTIVITIES

ICAR-IIVR organized National Seminar at Barhi, District Hazaribagh, Jharkhand

National Seminar on Nutritional and Livelihood Security through Vegetable Cultivation was organized in collaboration with NHB, Gurgaon at Barhi, district Hazaribagh, Jharkhand during 27th June 2015. The event was inaugurated by Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture & Farmers Welfare, Government of India, New Delhi in the presence of Jharkhand State Agriculture Minister and MLA from Hazaribagh, Secretary DARE & Director General (ICAR), Deputy Director General (AE) ICAR, Managing Director (NHB), from various Directors ICAR Institutes and other dignitaries from public and private sectors. Chief Guest, Hon'ble Shri Radha Mohan Singh ji in his inaugural address emphasized on the importance of vegetable sector for livelihood security of small and marginal farmers in the country. He said number of farmers involved in vegetable cultivation in Bihar and Jharkhand but due to lack of technical know-how the productivity is low compared to other states. He stressed that research institute should come forward with the help of KVKs to disseminate technologies among growers. Dr. B. Singh, Director, ICAR-IIVR briefly highlighted the achievements of

institute along with extension activities. The Secretary DARE & Director General, ICAR, New Delhi, Dr. S. Ayyappan emphasized on nutritional importance of vegetables and allied crops. He appealed the growers to conserve their available resources and rare species of agricultural crops. He also focused on the importance and export value of some of the underutilized vegetables and appealed for their commercial farming. Technical sessions were also organized for the benefit of all stakeholders. It was attended by more than 400 farmers.

Promotion of Vegetable Technologies in Prime Minister adopted village Jayapur, Varanasi

The institute has been promoting improved vegetable production technologies through demonstrations, training & field days in the Prime Minister's adopted village Jayapur for the last one decade. During 2015-16, this institute along with Bioversity International, New Delhi operated a

programme '*Apni Kheti Apna Beej*' at Jayapur village wherein farmers were provided seeds of different vegetable crops for seed production and storage for self-sustainability in seeds. As a part of this programme, a training programme on 'Dry storage of vegetable seeds' was organized at institute's campus on 23 2015 July in which 130 farmers and farm women from Jayapur village participated. The participants were acquainted with the seed production techniques along with their storage in which the moisture of the seeds is controlled in a simple way by storing the seeds with zeolite beads for minimum losses in the quality of seeds. These zeolite beads can be used for years together by repeated drying in oven.

This programme was inaugurated by Sh. Laxman Acharya, MLC, Varanasi who expressed his happiness over the efforts made by the organizations for the benefit of farmers of Jayapur. The Director of this institute said that vegetables give more profit per unit area as compared to other crops. The scientists of ICAR-IIVR and Bioversity International highlighted about the new techniques for safe storage of seeds and different techniques of producing vegetable seeds. Later, the chief guest distributed different vegetable seeds (Tomato-Kashi Aman; Brinjal-Kashi Taru; Chilli-Kashi Anmol; Bottle gourd-Kashi Ganga; Sponge gourd-Kashi Divya; Pumpkin-Kashi Harit; Okra-Kashi Kranti; Cowpea – Kashi Nidhi and Palak-All Green) and plastic container along zeolite beads for their safe storage.

DG, ICAR inaugurated Crop Residues Management Unit at ICAR-IIVR

Dr. S. Ayyappan, Secretary DARE and Director General ICAR inaugurated the Crop Residues Management Unit at ICAR-IIVR, Varanasi on 2nd April 2015. While addressing the institute staffs and over 300 farm women from Varanasi, Mirzapur, Bhadohi, Sonbhadra and Chandauli districts of Uttar Pradesh, he emphasized on the increasing importance of vegetables for nutritional and livelihood security, owing

to its nutritional richness, economic viability and ability to generate on-farm and off-farm employment. Highlighting the ill-effects of residue burning in the field, he stressed on the adoption of organic farming for vegetable cultivation. While appreciating the efforts of the staff of the Institute, he asked for enhanced focus on 'Per Drop More Crop', 'Farmers First', 'Mera Gaon Mera Gaurav' and 'Attracting Rural Youth in Agriculture.'

A Krishi Paricharcha on Crop Waste Management and Role of Women in Agriculture was also organized on this occasion which was presided over by Smt. Durgawati Devi, Gram Pradhan, Jayapur (village adopted by Hon'ble Prime Minister). Dr. B. Singh, Director, ICAR-IIVR enlightened the farmers about the importance of residue management in sustainable agricultural production. Awareness among the farming communities about the methods & importance of crop residue management for sustainability and resilience of Indian agriculture was created through this programme. Vegetable seedlings consisting of bottle gourd, pumpkin, cucumber & sponge gourd along with Trichoderma powder for kitchen garden were also distributed to the farm households. On this occasion, 35 extension folders, a technical bulletin on 'Sabjiyon Me Keetnashakon Ke Prayog Kee Vivaranika' and the 1st issue of 'Vegetable e-Newsletter' were also released.

ICAR-IIVR, Varanasi organized National Farmers' Fair cum Vegetable Show-Casing

A National Farmers' Fair Cum Vegetable Show-Casing was organized in collaboration with National Horticulture Board, Gurgaon and Association for Promotion of Innovation in Vegetable (APIV) on 30th January 2016 to educate the farmers regarding vegetable and agriculture production, which is economically, environmentally and technologically sustainable.

This event was inaugurated by Prof. Gautam Kalloo, Former Vice Chancellor, JNKVV, Jabalpur and Former DDG (Hort. & Crop Sciences), ICAR, New Delhi. In his inaugural address, he highlighted the new research and development in the area of vegetable production. He emphasized the importance of micronutrients and utilization of microbes in vegetable production. Dr. Gopalji Trivedi, former Vice Chancellor, RAU, Pusa, Bihar, Dr. A.K. Mehta, Former ADG (Extension), ICAR, New Delhi and Dr. R.P. Singh, Director, Institute of Agricultural Sciences, BHU, Varanasi, were the special guests of the function. Dr. B. Singh, Director of the Institute highlighted the achievements and transfer of technologies by ICAR-IIVR. He also emphasized women empowerment and farmer's participation in hybrid seed production. He informed that apart from 14 villages in Sonbhadra under TSP, the institute has adopted five villages from each district of Chandauli, Gazipur, Jaunpur, Mau, Mirzapur and Varanasi in collaboration with NHB, Gurgaon under the flagship programme of the Prime Minister, "Mera Gaon Mera Gaurav" and the scientists often use to visit these villages for interface with farmers and demonstrations of improved vegetable varieties and technologies. Farmer's president Shri Rameshwar Singh, a tribal progressive grower shared his happiness about the increase of farmer's welfare and women empowerment in the tribal region of Sonbhadra due to the intervention of ICAR-IIVR varieties and technologies under tribal sub-plan (TSP).

The farmer's fair was attended by about 4000 farmers from Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar, Uttarakhand, West Bengal and Gujarat. The total of 40 stalls related to vegetables, potato, seeds, fertilizer, beneficial microbes, fisheries, fruits *etc.* had been displayed by various ICAR Institutes, KVKs, SAUs and other Government and Private sectors. At the end of the function, famers were awarded for their contribution in vegetable production. At national level category, Shri Rajeshwar Mahato, Ranchi, Jharkhand; Shri Ram Chandra Prasad Kushwaha, East Champaran, Bihar and Shri Rajendra

Singh Rana, Deharadoon, Uttarakhand were received Gold, Silver and Bronze medal, respectively. At regional level, Shri Raghupat Singh (Muradabad) received Gold medal, Smt. Rajani Devi (Sonbhadra) and Shri Ramji Maurya (Bhadohi) shared Silver medal and Shri Anuj Kumar Singh (Deoria) received bronze medal. Hundreds of farmers participated in Vegetable Showcasing Competition with their produce and received first, second and third prizes in different categories.

National Symposium on "Vegetable Legumes for Soil and Human Health" organised at ICAR, IIVR Varanasi to commemorate "International Year of Pulses"

To commemorate 2016 as "International Year of Pulses," a National Symposium on "Vegetable Legumes for Soil and Human Health" was organized at ICAR-IIVR, Varanasi during February 12-14, 2016. Dr. NK Krishna Kumar, DDG (Horticultural Sciences), ICAR, New Delhi inaugurated the symposium on 12 February, 2016. In his inaugural address, Dr. Kumar

emphasized for holistic approach in research on legume vegetables for nutritional security and improving soil health. He opined that legumes have great significance in drylands for sustainable production as they maintain soil fertility and reduce soil erosion. He expressed concern over problems of pod borer and white fly in legumes and also emphasized to develop varieties resistant to viruses. He appreciated and congratulated the scientists of the Institute for their efforts in developing new varieties of pea, cowpea and Indian bean.

On this occasion, Dr. Kirti Singh, Ex- Vice Chancellor and Ex-Chairman, ASRB, Dr. G. Kalloo, Ex-Vice Chancellor, JNKV, Jabalpur and Ex-DDG (HS & CS), ICAR, Dr DP Ray, President, ISVS and Ex- Vice Chancellor, OUA&T Bhubneswar and Dr. RR Hanchinal, Chairman, Protection of Plant Varieties & Farmers Right Authority expressed their views on the importance of legumes towards food, nutritional and health security. Dr. Bijendra Singh, Director, ICAR-IIVR, Varanasi highlighted the status of vegetable legumes in the country along with their importance for nutritional security and soil health. Dr. NP Singh, Director, ICAR-IIPR, Kanpur stressed the need for increasing production of legumes as per capita availability of legumes is only 37 g/day as against 54 g/day.

Altogether 260 abstracts from 77 organizations across the country were received for presentation in the symposium divided into 9 sessions covering 35 lead lectures, 50 oral presentations, besides many poster presentations. The thematic areas deliberated in the symposium include vegetable legume genetic resources and conservation, Underutilized and underexploited legume vegetables, Pre-breeding and Breeding, biotechnological applications, production technology and cropping system, Climate change-biotic Stresses, climate change-abiotic stresses, post- harvest and value addition, seed enhancement, marketing and public private partnership.

The house felt to develop a collaborative project involving World Vegetable Centre (AVRDC); ICAR-IIPR, Kanpur and ICAR-IIVR, Varanasi for biotechnological interventions, particularly SNP genotyping, transcriptome sequencing and next

generation sequencing in vegetable legume crops. A total of 250 delegates including eminent scientists, scholars and students from ICAR institutes, State Agricultural Universities, State Departments, CSIR, private organization and NGOs participated in the symposium.

Farmers' Hostel and Training Center Inaugurated by Hon'ble Union Minister of Agriculture & Farmers Welfare, Government of India

In view of strengthening residential training programme at ICAR-IIVR, Farmers' Hostel and Training Centre was inaugurated by Hon'ble Shri Radha Mohan Singh, Union Minister for Agriculture and Farmers Welfare, Government of India on 6th November 2015 in the presence of Dr. S. Ayyappan, Secretary DARE & DG, ICAR and other dignitaries. On this occasion Hon'ble Minister said that capacity building played an important role in the development of knowledge, attitude and skills of people in general and farmers in particular for adoption of improved technologies. He emphasized that the institute should organize more number of trainings on different aspects of vegetables for farmers and also conducts massive demonstrations of improved technologies at farmers' field for more production per unit area.

Hon'ble Union Minister of Agriculture & Farmers Welfare, Government of India Visited Institute

Hon'ble Shri Radha Mohan Singh Ji, Union Minister for Agriculture and Farmers Welfare, Government of India visited the institute on 20th June 2015. During the visit, Hon'ble Minister discussed the research and extension activities with the scientists of the institute and emphasized to transfer the recommended technologies to the farmers field in not only adjoining districts but also in other states through demonstrations, training, exhibitions *etc*. He also addressed the press and media people and appealed them to give wide coverage of agriculture research and technologies, so that it will reach to masses. Later Hon'ble Minister laid the Foundation Stone in State Dairy Farm adjoining to this institute for conservation, promotion & development of improved local breed of cow Ganga Tiri, in Uttar Pradesh.

Swachh Bharat Abhiyan at ICAR-IIVR, Varanasi

National Cleanliness Campaign (Swachh Bharat Mission) was organized under the leadership of Dr. B. Singh, Director of the Institute. On the occasion of Gandhi Jayanti (2nd October, 2015), cleanliness drive was organized and all staff members of the institute took 'Swachhta Shapath' (cleanliness oath) to dedicate 100 hours every year towards 'Swachh Bharat Abhiyan'. The whole campaign includes cleaning of institutes premises and its adjoining areas, residential areas and nearby villages.

First Low-Energy Seed Gene Bank established at ICAR-IIVR, Varanasi

ICAR-Indian Institute of Vegetables Research, Varanasi became the first institute to have low-energy seed gene bank facility in the country The facility was inaugurated on 14th February 2016 by Dr. Kirti Singh, Ex-Chairman, ASRB in august presence of Dr. Prem Narain Mathur, regional representative of Bioversity International for Central and South Asia, Prof. G. Kalloo, Dr. Brahma Singh and other dignitaries.

The facility was established in collaboration with Bioversity International. This "Low- Energy Seed Gene Bank" is based on dry storage, which uses a very innovative technique based on use of zeolite beads as seed desiccants to reduce the moisture content of seeds. These beads dry the seeds during storage in air-tight boxes even at ambient conditions. This requires very low power for operation and enhances the shelf life of seeds. The beads can be recharged by drying in a hot air oven by heating at 225-250 °C for two hours. The technology is also cost effective as the beads can be reused more than 10,000 times. Bioversity International has been working with this technology for the last couple of years as most of the seeds deteriorate during storage due to high moisture content. This low energy seed genebank is currently harboring ~5000 germplasm accessions in 34 vegetable crops for long term storage and has the capacity to upscale the storage to five times more. The technology can also be used by farmers to increase seed quality and its longevity.

Inauguration of Low- Energy Seed Gene Bank at ICAR-IIVR, Varanasi

XXXIII Group Meeting of ICAR-All India Coordinated Research Project (Vegetable Crops)

The XXXIII Annual Group Meeting of All India Coordinated Research Project on Vegetable Crops (AICRP-VC) was inaugurated at ICAR-Indian Institute

of Vegetable Research, Varanasi on May 21, 2015 by Dr. NK Krishna Kumar, Deputy Director General (Horticultural Science), ICAR. The DDG in his inaugural address highlighted the role of vegetables in nutritional security. The guest of Honour, Dr. RR Hanchinal, Chairman, PPV & FRA and Dr. AK Joshi, Regional Coordinator, South East Asia, CIMMYT also addressed the gathering.

Plenary session was chaired by Dr N K Krishna Kumar, DDG (Horticultural Sciences) and co-chaired by Dr T Janakiram, ADG (Horticultural Sciences), ICAR, New Delhi. The DDG (Horticultural Science) emphasized for collaborative and multidisciplinary research to develop new varieties and hybrids in vegetable crops. He was concerned about the nutrient dilution in recently developed varieties/hybrids and suggested scientists to preserve or increase the nutrient content while developing new varieties/hybrids. He highlighted the need to develop cultivars suitable for low input technology, microgreens, leaf concentrates and varieties rich in health promoting micro-nutrients. He stressed upon initiation of hybrid development in new vegetables. "There is gap in between demand and supply of good quality seeds of hybrids, and it is to be fulfilled by new programmes like contract farming for seed production" he added.

Dr. B Singh, Director, ICAR-IIVR highlighted the need of climate smart agriculture and development of

new cultivars suitable for increasing temperature and low moisture, resistance to new pests and diseases and rich in nutrients. He also highlighted the importance of public private partnership for overall vegetable research and development.

The progress reports of previous year were discussed in length and technical programme of next year was formulated. One brinjal hybrid and one long melon variety identified through AICRP and recommended for released on this occasion. In addition, many production and protection technologies were also recommended in different vegetable crops for different agroclimatic zones.

About 350 scientists from 24 Agricultural Universities, 10 ICAR institutes, 45 private companies and state government officials participated in the programme.

Training–Cum-Workshop on Nutrition Rich Vegetable Crops

Training –cum- workshop on Nutrition Rich Vegetable Crops was organised in collaboration with ICAR-ZPD, Zone-VII, Jabalpur (M.P.) on 11-13 August 2015. Fifty horticulturists from KVKs of Madhya Pradesh, Chhattisgarh and Odisha participated in workshop. Dr. Kirti Singh, Former Chairman, ASRB, New Delhi inaugurated the function. In his inaugural speech, he stressed upon the extended role of KVKs in training, demonstration and extension of modern agricultural technologies to the farming community. The main objective of the workshop was to review the activities of the KVKs in the field of vegetables. The representatives of the KVKs presented the findings of previously conducted FLDs, success stories and proposal on OFTs for the year 2015-16. The technical and relevant aspects of OFTs were critically reviewed by the experts of ICAR-IIVR and were modified accordingly. During this three days training cum workshop, the participants were acquainted with modern vegetable production technologies through classroom lectures, hands on training and exposure

visits. Many important aspects on sustainable vegetable production were deliberated and discussed for the benefit of KVKs personnel. The Director of the institute highlighted the need of climate smart agriculture and development of new cultivars suitable for increasing temperature and low moisture, resistance to new pests and diseases as well as varieties rich in nutrients.

Inter-session Meeting of the Parliamentary Consultative Committee

A meeting of the Parliamentary Consultative Committee of the Ministry of Agriculture and Farmers Welfare on Aquaculture Development was organized at ICAR- Indian Institute of Vegetable Research, Varanasi on 6th November 2015 under the chairmanship of Hon'ble Minister of Agriculture and

Farmers Welfare, Govt of India Shri Radha Mohan Singh. Five members of Parliament from different states as well as the Secretary, DARE & DG-ICAR, Dr. S Ayyappan and Joint Secretary (Fisheries), Department of Animal Husbandry, Dairying & Fisheries (DADF), Shri Aditya Kumar Joshi as well as officials from the Ministry of Parliamentary Affairs, Department of Agriculture and Cooperation and DADF, Govt of India were also present. Hon'ble Minister in his inaugural address mentioned that aquaculture development has assumed significance and there is an immense need to enhance fish production for ushering the Blue Revolution in the country for socio-economic development and nutritional security. In this endeavor, he emphasized for large scale adoption of technologies of fish breeding and seed production by farmers across the country as a vital component of Blue Revolution and categorically stressed for organization of 'Fishery Day' in the country. On this occasion, he released the Hindi Patrika 'Sabji Kiran' and a technical bulletin on Value Addition in Vegetables published by the Institute. Hon'ble Minister, Members of Parliament and DG-ICAR appreciated the exhibition stalls showcasing the technologies evolved by the institute and KVKs for the benefits of the vegetable growers. Agriculture Minister interacted and inquired with vegetable growers present at the stall about the adoption of the ICAR-IIVR technologies. The meeting was coordinated by the Director, ICAR-IIVR Dr B Singh and Director (Fisheries, DADF) Shri PR Meshram. The meeting ended with vote of thanks by the Director of the Institute.

ICAR sponsored Winter School on "Novel genomic tools and modern genetics and breeding approaches for vegetable crops improvement"

ICAR sponsored 21 days Winter School on "Novel genomic tools and modern genetics and breeding approaches for vegetable crops improvement" from November 7-27, 2015 was inaugurated by Dr. G Kalloo, Ex. DDG, ICAR and VC, JNKV, Jabalpur at ICAR-Indian Institute of Vegetable Research, Varanasi who highlighted its importance and utility in modern vegetable breeding programmes.

A total of 25 participants working in the area of vegetable sciences covering 14 states including UP, MP, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Chhattisgarh, Maharastra, Karnataka, Tripura, J&K, Haryana and Arunachal Pradesh participated in

Welcome address delivered by Dr. G. Kalloo

Winter school participants along with Core faculty

winter school. A series of lectures (total 56) and practical sessions (total 22) on various aspects such as allele mining, hi-tech breeding, molecular mapping of genes/QTLs, genome engineering, NGS, novel genomic tools and modern genetic and breeding approaches, *etc* were covered. Besides, ICAR-IIVR, 31 learned faculties from other reputed public including private organizations shared their rich experiences in relevant fields with the participants. A manual was also compiled, which is the compilation of lectures delivered and practical, demonstrated by various experts during this winter school, and distributed among the trainees for their future reference. Dr. NP Singh, Director, IIPR, Kanpur graced the valedictory function as the chief guest. Dr. B Singh, Director, ICAR-IIVR was the Course Director, while Dr. Sudhakar Pandey coordinated the Winter School.

International Yoga Day celebrated at ICAR-IIVR, Varanasi

Yoga programme was organized at ICAR-Indian Institute of Vegetable Research, Varanasi at 6.45 AM in the morning on the occasion of "First International Yoga Day". All the staff of the institute have attended the programme under the leadership of the institute's Director, Dr. Bijendra Singh. In this programme, various exercises, yogaasans, pranayam, etc were demonstrated and conducted by Yoga expert Dr. Anant Bahadur. On this occasion, Dr. Bijendra Singh welcomed all the staff and thrown light on the importance of daily practicing yoga. At the end of the session, all the employees of the institute have resolved to practice yoga daily.

Hindi Chetna Maas Organized

Hindi Chetna Maas was organized from 14th September- 13th October, 2015 at ICAR-IIVR, Varanasi. Dr. B Singh, Director and Chairman of Hindi Cell inaugurated Hindi Chetna Maas on 14th September, 2015 and stressed that all staff should try to read, write and speak in Hindi. He desired that Scientists should also publish their research works and other publications in Hindi. Dr. NP Singh, Director, ICAR-Central Coastal Agricultural Research Institute, Goa also visited the Institute during this period and emphasised that Hindi should be used in scientific analysis so that technology can reach to the farmers. During the Hindi Chetna Maas, on 19th September 2015

an essay competition on "**नमामिगंगे प्रसांगिकता व व्यवहारिकता**"; on 26th September 2015 a debate on "**उत्तर भारत में ड्रिप सिंचाई**"; on 3rd October 2015 a poster competition on "**सब्जियाँ हमारा स्वास्थ**" and lastly on 9th October 2015 a quiz competition were organized. The Hindi Chetna Mas was concluded on 13th October, 2015 with the valedictory lecture from Dr. Harikesh Singh, Former Dean, Education, B.H.U, Varanasi. He emphasised the need of hindi language for effective transfer of technology to the farmers and also distributed prizes to the winners of the various events.

AWARDS, HONOURS AND RECOGNITION

1. Dr. PM Singh nominated as member of Central Variety Notification Committee by ICAR.
2. Dr. PM Singh nominated as member of Institute Management Committee of DSR, Mau.
3. Dr. N Rai honoured as Fellow in Horticultural Sciences by Uttar Pradesh Agricultural Scientist Association, U.P.
4. Sh. RS Gujjar awarded Netaji Subhas- ICAR International Fellowship for the year 2015-16
5. Dr. N Rai received Best Poster Presentation Award in National symposium on Vegetable Legumes for Soil and Human Health at ICAR-IIVR, Varanasi from 12-14th February 2016 by ISVS, Varanasi
6. Dr. Pragya got second Best Poster Presentation Award on 'Assessment of genetic diversity for agro-morphological and biochemical traits in fenugreek leaves' in National symposium on Vegetable Legumes for Soil and Human Health at ICAR-IIVR, Varanasi from 12-14th February 2016.
7. Dr. SK Tiwari awarded Best Poster Presentation Award in BITS Conference on Gene and Genome Regulation in BITS Pilani, Pilani Campus, 18-21, February 2016.
8. Mr. RS Gujjar received Best Poster Presentation Award for presentation on Identification, phylogeny and expression analysis of WRKY transcription factors in tomato (*Solanum lycopersicum* L.) BSH1 in National conference on horticulture in north eastern region, 16-18, January 2016.
9. Dr. T Chaube awarded with Best Poster Presentation Award on 'Evaluation of genetic characters of vegetable pea varieties on the basis of DUS guidelines'. In National Symposium on Vegetable legumes for soil and human health, ICAR-IIVR, Varanasi from 12-14, February 2016.
10. Dr. Shubhadeep Roy received Young Scientist Award for outstanding work in the field of extension research and field of extension services during ISEE Golden Jubilee National Seminar during November 5-7, 2015.
11. Dr. SNS Chaurasia received Fellowship from the Horticulture Society of India in 2016 at CITH, Srinagar.
12. Dr. Neeraj Singh received Dr. GS Vidyarthi Memorial Award for excellence in farm information communication and field extension services from Indian Society of Extension Education, New Delhi, during ISEE Golden Jubilee National Seminar on November 5-7, 2015.

HUMAN RESOURCE DEVELOPMENT

Training and Capacity Building

Training

Name of Scientist	Title of training	Duration	Held at
A K Chaturvedi	ICAR sponsored winter school on Novel genomics tools and modern genomics & breeding approaches for vegetable crop improvement	November 7-27, 2015	ICAR-IIVR, Varanasi
AP Singh	Competence Enhancement Training Programme for Technical Officers of ICAR	March 1-10, 2016	NAARM, Hyderabad.
AR Kumari	Short Course on A total value chain for processing of vegetable crops for nutritional security	September 1 - 11, 2015	ICAR-IIVR, Varanasi
B Rajasekhar Reddy	Training programme on Recent Advance in Statistical Genetics and Genomics	March 4–24, , 2016	IASRI, New Delhi.
B Rajsekhar Reddy	Three months professional attachment training	May 28–August 27, 2015	ICAR-IARI, New Delhi
Bharat Raj Meena	Three months professional attachment training	November 26, 2015 – February 25, 2016	ICAR-NBAIM, Mau
C Sellaperumal	ICAR sponsored winter school on Designing modern crop pest combat strategies with nematodes against nematodes	January 27– 16 February, 2016	ICAR-IARI, New Delhi.
DK Agnihotri	Training Programme on Public Procurement	July 6-11, 2015	NIFM, Faridabad
Divekar Pratap Adinath	Three months professional attachment training	November 23, 2015 – February 22, 2016	ICAR-NBAIR ,Bengaluru
Jyoti Devi	ICAR Sponsored winter school on Advances in Improvement of Vegetable Crops using Biotechnological Approaches	September 18- October 08, 2015	ICAR-IARI, New Delhi.
K Nagendran	Three months professional attachment training	May 28- August 27, 2015	IASc., BHU, Varanasi
Kesav Kant Gautam	Three months professional attachment training	May 28- August 27, 2015	ICAR-IIHR, Bengaluru
MH Kodandaram	Biosafety Compliance readiness training of ICAR Scientists	May 28- August 27, 2015	ICAR and BCIL, New Delhi
Manjunatha Gowda T	Three months professional attachment training	May 28- August 27, 2015	ICAR-NBAIR, Bengaluru
Manoj Kumar Pandey	Training on Integrated Pests and Disease Management in Sugarcane Under National training on Sugarcane Production Technology	February 25-26, 2016	ICAR- IISR, Lucknow.
Nakul Gupta	Three months professional attachment training	November 23, 2015 – February 22, 2016	ICAR-IIHR, Bengaluru
Neeraj Singh	MDP on leadership development (a pre-RMP programme)	November 30 – December 11, 2015	NAARM, Hyderabad
PM Singh	National Training Programme on Entrepreneurship Development & Management	December 7-11,2015	ED&M Institute of India, Ahmedabad.
Paresh B Chaukhande	Three months professional attachment training	May 28- August 27, 2015	ICAR-IIHR, Bengaluru
RN Prasad	MDP on leadership development (a pre-RMP programme)	November 30 –Dec. 11, 2015	NAARM, Hyderabad
RP Sahu	ICAR sponsored winter school on "Entrepre-neurship among rural community for sustainable development"	December 2– 22, 2015	MPUAT, Udaipur, Rajasthan.
Rakesh Pandey	Short course on Mushroom Cultivation	July 15-21, 2015	ICAR-DMR, Solan
Rekha Singh	Short Course on A total value chain for processing of vegetable crops for nutritional security	September 1 - 11, 2015	ICAR-IIVR, Varanasi
SG Karkute	Training on Advanced computational tools and technology for molecular data analysis in agriculture	February 11- March 02, 2016	IASRI, New Delhi.
Tania Seth	Three months professional attachment training	May 28- August 27, 2015 May 28- August 27, 2015	ICAR-NRCPB, New Delhi
Y Suresh Reddy	ICAR sponsored winter school on Genomics and Phonemics assisted Crop Breeding: Principles and Practices	18 November– 8 December, 2015	ICAR-IARI, New Delhi

Training and Skill Development of Farmers, Field Functionaries and Enterpreneur:

Name of the Programme	Date	Sponsored by	Number & Nature of Participants
Dry storage of vegetable seeds	23 July 2015	IIVR-Bioversity International, New Delhi	130 Farmers from Jayapur, Varanasi
Vegetable for nutritional security	25 November 2015	ICAR-IIVR	100 Tribal Women of Bhalukudar, Sonbhadra
Vegetable for nutritional security	16-17 December 2015	ICAR-IIVR	50 Tribal Women of Sonbhadra
Integrated production & protection technologies in vegetable crops	28-30 December 2015	ATMA, Jahanabad	25 Farmers from Jahanabad, Bihar
Improved production technologies in vegetable crops	6-8 January 2016	ATMA, Sahibganj, Jharkhand	16 Farmers from Sahibganj, Bihar
Improved production technologies in vegetable crops	23-25 February 2016	Reddy's Foundation, Hyderabad	30 Field functionaries and farmers from Bihar & U.P.
Improved production technologies in vegetable crops	17-18 February 2016	DDA, Mau	18 Farmers from Mau, U.P.
Integrated production & protection technologies in vegetable crops	17-19 March 2016	ATMA, Jabalpur	26 Farmers from Jabalpur, M.P.
Integrated production & protection technologies in vegetable crops	27-30 March 2016	KHISTIZ Agro Tech Pvt. Ltd., Patna	31 Farmers from Patna, Bihar
Integrated production & protection technologies in vegetable crops	27-31 March 2016	ATMA, Sidhi, MP	18 Farmers from Sidhi, M.P.
Improved production technologies in vegetable crops	30-31 March 2016	ATMA, Rohtash	20 Farmers from Rohtash, Bihar
Entrepreneur development through value addition & seed production in vegetables	28-29 March 2016	IIVR, Varanasi	20 Agri-prenurer from Eastern Uttar Pradesh

Training and Skill Development of ICAR/SAUs/State/KVKs Officials:

Name of the Programme	Date	Sponsored by	Number & Nature of Participants
Improved production technologies in vegetable crops	29 April-1 May 2015	Hort Dept, Tikamgarh, MP	10 State officials from Tikamgarh, M.P.
Training cum workshop on Nutrition rich vegetable crops	11-13 August 2015	ZPD Zone VII, Jabalpur	80 KVKs officials from M.P., Odisha, Chhattishgarh
A total value chain for processing of vegetables for nutritional security	1-11 September 2015	ICAR Short Course	22 ICAR/KVK officials
Winter school-novel genomic tools & modern genetics & breeding approaches for vegetable crop improvement	7-27 November 2015	ICAR winter school	25 ICAR/KVK officials
Technologies commercialization in solaneceous vegetables	18 January 2016	ICAR-IIVR	13 Officials from ICAR/SAUs
Improved production technologies in vegetable crops	17-18 February 2016	University of Hort. Sci., Bagalkot	72 Students & 3 teachers from UHS, Bagalkot, Karnataka
Improved production technology of vegetable crops	23-25 February 2016	Dr Reddy Foundation, Hyderabad	28 field functionaries

Seminar/Symposium/Conference/Workshop attended:

Name of Scientist	Title of seminar/symposium/conference/workshop	Duration	Held at
AR Kumari	International Extension Education Conference on Education, Research and Services	January 27-30, 2016	BHU, Varanasi
AR Kumari	ISEE Golden Jubilee National Seminar 2015	November 05 -07,2015	BHU, Varanasi
AN Tripathi	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016. held at ICAR-IIVR, Varanasi	ICAR-IIVR, Varanasi
Anant Bahadur	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	IIVR, Varanasi
Anant Bahadur	National seminar on Breeding of field crops for biotic and abiotic stresses in relation to climate change	March 28-29, 2016.	VNMKV, Parbhani
BK Singh	Inter-session meeting of the consultative committee, Ministry of Agriculture and Farmers Welfare	November 6, 2015	ICAR-IIVR, Varanasi, UP
BK Singh	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
BK Singh	All India coordinated research project (Vegetable crops).	May 21-24, 2015	ICAR-IIVR, Varanasi
DK Singh	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	IIVR, Varanasi
DK Singh	Agri-Consortia Research Platform on Water (Efficient water management in horticultural crops)	March 15 2016	IIWM, Bhubaneswar
DR Bhardwaj	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
DR Bhardwaj	All India coordinated research project (Vegetable crops).	May 21-24, 2015	ICAR-IIVR, Varanasi
GP Mishra	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
Hira Lal	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
J Halder	IES International conference on Natural Resource Management: Ecological Perspective.	February 18-20, 2016	SKUAS&T, Jammu
JK Ranjan	All India coordinated research project (Vegetable crops).	May 21-24, 2015	ICAR-IIVR, Varanasi
JK Ranjan	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
JK Ranjan	Workshop of Nodal Officers of ICAR Research Data Repository For Knowledge Management initiative.	August 4-5, 2015	New Delhi
Jyoti Devi	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
K Nagendran	3rd International Symposium on Phytophytora : Taxonomy, Genomics, Pathogenicity, Resistance & Disease Management	September 9 -12, 2015	ICAR-IIHR, Bengaluru
K Nagendran	Workshop on Rapid Diagnostic Tools for Phytophthora	September 8, 2015	ICAR-IIHR, Bengaluru
K Nagendran	24th National Conference on Transboundary Viral Diseases Under One Health: Perspectives and Challenges	October 08 - 10, 2015	Indian Virological Society, New Delhi
K Nagendran	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
K Nagendran	3rd International Symposium Phytophthora: Taxonomy, Genomics, Pathogenicity, Resistance & Disease Management	September 9-12, 2015	ICAR-IIHR, Bengaluru
KK Gautam	All India coordinated research project (Vegetable crops).	May 21-24, 2015	ICAR-IIVR, Varanasi
KK Gautam	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
M Manjunath	National symposium on vegetable legumes for soil and human health	February 12-14, 2016	ICAR-IIVR, Varanasi
M H Kodandaram	National symposium on vegetable legumes for soil and human health	February 12-14, 2016	ICAR-IIVR, Varanasi

Name of Scientist	Title of seminar/symposium/conference/workshop	Duration	Held at
M K Pandey	National symposium on vegetable legumes for soil and human health	February 12-14, 2016	ICAR-IIVR, Varanasi
M Manjunath	National conference on emerging trends in fungal biology and plant protection	February 16-18, 2016	BHU, Varanasi
M Manjunath	Microbial ecology international workshop	June 29 - July 03, 2015	NBAIM, Mau
M. Manjunath	6th International Conference on Plant, Pathogens and People Challenges in Plant Pathology to Benefit Humankind	February 23-27, 2016	NASC Complex, New Delhi
M. Gowda Thondihalu	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
Neeraj Singh	ISEE Golden Jubilee National Seminar on Strategy to drive skill based agriculture development forward for sustainability and rural employability	November 5-7, 2015	BHU, Varanasi
Neeraj Singh	International Extension Education Conference on Education, Research and Services	January 27-30, 2016	BHU, Varanasi
Neeraj Singh	National Symposium on Vegetable legumes for soil and human health	February 12-14, 2016	ICAR-IIVR, Varanasi
PB Chaukhande	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
Pragya	National symposium on vegetable legumes for soil and human health	February 12-14, 2016	ICAR-IIVR, Varanasi
Pragya	All India coordinated research project (Vegetable crops)	May 21-24, 2015	ICAR-IIVR, Varanasi
R Prasad	ISEE Golden Jubilee National Seminar 2015 on Strategy to drive skill based agriculture development forward for sustainability and rural employability	November 05-07, 2015	BHU, Varanasi
R Sahu	International Extension Education Conference on Education, Research and Services	January 27-30, 2016	BHU, Varanasi
Raghwendra Singh	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	IIVR, Varanasi
Rajesh Kumar	All India coordinated research project (Vegetable crops)	May 21-24, 2015	ICAR-IIVR, Varanasi
Rajesh Kumar	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
RK Dubey	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
RP Choudhary	ISEE Golden Jubilee National Seminar on Strategy to drive skill based agriculture development forward for sustainability and rural employability	November 05-07, 2015	BHU, Varanasi
RP Sahu	ISEE Golden Jubilee National Seminar on Strategy to drive skill based agriculture development forward for sustainability and rural employability	November 05-07, 2015	BHU, Varanasi
Shubhadeep Roy	International Extension Education Conference on Education, Research and Services	January 27-30, 2016	BHU, Varanasi
Shubhadeep Roy	ISEE Golden Jubilee National Seminar 2015 on Strategy to drive skill based agriculture development forward for sustainability and rural employability	November 5-7, 2015	BHU, Varanasi
Shubhadeep Roy	National Symposium on Vegetable legumes for soil and human health.	February 12-14, 2016	ICAR-IIVR, Varanasi
SK Tiwari	BITS conference on Gene and Genome regulation.	February 18-12, 2016	BITS , Pilani
SK Tiwari	National symposium on 'Vegetable Legumes for Soil and Human Health'	February 12-14, 2016	ICAR-IIVR, Varanasi
SK Tiwari	All India coordinated research project (Vegetable crops)	May 21-24, 2015	ICAR-IIVR, Varanasi
SK Tiwari	Workshop on CRP-Agrobiodiversity	October 14, 2015	ICAR-NBPGR, New Delhi
SK Tiwari	Interaction meet cum workshop on National Agricultural Innovation Fund (NAIF)	December 23, 2015	NASC Complex, New Delhi

Name of Scientist	Title of seminar/symposium/conference/workshop	Duration	Held at
SK Tiwari	National Conference on Strategies in Plant Physiological Research for Meeting Challenges in Agriculture	March 03-05, 2016	BHU, Varanasi
SNS Chaurasia	XXXIIIrd AICRP group meeting	May 21-29 2015.	ICAR- IIVR, Varanasi
SNS Chaurasia	National conference on vegetable legume for soil and human health	February 12-14 , 2016.	ICAR- IIVR, Varanasi
Sudhakar Pandey	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
Sudhakar Pandey	10th review meeting of DUS test	February 26-27 2016.	ICAR-IIVR, Varanasi
Sudhakar Pandey	All India coordinated research project (Vegetable crops).	May 21-24, 2015	ICAR-IIVR, Varanasi
Sudhir Singh	National seminar on Dairy value chain in Eastern India: Prospects and Challenges	December 16-17,2015	BHU, Varanasi
Sudhir Singh	Advances in packaging technology	October 6-7, 2015	IIT, Roorkie
TK Koley	3rd Annual Conference of the India Section of AOAC international	November 19-20,2015.	Pune, Maharashtra
T Chaubey	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
T Chaubey	All India coordinated research project (Vegetable crops)	May 21-24, 2015	ICAR-IIVR, Varanasi
Tania Seth	National symposium on Vegetable Legumes for Soil and Human Health	February 12-14, 2016	ICAR-IIVR, Varanasi
TK Koley	National Symposium on Vegetable Legumes for Soil and Human Health	February 12-14,2016	IIVR, Varanasi
Y. Bijen Kumar	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	March 04-06, 2016	Imphal, Manipur

PUBLICATIONS

Research papers

International

1. Gowda Manjunath T, Patil Jagadeesh, Mansheppa Devindrappa, Rangasamy Vijayakumar and Verghese Abraham. 2016. Entomopathogenic nematodes: A potential biocontrol agent against Eggplant Ash weevil *Myllocerus subfaciatus* Guerin, (Colepotera: Curculionidae). *Nematology*, DOI: 10.1163/15685411-00002989.
2. Halder Jaydeep and Rai AB. 2016. Suitability of different prey aphids on the growth, development and reproduction of *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Chrysopidae: Neuroptera), *Proceedings of the Zoological Society*, 69(1):89-95. DOI 10.1007/s12595-014-0131-6.
3. Karkute SG, Easwaran M, Gujjar RS, Piramanayagam S and Singh M. 2015 Protein modeling and molecular dynamics simulation of SlWRKY4 protein cloned from drought tolerant tomato (*Solanum habrochaites*) line EC520061. *Journal of Molecular Modelling* 21:255
4. Khemaria P, Singh S, Jaiswal N and Chaurasia SNS. 2016. Isolation and Identification of *Lactobacillus plantarum* from vegetable samples, *Journal of Food Biotechnology*, 30(1): 49-62.
5. Kumari AR, Sanwal S and Shekhar S. 2015. A comparative on Apiculture Technology among Trained & Untrained Women. *International Journal on Recent and Innovation Trends in Computing & Communication*, 3(1): 140-143.
6. Kumari. A R, Shekhar S. and Sanwal S. 2015. Awareness of KVK Programme among Trainees in Deoria District, U.P. *International Journal in Management and Social Science*. 3(3): 116-119.
7. Lal H, Singh PM, Vishwa Nath and Singh R.. 2015. An impact assessment of vegetable cowpea (*Vigna unguiculata* (L.) Walp.) var. Kashi Kanchan. Proc. Nat. Acad. Sci., India, Section B : *Biological Sciences*, DOI 10.1007/s40011-014-0477-6.
8. Lama TD, Singh R K, Saikia US and Satapathy K K. 2015. Geomorphometric analysis of a hilly watershed in north east India. *International Journal of Agriculture, Environment & Biotechnology*. 8(1): 29-36.
9. Manjunath M, Kanchan A, Ranjan K, Venkatachalam S, Prasanna R, Ramakrishnan B, Hossain F, Nain L, Shivay YS, Rai AB and Singh B. 2016. Beneficial cyanobacteria and eubacteria synergistically enhance bioavailability of soil nutrients and yield of okra. *Heliyon*e, 66: 1-28.
10. Mintoo Sonakar VK, Kumar R, Loganathan M and Chandra R . 2015. Interspecific hybridization in *Capsicum* for management of anthracnose disease. *Trends in Biosciences* 8(16): 4389-4393.
11. Prasanna HC, Sinha DP, Rai GK, Krishna R, Kashyap SP, Singh NK and Singh M. 2015. Pyramiding Ty-2 and Ty-3 genes for resistance to monopartite and bipartite tomato leaf curl viruses of India. *Plant Pathology* 64 (2), 256-264
12. Prasanna HC, Kanakala S, Archana K, Jyothsna P, Varma R K and Malathi V G. 2015. Cryptic species composition and genetic diversity within *Bemisia tabaci* complex in soybean in India revealed by *mtCOI* DNA sequence. *Journal of Integrative Agriculture* 14(9): 1786-1795.
13. Prasanna H C , Kashyap S P, Krishna R , Sinha D P, Reddy Suresh and Malathi V G. 2015. Marker assisted selection of Ty-2 and Ty- 3 carrying tomato lines and their implications in breeding tomato leaf curl disease resistant hybrids. *Euphytica*, DOI: 10.1007/1s10681-015- 1357-8.
14. Rai N, Rai KK, Venkataravanappa V and Saha S. 2015. Molecular approaches coupled with biochemical attributes to elucidate the presence of DYMV in leaf sample of *Lablab purpureus* L. genotypes. *Applied Biochemistry and Biotechnology*, DIO 10-10071s 2010-015-1915-5.
15. Rai N, Rai KK, Tewari G and Singh PK. 2015. Changes in free radical generation, metabolites and antioxidant defence machinery in hyacinth bean (*Lablab purpureus* L) in response to high temperature stress. *Physiologia Pantatrum*, **37**: 46. (AO26)
16. Roy S, Singh N, Vanitha SM, Rai AB and Naik PS. 2015. E-Survey to analyse perception of agricultural experts regarding priority setting for future research in vegetables in India. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* pp.1-8. DOI: 10.1007/s40011-015-0562-5. Published online: 07 June 2015.
17. Shah K, Singh M and Rai AC. 2015. Bioactive compounds of tomato fruits from transgenic plants tolerant to drought. *LWT-Food Science and Technology* 61 (2), 609-614

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19. Shukla A, Singh VK, Bhardwaj DR, Kumar R, Rai A, Rai AK, Mugasimangalam R, Arameswaram., Singh M and Naik PS. 2015. *De Novo* assembly of bitter gourd Transcriptome: Gene expression and sequence variations in gynoecious and monoecious line. *PLOS/ONE*, DOI: 10:1371, 1-19.

20. Singh G, Saha S, Garg R, Sharma BK, Rai AB and Singh RP. 2015. Evaluation of suitable antagonists in the management of early blight of tomato cultivar CO-3. *International Journal of Agriculture, Environment and Biotechnology*, 8 (2): 127-133. DOI: 10.5958/2230-732X.2015.00017.0

21. Singh RK, N Rai, M Singh, SN Singh and K Srivastava 2015. Detection of tomato leaf curl virus resistance and inheritance in tomato (*Solanum lycopercicum* L.). *Journal of Agricultural Science* 153(1), 78-89.

22. Singh RK, N Rai, M Singh, SN Singh and K Srivastava 2015. Selection of tomato genotypes resistant to tomato leaf curl virus disease using biochemical and physiological markers. *Journal of Agricultural Science* 153 (4), 646-655

23. Singh RK, Rai N, Lima JM, Singh M, Singh SN and Kumar S. 2015.Genetic and molecular characterization of tomato leaf curl virus (*ToLCV*) resistance in tomato. *The Journal of Horticultural Science & Biotechnology*, 90(5):503-510.

24. Singh AK, Kumar S, Singh H, Rai VD, Singh BD and Pandey S. 2015. Genetic diversity in Indian snapmelon (*Cucumis melo* var. *momordica*) accessions revealed by ISSR markers. *Plant Omics Journal*, 8 (1): 9-16.

25. Singh Geeta, Saha S, Garg R, Sharma B K, Rai A B and Singh R P. 2015. Evaluation of suitable antagonists in the management of early blight of tomato cultivar CO-3. *International Journal of Agriculture, Environment and Biotechnology*, 8 (1): 127-133. DOI: 10.5958/2230-732X.2015.00017.0.

26. Singh Satyandra, Singh Bijendra and Singh AP. 2015. Nematodes: A threat to sustainability of agriculture. *Procedia Environmental Science.* 29 (2015) 215-216.

27. Srivastava S, Koley TK, Singh SK and Tripathi, YB. 2015. The tuber extract of puerariatuberosalinn. Competitively inhibits DPP-IV activity in normoglycemic rats. *International Journal of Pharmacy and Pharmaceutical Sciences*, 7(9).

28. Upadhyay P, Rai A, Kumar R, Singh M and Sinha B. 2015. Microarray analyses during early stage of the tomato/*A. solani* interaction. *Genomics Data* 6: 170–172.

29. Upadhyay R, Kashyap S, Singh C, Tiwari K, Singh K and Singh M. 2015 Assessment of factors on shoot proliferation potential of nodal explants of Phyllanthus fraternus and assessment of genetic fidelity of micropropagated plants using RAPD marker. *Biologia* 69 (12), 1685-1692

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National

1. Bahadur A, Rai N, Kumar R, Tiwari SK, Singh AK, Rai AK, Singh U, Patel PK, Tiwari V, Rai AB, Singh M and Singh B. 2015. Grafting tomato on eggplant as a potential tool to improve waterlogging tolerance in hybrid tomato. *Vegetable Science*, 42 (2): 82-87.

2. Bahadur Anant, Lama TD and Chaurasia SNS. 2015. Gas exchange, chlorophyll fluorescence, biomass production, water use and yield response of tomato (*Solanum lycopersicum*) grown under deficit irrigation and varying nitrogen levels. *Indian Journal of Agricultural Sciences* 85 (2): 224-228.

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4. Devi J, Sharma A, Singh Y, Katoch V and Sharma KC. 2015.Genetic variability and character association studies in French bean (*Phaseolus vulgaris* L.) under North-Western Himalayas. *Legume Research*, 38 (2): 149-156.

5. Devi J, Sood S, Vidyasagar and Y Singh. 2015. Inheritance of bacterial wilt resistance and performance of horticultural traits in bell pepper (*Capsicum annuum* var. *grossum*). *Indian Journal of Agricultural Sciences* 85 (11): 1498-1503

6. Gautam HK, Singh NN and Rai AB. 2015. Effect of some plant extract and an insecticide on the

incidence of *Earias vittella* in okra. *Indian Journal of Agricultural Research*, 49(2): 175-179.

7. Halder Jaydeep, Kodandaram MH, Rai AB and Singh B. 2015. Bio-efficacy of Some newer acaro-insecticides against yellow mite (*Polyphagotarsonemus latus* (Banks) and thrips (*Scirtothrips dorsalis* Hood) in chilli. *Pesticide Research Journal,* 27(2): 171-174.
8. Halder J, Sanwal SK, Rai AK, Rai AB, Singh B and Singh BK. 2015. Role of physico-morphic and biochemical characters of different okra genotypes in relation to population of okra shoot and fruit borer, *Earias vittella* (Noctuidae: Lepidoptera). *Indian Journal of Agricultural Sciences*, 82(2): 278-282.
9. Halder Jaydeep, Khushwaha Deepak, Singh Arpita, Tiwari SK, Rai AB and Singh B. 2015. Whether *Leucinodes orbonalis* Gunee is becoming a serious problem to brinjal seedlings in nursery? *Pest Management in Horticultural Ecosystems*, 21(2):231-232.
10. Halder Jaydeep, Kodandaram MH, Rai AB, Kumar Rajesh and Singh B. 2015. Impact of different pest management modules against the major sucking pest's complex of chilli. *Indian Journal of Agricultural Sciences*, 84 (11): 1431–143.
11. Halder Jaydeep, Kushwaha Deepak, Yadava RB, Rai AB and Singh B. 2015. Incidence of Amaranthus foliage feeders in relation to different organic soil amendments. *Pest Management in Horticultural Ecosystems*, 21(1):112-114.
12. Halder Jaydeep, Rai AB and Dey Debjani. 2015. Occurrence of *Phenococcus solenopsis* (Tinsley) in vegetable ecosystem and host-mediated effects on its dominant parasitoid, *Aenasius bambawalei* Hayat. *Vegetable Science*, 42 (2): 30-33.
13. Kodandaram MH, Rai AB, Sireesha K and Halder Jaydeep. 2015. Efficacy of cyantraniliprole a new anthranilic diamide insecticide against fruit and shoot borer *Leucinodes orbonalis* (Lepidoptera: Crambidae) on brinjal. *Journal of Environmental Biology*, 36: 1415-1420.
14. Kodandaram MH, Rai AB and Halder Jaydeep. 2015. Baseline susceptibility of whitefly *Bemisia tabaci* to a new anthranilic diamide insecticide cyantraniliprole 10 OD. *Indian Journal of Plant Protection*, 43(4): 503-505.
15. Kumari AR , Laxmikant , Kumar R, and Kumar S. 2015. Constraints and Strategies in Adoption of Beekeeping by Beekeeping Entrepreneurs. *Journal of Plant Development Sciences*, 7 (3): 221- 224.
16. Kumari AR and Laxmikant. 2015. Role of Farm Women in Agricultural activities. *Agriculture Update*, 10 (1): 31-35.
17. Lesha Bohane, Rajesh Tiwari and K.K. Gautam. 2016. Integrated nutrient management in ber (*Zizyphus mauritiana Lamk.*) *cv.* Gola under Malwa Plateau conditions of Madhya Pradesh. *Indian Journal of Horticulture*. 73(1): 128-132.
18. Loganathan M, Manjunath M, Saha S, K Akhilesh, Rai AB and Singh B. 2015. Comparative efficacy of different fungicides in the control of chilli anthracnose. *Indian Journal of Plant Protection*, 43 (2): 214-216.
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20. Prasad V, Dwivedi VK, Deshpande AA and Singh BK. 2015. Genetic combining ability for yield and other economic traits in brinjal (*Solanum melongena* L.). *Vegetable Science* 42(2): 25-29.
21. Ranjan Pragya, Gangopadhyay KK, Bag, Manas Kumar , Roy Anirban, Srivastava R, Bhardwaj R and Dutta M. 2015. Evaluation of cucumber germplasm for agronomic traits and disease resistance and estimation of genetic variability. *Indian Journal of Agricultural Sciences* 85 (2): 234-9.
22. Roy S, Singh N, Vanitha SM, Rai AB and Naik PS. 2015. E-Survey to Analyse Perception of Agricultural Experts Regarding Priority Setting for Future Research in Vegetables in India. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences*, 1-8.
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27. Singh B , Chaubey T, Upadhyay DK, Jha A, Pandey SD and Sanwal SK. 2015. Varietal characterization of okra (*Abelmoschus esculentus*) based on morphological descriptions. *Indian Journal of Agricultural Sciences* 85 (9): 1192–1200.

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Popular article

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12. Singh BK, Lal H, Ranjan JK and Singh B. 2016. Snap bean (*Phaseolus vulgaris* L.): advances in genetic improvement. In: Souvenir & abstract, National Symposium on Vegetable legumes for soil and human health, ICAR-IIVR, Varanasi, pp 125-136.
13. Verma VK, Jha AK, Pandey A and Singh BK. 2016. An overview of legume vegetables in North Eastern India. In: Souvenir & abstract, National Symposium on Vegetable legumes for soil and human health, ICAR-IIVR, Varanasi, pp 17-25.

Newsletter

1. Singh B, Singh BK, Roy S, Koley TK and Singh Neeraj. 2015. Vegetable Newsletter. Vol-2, Issue-1, January-June, 2015, ICAR-IIVR, Varanasi.

Radio Talks: 12

TV Talks : 15

Appointments, Transfers and Promotion

Appointments

1. Dr. Tania Seth joined the post of Scientist (Vegetable Science) on 10.04.2015 at ICAR-IIVR.
2. Sh. Keshav Kant Gautam joined the post of Scientist (Vegetable Science) on 10.04.2015 at ICAR-IIVR.
3. Sh. P.B. Chaukhande joined the post of Scientist (Vegetable Science) on 10.04.2015 at ICAR-IIVR.
4. Sh. Manjunatha GowdaT joined the post of Scientist (Nematology) on 10.04.2015 at ICAR-IIVR.
5. Dr. Nagendran Krishnan joined the post of Scientist (Plant Pathology) on 10.04.2015 at ICAR-IIVR.
6. Dr. B. Rajasekhar Reddy joined the post of Scientist (Vegetable Science) on 10.04.2015 at ICAR-IIVR.
7. Sh. Bharat Raj Meena joined the post of Scientist (Plant Pathology) on 12.10.2015 at ICAR-IIVR.
8. Sh. Pratap A. Divekar joined the post of Scientist (Agricultural Entomology) on 12.10.2015 at ICAR-IIVR.
9. Sh. Nakul Gupta joined the post of Scientist (Seed Science & Technology) on 12.10.2015 at ICAR-IIVR.
10. Dr. Raghwendra Singh joined the post of Senior Scientist (Horticulture- Vegetable Science) on 30.10.2015 at ICAR-IIVR.
11. Dr. Rakesh Kumar Dubey joined the post of Senior Scientist (Horticulture-Vegetable Science) on 6.11.2015 at ICAR-IIVR.
12. Dr. Vikas Singh joined the post of Senior Scientist (Seed Science & Technology) on 24.11.2015 at ICAR-IIVR.
13. Dr. Achuit K. Singh joined the post of Senior Scientist (Biotechnology) on 08.02.2016 at ICAR-IIVR
14. Dr. Gyan P. Mishra joined the post of Senior Scientist (Genetics & Plant Breeding) on 26.10.2015 at ICAR-IIVR .

Promotions

1. Dr. Jaydeep Halder, Scientist (Agril. Entomology) promoted from Rs.15600-39100 +RGP 6000 to 15600-39100 +RGP 7000 *w.e.f.* 21.04.2013.
2. Dr. Shailesh Kumar Tiwari, Scientist (Plant Breeding) promoted from Rs. 15600-39100 + RGP 6000 to 15600-39100 + RGP 7000 *w.e.f.* 22.062013.
3. Dr. Ranjan Srivastawa, Senior Technical Officer promoted to Assistant Chief Technical Officer from Rs. 15600-39100 + RGP 5400 to 15600-39100 + RGP 6600 *w.e.f.* 15.06.2015.
4. Sh. ML Viswakarma, Technical Assistant promoted to Technical Officer from 5200--20 200 + RGP 2800 to 9300-34800 + RGP 4600.
5. Sh. Sanjay Singh, Technical Assistant promoted to Senior Technical Assistant from 5200-20200 + RGP 2800 to 9300-34800 + RGP 4200.

Transfers

1. Dr. T.D. Lama, Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-CSSRI Regional Station, Canning Town, West Bengal on 16.05.2015.
2. Dr. S.K.Sanwal , Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-CSSRI , Karnal on 16.05.2015.
3. Dr. Satyendra Singh, Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-NCIPM, New Delhi on 16.05.2015.
4. Dr. M. Loganathan, Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-Directorate of Cashew Research, Puttur, Karnataka on 16.05.2015.
5. Dr. Sujoy Saha , Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-NRC on Grapes, Pune on 16.05.2015.
6. Dr. P.K. Singh, Senior Scientist transferred from ICAR-IIVR, Varanasi to ICAR-IARI, New Delhi on 16.05.2015.
7. Dr. V. Venkataravanappa , Scientist transferred from ICAR-IIVR, Varanasi to ICAR-IISR, Calicut on 16.05.2015.
8. Dr. Ranjan Srivastawa, Senior Technical Officer transferred from ICAR-IIVR, Varanasi to ICAR-IIPR, Kanpur on 13.07.2015.
9. Dr. S.K. Singh joined the post of Principal Scientist (Agronomy) on 11.09.2015 at ICAR-IIVR after his transfer from ICAR-CPRS, Patna.
10. Dr. A. N. Tripathi joined the post of Scientist (Plant Pathology) on 13.11.2015 at ICAR-IIVR after his transfer from CRIJAF, Barrackpore.
11. Dr. K.K. Pandey joined the post of Principal Scientist (Plant Pathology) on 17.12.2015 at ICAR-IIVR after his transfer from ICAR-CPRI, Shimla.
12. Dr. Anant Bahadur Senior Scientist joined at ICAR-IIVR, Varanasi on 4.5.2015 after his transfer from RRS, Sargatia, Kushinagar.

Classified Abstracts of Expenditures

Indian Institute of Vegetable Research (plan and non-plan) 2015-2016

(In Lakhs)

Sub-head	Plan		Non-Plan	
	Provision made in RE 2015-2016	Expenditure	Provision made in RE 2015-2016	Expenditure
Establishment Charges	-	-	900.00	895.92
Wages	-	-	-	-
O.T.A.	-	-	0.30	-
T.A.	15.00	15.00	4.00	4.00
Other Charges (Contingency)	387.18	387.18	75.30	53.16
H.R.D.	7.12	7.12	-	-
Works	156.62	156.62	-	-
Equipment	49.90	36.08	0.50	0.50
Library	14.86	14.85	-	-
Vehicle	-	-	-	-
Annual Repairs / Maintenance	-	-	2.00	1.97
Information Technology	0.42	0.42	-	-
TSP NEH	10.00	9.99	-	-
Total	**941.10**	**627.26**	**982.10**	**955.55**

Revenue generation (2015-2016)

(In Lakhs)

Particulars	Target	Revenue generation
IIVR	**183.51**	**132.11**

Krishi Vigyan Kendra (plan) 2015-2016

(In Lakhs)

KVKs	RE 2015-2016	EXPENDITURE
KVK, Kushinagar	99.75	96.36
KVK, Deoria	85.50	64.90
KVK, Bhadohi	109.40	109.07
Total	**294.65**	**270.33**

Externally Funded Projects

(In lakhs)

Name of project	Funding agency	Duration of projects	Total allocation	Allocation & Expenditure 2015-16	
				Allocation	Expenditure
Crop Improvement					
Gene expression studies and development of functional markers for anthracnose disease in *Capsicum species* (Completed on 16 July, 2015)	DST	2012-15	39.30	6.04	(-) 3.76
Studies on male sterility system to increase the efficiency F_1 hybrid development in horticultural crops: Chilli	ICAR	2014-17	20.00	5.88	4.63
Genomics-assisted selection of *Solanum chilense* introgression lines for enhancing drought resistance in tomato	DBT, India – BBSRC, UK	2015-18	132.00	74.08	41.22
Introgression of begomo virus resistance genes in tomato (*Solanum lycopersicum* L.) using MAS and genomics approach	DBT	2014-19 (Dec.-Dec.)	73.73	-	-
National Innovation in Climate Resilient Agriculture (NICRA)	ICAR	2011-17	336.00	110.50	81.95
CRP on Hybrid Technology (Tomato)	ICAR	2015-17	26.87	11.27	10.20
Network Project on Transgenic Crops (NPTC)	ICAR	2005-17	147.00	22.50	22.30
Evaluation of high yielding varieties/hybrids of cucurbitaceous vegetables for riverbed (diara land) cultivation and standardization of their agro-techniques	UPCAR	2015-17	20.988	6.27	4.14
CRP on Agrobiodiversity	ICAR	2015-17	44.00	14.00	10.14
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)	PPVFRA	2009-16	19.50	*30.597	8.76
Agri Business Incubator-IIVR, Varanasi	ICAR	2016-17 (January)	79.15	19.15	3.13
Zonal Technology Management Unit-IIVR, Varanasi	ICAR	2015-17	--	10.00	9.87
Crop Production					
Network project on Micronutrients Management in Horticultural Crops for Enhancing Yield and Quality	ICAR	2014-17	44.60	14.53	13.82
Network Project on Organic Farming in Horticultural Crops	ICAR	2014-17	22.62	9.63	8.96
Network project on new initiatives in protected horticulture	ICAR	2014-17	53.80	25.296	6.645
Efficient water management in horticultural crops under Agri-CRP on water	ICAR	2015-17	27.00	23.98	0.39
A total value chain on commercialization of value added convenience vegetable products	UPCAR	2014-17	17.82	4.67	5.95
Network project on phytochemicals/high value compounds	ICAR	2014-17	141.17	22.00	11.73

(In lakhs)

Name of project	Funding agency	Duration of projects	Total allocation	Allocation & Expenditure 2015-16	
				Allocation	Expenditure
ICAR Inter-institutional Collaborative Project on Livelihood and Nutritional Improvement of Tribal Farm Women through Horticulture	ICAR	2015-17	13.50	6.50	4.20
NHB Project on Promotion of Vegetables for Nutritional Security in Eastern Uttar Pradesh	NHB	2015-18	24.90	8.80	5.60
Tribal Sub-Plan (TSP) for Schedule Tribes of Sonbhadra district in Uttar Pradesh	ICAR	2012-17	70.00	10.00	10.00
Crop Protection					
NICRA project on Real Time Pest Dynamics (RTPD) in tomato	ICAR-NCIPM, New Delhi	2011-2017	5 .00	4.36	4.44
ORP on management of sucking pests in horticultural crops	ICAR-IIHR, Bengaluru.	2014-2017	15.0	8.00	9.37
Consortium research project on insect borers	ICAR-IIHR, Bengaluru.	2014-2017	68.50	6.90	6.37
Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops (PHYTOFURA)	ICAR-IISR, Calicut	2009-2017	48.80	4.50	11.91
Development and validation of effective formulation(s) of PGPR having multicide mechanism for pest management in vegetables	UPCAR	2014-2017	24.8975	5.64	5.39
Synthesis and validation of sustainable and adoptable IPM technology for cucurbitecious vegetable crops	ICAR-NCIPM	2014-17	6.00	1.31	1.17

*Amount received against DUS testing fee to increase the height of boundary wall (D1 & D2 plots.)

Personal (as on 31.03.2016)

S.N.	Category	Sanctioned Strength	Staff in Position	Vacant
SCIENTIFIC				
1.	Scientist	41	39	02
2.	Senior Scientist	17	11	06
3.	Principal Scientist	06	04	02
	TOTAL	**64**	**54**	**10**
TECHNICAL				
1.	Technician	11	10	01
2.	Sr. Technician	-	-	-
3.	Technical Assistant	13	08	05
4.	Sr. 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 Fin. & Accounts Officer	01	01	-
4.	Assistant Adm. Officer	01	01	-
5.	Assistant	05	03	02
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**	**-**

Staff strength of KVKs

KVK Sargatia, Kushinagar

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	01	-
2.	Subject Matter Specialist	06	06	-
3.	Farm Manager	01	01	-
4.	Programme Assistant	01	-	1
5.	Programme Assistant (Computer)	01	-	01
6.	Assistant	01	01	
7.	Stenographer Gr. III	01	-	01
8.	T-1 (Driver)	02	02	-
9.	SSS	02	-	02
	Total	**16**	**11**	**05**

KVK Deoria

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	-	01
2.	Subject Matter Specialist	06	06	-
3.	Farm Manager	01	01	-
4.	Prog. Assistant	01	01	-
5.	Prog. Assistant (Comp.)	01	-	01
6.	Assistant	01	-	01
7.	Stenographer Gr. III	01	-	01
8.	T-1 (Driver)	02	02	-
9.	SSS	02	-	02
	Total	**16**	**10**	**06**

KVK Bhadohi

Sl. No.	Designation	Sanctioned strength	Staff in position	Vacant
1.	Programme Coordinator	01	01	-
2.	Subject Matter Specialist	06	05	01
3.	Farm Manager	01	01	-
4.	Prog. Assistant	01	01	-
5.	Prog. Assistant (Comp.)	01	01	-
6.	Assistant	01	01	-
7.	Stenographer Gr.III	01	-	01
8.	T-1 (Driver)	02	02	-
9.	SSS	02	-	02
	Total	**16**	**12**	**04**

Staff in position (as on 31-03-2016)

Sl. No.	Name	Designation	Email
1.	Dr. Bijendra Singh	Director	directoriivr@gmail.com
Director's Cell			
2.	Sh. S.K. Srivastava	Personal Assistant	-
3.	Sh. Ajayan P.	Personal Assistant	ajaynair27@gmail.com
Project Coordinator Cell			
4.	Dr. Major Singh	Project Coordinator	singhvns@gmail.com
5.	Dr. T. Chaubey	Senior Scientist	tchaubay@gmail.com
6.	Dr. B. Rajasekhar Reddy	Scientist	rajasekharhortico@gmail.com
7.	Dr. A.P. Singh	Senior Technical Officer	apsinghcuts@gmail.com
Division of Vegetable Improvement			
8.	Dr. P.M. Singh	Principal Scientist and I/C Head	pmsiivr@gmail.com
9.	Dr. Hira Lal	Principal Scientist	hiralaliivr@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	Senior Scientist	rajes74@gmail.com
13.	Dr. Prasanna H.C.	Senior Scientist	prasannahc@yahoo.com
14.	Dr. Gyan P. Mishra	Senior Scientist	Gyan.gene@gmail.com
15.	Dr. Sudhakar Pandey	Senior Scientist	sudhakariivr@gmail.com
16.	Dr. J.K. Ranjan	Senior Scientist	jkranjan2001@yahoo.co.in
17.	Dr. Pragya	Senior Scientist	ruchi_105@rediffmail.com
18.	Dr. Achuit K. Singh	Senior Scientist	achuit@gmail.com
19.	Dr. Rakesh Kumar Dubey	Senior Scientist	rksdubey@gmail.com
20.	Sh. C. Manimurugan	Scientist	manimuruganc@gmail.com
21.	Dr. Shailesh Kumar Tiwari	Scientist	tiwarishailu@gmail.com
22.	Dr. Y. Suresh Reddy	Scientist	yerasusureshreddy@yahoo.co.in
23.	Sh. Ranjeet Singh Gujjar	Scientist	ranjit.gujjar@gmail.com
24.	Dr. Binod Kumar Singh	Scientist	bksinghkushinagar@yahoo.co.in
25.	Dr. Jyoti Devi	Scientist	Jyoti17iivr@gmail.com
26.	Sh. S.G. Karkute	Scientist	suhaskarkute@gmail.com
27.	Dr. Tania Seth	Scientist	taniaseth.19@gmail.com
28.	Sh. Keshav K. Gautum	Scientist	kkgautam008@gmail.com
29.	Sh. Nakul Gupta	Scientist	nakulgupta1988@gmail.com

Sl. No.	Name	Designation	Email
30.	Sh. A.K. Singh	Assistant Chief Technical Officer	ashoksinghiivr@gmail.com
31.	Sh. Vishwanath	Senior Technical Officer	vishwanathbhargava@gmail.com
32.	Sh. Ashutosh Goswami	Senior Technical Officer	Ashutosh12031972@gmail.com
33.	Sh. Chandra Bushan	Technical Officer	Cb.dubey2011@gmail.com
34.	Sh. Subhash Chandra	Technical Assistant	Subhash301269@gmail.com
Division of Vegetable Production			
35.	Dr. R.N. Prasad	Principal Scientist & I/C Head	rnprasad_zcu@rediffmail.com
36.	Dr. Sudhir Singh	Principal Scientist	sudhiriivr@gmail.com
37.	Dr. S.N.S. Chaurasia	Principal Scientist	chaurasiaiivr@yahoo.com
38.	Dr. Neeraj Singh	Principal Scientist	neerajatic@gmail.com
39.	Dr. D. K. Singh	Principal Scientist	dharmendradksingh@rediffmail.com
40.	Dr. S.K. Singh	Principal Scientist	skscprs@gmail.com
41.	Dr. Anant Bahadur	Senior Scientist	singhab98@ gmail.com
42.	Dr. Raghwendra Singh	Senior Scientist	singhraghu75@gmail.com
43.	Dr. Shubhadeep Roy	Scientist	shubhadeepiari@gmail.com
44.	Dr. Tanmay Kumar Koley	Scientist	tanmay_iari@rediffmail.com
45.	Ms. S. M. Vanitha	Scientist	vanita.gkvk@gmail.com
46.	Sh. P.B. Chaukhande	Scientist	paresh.chaukhande@gmail.com
47.	Sh. Y.P. Singh	Technical Officer	ybsinghiivr@gmail.com
48.	Sh. P. C. Tripathi	Senior Technical Assistant	tripa732003yahoo.co.in
49.	Sh. Pankaj Kumar Singh	Senior Technician	-
50.	Rajesh Kumar Rai	Technician	rkrairk@rediffmail.com
Division of Vegetable Protection			
51.	Dr. A.B. Rai	Principal Scientist & Head	abraiiivr@gmail.com
52.	Dr. K.K. Pandey	Principal Scientist	kkpiivr@gmail.com
53.	Dr. M.H. Kodandaram	Senior Scientist	kodandaram75@gmail.com
54.	Dr. Jaydeep Halder	Scientist	jaydeep.halder@gmail.com
55.	Dr. M. Manjunath	Scientist	manjumbl@gmail.com
56.	Dr. A.N. Tripathi	Scientist	antripathi_patho@rediffmail.com
57.	Sh. C. Sellaperumal	Scientist	perumal14@gmail.com
58.	Sh. Y. Bijen Kumar	Scientist	bijen_ac@yahoo.in
59.	Dr. Nagendran Krishnan	Scientist	krishnagendra@gmail.com
60.	Sh. Manjunatha Gowda T.	Scientist	goudru9@gmail.com
61.	Sh. Pratap A. Divekar	Scientist	pratapento@gmail.com
62.	Sh. Bharat Raj Meena	Scientist	brrm1406@gmail.com
63.	Sh. Raghubansh Mani Rai	Assistant Chief Technical Officer	raghubanshmaniiivrgmail.com
Administrative Staff			
64.	Sh. Sumit Kumar Jindal	Senior Administrative Officer	saoiivr@gmail.com
65.	Sh. D.K. Agnihotri	Assistant Finance & Account Officer	dkagnihotri@yahoo.com
66.	Sh. U.N. Tiwari	Assistant Administrative Officer	udainarayantiwari@gmail.com
67.	Sh. Ajayan P.	Personal Assistant	ajaynair27@gmail.com
68.	Sh. Gopi Nath	Assistant	gopiiivr@gmail.com
69.	Sh. Rajesh Kumar Rai	Assistant	rai.rajesh72@gmail.com
70.	Sh. R.K. Mehrotra	UDC	ritesh.iivr@gmail.com
71.	Sh. A.K. Mishra	UDC	arunmishraiivr@gmail.com
72.	Sh. S.K. Gupta	UDC	sushilskg@yahoo.co.in

Sl. No.	Name	Designation	Email
Farm Section			
73.	Dr. T. Chaubey	In-charge Farm	tchaubay@gmail.com
74.	Sh. Vishwanath	Farm Manager	vishwanathbhargava@gmail.com
75.	Sh. Pankaj Kumar Singh	Senior Technician	
76.	Sh. K.K. Upadhyay	Senior Technical Assistant	upadhyay@gmail.com
PME Cell			
77.	Dr. A.B. Rai	Chairman	abraiiivr@gmail.com
78.	Dr. Sunil Gupta	Assistant Chief Technical Officer	gupta.sunil191@gmail.com
Library			
79.	Sh. S.K. Singh	Assistant Chief Technical Officer	Sksinghiivr@gmail.com
Institute Service Unit			
80.	Dr. B.K.Singh	Chairman	
81.	Sh. Ashutosh Goswami	Senior Technical Officer	Ashutosh12031972@gmail.com
82.	Sh. M.L. Vishwakarma	Senior Technical Assistant	-
83.	Sh. Sanjay Singh	Senior Technical Assistant	
84.	Sh. Rajendra Kumar	Technical Assistant	-
85.	Sh. Manoj Kumar	Technical Assistant	
86.	Sh. Ram Ashrey	Technical Assistant	-
Supporting Staff			
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	-
94.	Sh. Ramraj	SSS	-
95.	Sh. Suresh Kumar Yadav	SSS	-
96.	Sh. Shuresh 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. R.B. Yadava	Principal Scientist & Incharge	raj_yadava@rediffmail.com
104.	Dr. Vikas Singh	Senior Scientist	vikaschf@gmail.com
105.	Mr. Pradip Karmakar	Scientist	pradip9433@gmail.com
106.	Dr. B. Mahesha	Scientist	maheshapathology@gmail.com
107.	Dr. Rameshwar Singh	Assistant Chief Technical Officer	bisen.singh@gmail.com
108.	Sh. Motilal Kushwaha	Programme Assistant	motilal.kushwaha@yahoo.com

Sl. No.	Name	Designation	Email
Krishi Vigyan Kendra, Sargatia, Kushinagar			
109.	Dr. A. K. Dubey	Programme Coordinator	akdubeykvk@yahoo.co.in
110.	Sh. Ashok Rai	SMS (Ag. Extn)	-
111.	Sh. Ajay Kumar Rai	SMS (PP)	-
112.	Sh. Rajneesh Srivastava	SMS (Hort)	-
113.	Sh. Yogesh Kumar	SMS (AS)	-
114.	Smt. Anjali Sahu	SMS (HS)	-
115.	Dr. T.N. Rai	SMS (Soil Science)	-
116.	Sh. Sanjay Gautam	Programme Assistant	-
117.	Prasant Kumar Gupta	Office Superintendent	-
118.	Sh. Pankaj Kumar Singh	T-1 (Driver)	-
119.	Sh. Satish Kumar Singh	T-1 (Driver)	-
Krishi Vigyan Kendra, Deoria			
120.	Smt. A. R. Kumari	SMS (HS)	anuradha_rau@rediffmail.com
121.	Sh. Anil Kumar	SMS (Hort.)	anil_kumar793@yahoo.co.in
122.	Sh. Kamalesh Meena	SMS (SS & Agro)	kamalaagronomy@gmail.com
123.	Dr. Manoj K. Pandey	SMS (PP)	mkp_bxr@yahoo.co.in
124.	Sh. Ajay Tiwari	Farm Manager	ajitiwariiivr@gmail.com
125.	Sh. Vikash Kumar	Programme Assistant (Comp.)	vikashkumar@gmail.com
126.	Sh. Bharat Singh	T-1 (Driver)	-
127.	Sh. Sharad Chand Rai	T-1 (Driver)	-
Krishi Vigyan Kendra, Bhadohi			
128.	Dr. Rajendra Prasad	Programme Coordinator	rprasadZCU4@rediffmail.com
129.	Dr. A. K. Chaturvedi	SMS (Hort.)	akciivr@gmail.com
130.	Dr. Rakesh Pandey	SMS (PP)	rakesh_pandey01@rediffmail.com
131.	Dr. G. K. Choudhary	SMS (Vet. Science)	drgovindvet@yahoo.co.in
132.	Dr. R. P. Choudhary	SMS (Ag. Extn)	-
133.	Smt. Rekha Singh	SMS (HS)	rekhaiivr@gmail.com
134.	Dr. A.K. Singh	SMS (Vet. Science)	-
135.	Sh. V. V. Diptikar	Programme Assistant (Comp.)	v_v_diptikar@rediffmail.com
136.	Dr. P. C. Singh	Farm Manager	prabhashiivr@gmail.com
137.	Sh. Roshan Lal	Office Superintendent	-
138.	Sh. D.P. Singh	Programme Assistant	-
139.	Sh. Sanjay K. Yadav	T-1 (Driver)	-
140.	Sh. Pramod Paswan	T-1 (Driver)	-

Annexure I

Institute Management Committee (IMC)

Dr. Bijendra Singh Director ICAR-IIVR, Varanasi	Chairman
Dr. T.S. Aghora Principal Scientist (Vegetable Breeder) ICAR-Indian Institute of Horticulture Research Hessarghatta Lake Post Bengaluru- 560089 (Karnataka)	Member
Dr. Pratibha Brahmi Principal Scientist (Vegetable Botanist) ICAR-National Bureau of Plant Genetics Resources Indian Agriculture Research Institute Pusa Campus, New Delhi – 110012	Member
Dr. A.K. Srivastava Principal Scientist (Soil Science) ICAR-National Research Centre for Citrus P.B. No.464, Shankar Nagar Post Office Nagpur – 440010 (Maharastra)	Member
Dr. (Mrs.) Anju Bajpai Senior Scientist Central Institute of Sub-tropical Horticulture Rahmankhera, P.O. Kakori, Lucknow-227107	Member
Dr. Ranvir Singh Principal Scientist (Hort.) Indian Council of Agriculture Research Krishi Anusandhan Bhawan-II Pusa, New Delhi-110012	Member
Dr. N.C. Gautam Dean, College of Horticulture Narendra Dev University of Agriculture & Technology Faizabad (UP)	Member
The Finance & Accounts Officer Central Institute for Sub-tropical Horticulture Rahmankhera, P.O. Kakori, Lucknow - 227107 (UP)	Member
Shri Brijesh Tripathi 303, Poonam Apartment Plot No.104, Sector No.2 Kopar Khairne, Navi Mumbai- 400701	Non Official Member
Shri Mohammed Talib Ali House No.369/14-Kha Bibi Ganj, Post – Saadat Ganj Lucknow – 226003 (UP)	Non Official Member
Shri O.N. Singh Director (Hort.) Govt. of Uttar Pradesh, 2 Sapru Marg, Lucknow	Member
Shri Ajay Yadava Director (Hort.) Department of Agriculture, Govt. of Bihar Vikas Bhavan, Balley Road, Patna-800015 (Bihar)	Member

Annexure II

Research Advisory Committee (RAC)

Dr. P. Parvatha Reddy Director (Retd.) Indian Institute of Horticultural Research House No.34, UAS Layout Ist Main, 7th Cross, Sanjay Nagar Bengaluru-560094	Chairman
Dr. O.P. Dutta Director (Research) M/s Namdhari Seeds Bidadi (Near Bengaluru) Karnataka– 562109	Member
Dr. T. Mahapatra Director Central Rice Research Institute Cuttack Odisha-753006	Member
Dr. C.K. Narayana HoD, PHT Indian Institute of Horticulture Research Hessaraghatta Lake Post Bengaluru-560089	Member
Dr. Kaushik Banerjee Principal Scientist NRC for Grapes P.B. No.-3, Manjri Farm Post Solapur Road, Pune-412307	Member
Dr. Sudha Mysore Principal Scientist Indian Institute of Horticulture Research Hessaraghatta Lake Post Bengaluru-560089	Member
Sh. Brijesh Tripathi 303 Poonam Apartment Plot No. 104, Sector No. 2 Kopar Khaire, Navi Mumbai-400701.	Non official member
Sh. Md. Talib Ali House No. 369/114-kha Bibiganj, Post – Sadatganj Lucknow-226003.	Non official member
Dr. T. Janakiram Asstt. Director General (Hort.-II) ICAR, Krishi Anusandhan Bhawan-II, Pusa, New Delhi-110012	Ex- officio Member
Dr. B. Singh Director ICAR-IIVR, Varanasi-221305	Ex- officio Member
Dr. P.M. Singh Principal Scientist ICAR-IIVR, Varanasi-221305	Member Secretary

Annexure III

Quinquennial Review Team (QRT)

1.	Dr. S.K. Pandey Former Director CPRI, Shimla 78, Marutipuram, Faizabad Road Lucknow-226016 (U.P.)	Chairman
2.	Dr. V. A. Parthasarathy Former Director Indian Institute of Spices Research (IISR), P.B. No. 1701, Marikunnu, Calicut-673012 (Kerala	Member
3.	Dr. V.K. Gupta (Retired Dean, CSK, HPKVV, Palampur) Godavari Kunj, Khundidhar Post Office Shamti, Rajgarh Road, Solan-173212 (H.P.).	Member
4.	Dr. R.P. Gupta Director National Horticultural Research & Development Foundation Chitegaon Phata, Post Darma Sangvi Tq. Niphad, District Nashik-422001 (Maharashtra).	Member
5.	Dr. B.B. Lal Kaushal Retired Professor & Head Post Harvest Technology House No. 21, Scientist colony, Khundidhar Post Office Shamti, Distt. Solan-173212 (H.P.)	Member
6.	Dr. P.S. Sirohi Ex-Head (Vegetables) IARI, EA-172, Near Arya Samaj Mandir Inderpuri, New Delhi 110 012	Member
7.	Dr. D. R. Bhardwaj Principal Scientist Division of Vegetable Improvement ICAR-IIVR, Varanasi-221305 (U.P.)	Member Secretary

Annexure IV

Institute Joint Staff Council (IJSC)

Dr.B. Singh	Director	Chairman
Dr. A.B. Rai	Head, Vegetable Protection	Nominated Member, Official Side
Dr.P.M .Singh	I/C ,Vegetable Improvement	Nominated Member, Official Side
Dr. R.N.Prasad	I/C ,Vegetable Production	Nominated Member, Official Side
Sh. S.K. Jindal	S.A.O	Nominated Member, Official Side
Dr. Rajesh Kumar	Sr. Scientist & I/C F.A.O	Nominated Member, Official Side
Sh. U.N.Tiwari	A.A.O	Nominated Member, Official Side
Sh. P.C.Tripathi	Sr. Technical Assistant	Elected Member, Staff Side
Sh. Gopi Nath	Assistant	Elected Member, Staff Side
Sh. Suresh Kr. Yadav	S.S.S	Elected Member, Staff Side
Rajesh Rai	Senior Technician	Elected Member, Staff Side
Sh. S.K.Gupta	U.D.C	Elected Member, Staff Side

Annexure V

List of Ongoing Research Projects

A. Institutional

MEGA PROGRAMME-1: INTEGRATED GENE MANAGEMENT			
Mega-Programme Leader: Major Singh/ P.M. Singh			
Code	**Title of the project**	**P.I.**	**Co-PIs**
1.1	Management of vegetable genetic resources including under-utilized crops	Shailesh K Tiwari	DR Bhardwaj, Pragya , H Lal, N Rai, Sudhakar Pandey, Rajesh Kumar, SK Sanwal, HC Prasanna, PK Singh, T Chaubey, BK Singh, JK Ranjan,YS Reddy, P Karmakar, Jyoti Devi, Tania Seth (*w.e.f.* 29.8.15), KK Gautam (*w.e.f.* 31.8.15) and B Rajshekhar Reddy (*w.e.f.* 29.8.15)
1.2	Genetic improvement of solanaceous vegetables	Major Singh	N Rai, Rajesh Kumar, J K Ranjan SK Tiwari, YS Reddy, RS Gujjar, AB Rai, M H Kodandaram, B Mahesha and C Sellaperumal
1.3	Genetic improvement of legume vegetables	Hira Lal	N Rai, RK Dubey (*w.e.f.* 16.11.15), BK Singh and Jyoti Devi and B Rajshekhar Reddy
1.4	Genetic improvement of gourds	D.R. Bharadwaj	Sudhakar Pandey, T Chaubey, PK Singh, S Saha, Pradip Karmakar and KK Gautam (*w.e.f.* 31.8.15)
1.5	Genetic improvement of melon, pumpkin and cucumber	Sudhakar Pandey	D. R. Bhardwaj, P. Karmakar, B. Mahesha, T. Koley and KK Gautam (*w.e.f.* 31.8.15)
1.6	Genetic improvement of okra	Gyan P. Mishra (*w.e.f.* 26.10.15)	B. Singh, J.K. Ranjan, Tania Seth (*w.e.f.* 29.8.15), Jaydeep Halder and Nagendran Krishanan B (*w.e.f.* 28.8.15)
1.7	Genetic improvement of cauliflower	B.K. Singh	Jyoti Devi
1.8	Transgenic and regeneration protocols	J K Ranjan	Major Singh, Pragya, YS Reddy, RS Gujjar and Suhas G Karkute
1.9	Biotechnological interventions for improvement of selected vegetable crops	H.C. Prasanna	Major Singh, SK Tiwari, S Pandey, Rajesh Kumar, Ranjit Singh Gujjar, Pradip Karmakar, Tania Seth (*w.e.f.* 29.8.15), Suhas Karkute and Gyan P Mishra (*w.e.f.* 26.10.15)
1.10	Genetic improvement of under-utilized vegetables, including vegetable soybean, leafy and root vegetables	BK Singh	DR Bhardwaj, Pragya and SK Tiwari
MEGA PROGRAMME-2: SEED ENHANCEMENT IN VEGETABLES			
Mega-Programme leader: P.M. Singh			
2.0	Seed enhancement in vegetables	P.M. Singh	PM Singh Rajesh Kumar, T Chaubey, Sudhir Singh, TK Koley, J Halder, RN Prasad, N Rai, SK Tiwari and Manimurugan, C

MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT			
Mega-Programme Leader: R.N. Prasad			
3.1	Technologies for protected and off season vegetable production.	S.N.S. Chaurasia	R.N. Prasad, R.B. Yadava, Sudhir Singh, D.K. Singh, Anant Bahadur, T.K. Koley and M.H. Kodandaram
3.2	Precision farming in vegetable crops.	R.N. Prasad	R.B. Yadava
3.4	Impact of organic and inorganic management systems on vegetable productivity, quality and soil health.	SK Singh	RB Yadava, RN Prasad, Sudhir Singh, DK Singh, Jaydeep Halder, Manjunath M and Sellaperumal C
3.5	Improving soil health and carbon sequestration in vegetable production system through conservation tillage and residue incorporation.	Anant Bahadur	SK Singh, DK Singh, M. Manjunath and RB Yadava
3.6	Enhancing water and nutrient use efficiency in vegetable crops	Anant Bahadur	DK Singh, SNS Chaurasia RN Prasad and Paresh B Chaukhande (*w.e.f.* 29.8.15)
3.8	Performance of vegetable crops under subsurface drip irrigation system.	DK Singh	Anant Bahadur and SNS Chaurasia
MEGA PROGRAMME-4: POST HARVEST MANAGEMENT AND VALUE ADDITION			
Mega-Programme Leader: Dr. Sudhir Singh			
4.1	Shelf life extension of vegetables.	Sudhir Singh	TK Koley
4.2	Exploration of vegetable nutraceuticals for the development of functional food .	TK Koley	Sudhir Singh, Suhas Karkute and Y Bijen Kumar
MEGA PROGRAMME-5: PRIORITIZATION OF R&D NEEDS AND IMPACT ANALYSIS OF TECHNOLOGIES DEVELOPED BY IIVR			
Mega-Programme Leader: Dr. Neeraj Singh			
5.1	Research prioritization for vegetable crops.	Shubhadeep Roy	Neeraj Singh
5.2	Impact of technologies developed by IIVR.	Neeraj Singh	S. Roy and Vanitha S.M.
MEGA PROGRAMME-6: INTEGRATED PLANT HEALTH MANAGEMENT			
Mega-Programme Leader: Dr. A. B. Rai			
6.1	Bio-Intensive Management of Major Insect Pests of Vegetables in the Current Scenario of Climate Change	A.B. Rai	M.H. Kodandaram, J. Halder, Neeraj Singh, Y. Bijen and K. Nagendran (*w.e.f.* 28.8.15)
6.2	Toxicological investigations on the novel insecticide molecules and plant origin insecticides against major insect pests of vegetables.	M.H. Kodandaram	A.B. Rai, J. Halder, Y. Bijen Kumar and K.K. Pandey (*w.e.f.* 17.12.15)

6.3	Biological Control of major Insect Pests of Vegetable crops	Jaydeep Halder	A.B. Rai, M.H. Kodandaram, M. Manjunath and A.N. Tripathi (*w.e.f.* 10.11.15)
6.4	Management of important fungal diseases of vegetable crops	K. Nagendran	M. Manjunath, C. Sellaperumal, K.K. Pandey (*w.e.f.* 17.12.15) and A.N. Tripathi (*w.e.f.* 13.11.15)
6.5	Bioprospecting of microorganisms associated with vegetables against plant pathogens	M. Manjunath	B. Mahesha, A.N. Tripathi (*w.e.f.* 13.11.15) and K.K. Pandey (*w.e.f.* 17.12.15)
6.6	Management of Important Bacterial Diseases of Vegetable Crop	M. Manjunath	Y. Bijen Kumar, A.N. Tripathi (*w.e.f.* 13.11.15) and K.K. Pandey (*w.e.f.* 17.11.15)
6.7	Development of diagnostics kits for major viruses infecting vegetable crops	B. Mahesha	B. Mahesha, K. Nagendran (*w.e.f.* 28.8.15), K.K. Pandey (*w.e.f.* 17.12.15), A.N. Tripathi (*w.e.f.* 13.11.15) and Achuit Singh
6.8	Management of Important Viral Diseases of Vegetable Crops	B. Mahesha	K. Nagendran and M.H. Kondandaram
6.9	Management of Nematodes Infesting Major Vegetable Crops	C. Sellaperumal	Manjunatha, Jaydeep Halder, Subhadeep Roy, M.N. Gowda (*w.e.f.* 29.8.15) and K.K. Pandey (*w.e.f.* 17.12.15)
6.10	Dynamics of pest and diseases and development of forecasting models	A.B. Rai	M.H. Kodandaram, J Halder and K.K. Pandey (*w.e.f.* 17.12.15)

B. Externally Funded

Division of Crop Improvement			
	Title of the project	**P.I.**	**Co-PIs**
1.	Gene expression studies and development of functional markers for anthracnose disease in Capsicum species	Rajesh Kumar	Major Singh
2.	Studies on male sterility system to increase the efficiency F_1 hybrid development in horticultural crops: Chilli	Rajesh Kumar	J K Ranjan
3.	Genomics-assisted selection of *Solanum chilense* introgression lines for enhancing drought resistance in tomato	H C Prasanna	Major Singh and M Sheshshayee
4.	Introgression of begomovirus resistance genes in tomato (*Solanum lycopersicum* L.) using MAS and genomics approach	H C Prasanna	B Mahesha
5.	National Innovation in Climate Resilient Agriculture (NICRA)	Major Singh	N Rai, Rajesh Kumar, Anant Bahadur, Shailesh K Tiwari and AB Rai
6.	CRP on hybrid technology (Tomato)	Major Singh	N. Rai
7.	Network Project on Transgenic Crops (NPTC)	Major Singh	Achuit K Singh (*w.e.f.* 8.2.16), Suhas Karkute, A. B. Rai, Rajesh Kumar and H. C. Prasanna
8.	Evaluation of high yielding varieties/hybrids of cucurbitaceous vegetables for riverbed (diara land) cultivation and standardization of their agro-techniques	Sudhakar Pandey	Pradip Karmakar
9.	CRP on Agrobiodiversity	Shailesh K Tiwari	Y Suresh Reddy, JK Ranjan, Tania Seth (*w.e.f.* 29.8.2015) and DR Bhardwaj

10.	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	T. Chaubey and Sudhakar Pandey
11.	Agri Business Incubator-IIVR, Varanasi	P.M. Singh	Shailesh K. Tiwari, Neeraj Singh, Sudhir Singh and S. Roy
12.	Zonal Technology Management Unit-IIVR, Varanasi	P.M. Singh	Shailesh K. Tiwari, Neeraj Singh, Sudhir Singh and S. Roy
Division of Crop Production			
13.	Network project on micronutrients mana management in horticultural crop for enhancing yield and quality.	R.B. Yadava	SNS Chaurasia, T.D. lama and Manjunath, M
14.	Network project on organic farming in horticultural crops.	R.B. Yadava	SNS Chaurasia, Sudhir Singh, Jaydeep Haldher and Manjunath, M
15.	Network project on new initiatives in protected horticulture.	S.N.S. Chaurasia	R.N. Prasad, R.B. Yadava, Sudhir Singh, D.K. Singh, Anant Bahadur, M.H. Kodandaram and T.K. Koley
16.	Efficient water management in horticultural crops under Agri-CRP on water.	DK Singh	Anant Bahadur and SNS Chaurasia
17.	A total value chain on commercialization of value added convenience vegetable products	Sudhir Singh	T K Koley
18.	Network project on phytochemicals/high value compounds.	T K Koley	Sudhir Singh
19.	ICAR Inter-institutional Collaborative Project on "Livelihood and Nutritional Improvement of Tribal Farm Women through Horticulture" (2015-17).	Neeraj Singh	Shubhadeep Roy
20.	NHB Project on "Promotion of Vegetables for Nutritional Security in Eastern Uttar Pradesh" (2015-18).	Neeraj Singh	PM Singh, RN Prasad, DR Bhardwaj, Shubhadeep Roy, YP Singh and B Singh
21.	Tribal Sub-Plan (TSP) for Schedule Tribes of Sonbhadra district in Uttar Pradesh (National Assignment by ICAR, New Delhi under 12th Plan 2012-17)	B. Singh	Neeraj Singh, Shubhadeep Roy, RN Prasad, SNS Chaurasia, Sudhakar Pandey, AK Chaturvedi, Rakesh Pandey and RP Chaudhary
Division of Crop Protection			
22.	ORP on management of sucking pests in horticultural crops.	MH Kondadaram	AB Rai, J. Halder, M. Manjunath and K Nagendra (*w.e.f.* 28.8.2015)
23.	NICRA Project on real time pest dynamics in tomato crop	MH Kodandaram	AB Rai and AN Tripathi (*w.e.f.* 13.11.2015)
24.	CRP on insect borers	AB Rai	MH Kodandaram, J Halder and Manjunath M
25.	Outeach project on Phytophthora, Fusarium and Ralostonia diseases of horticultural and field crops	K. Nagendran	KK Pandey (*w.e.f.* 17.12.2015)
26.	Synthesis and validation and sustainable and adaptable IPM technologies for cucurbitaceous vegetables	Jaydeep Halder	C Sellaperumal, K. Nagendran (*w.e.f.* 28.8.2015) and AN Tripathi (*w.e.f.* 13.11.2015)
27.	Development and validation of effective formulation(s) of plant growth promoting rhizobacteria (PGPR) having multicide mechanisms for pest management in vegetable	AB Rai	Manjunath M, J Halder, C Sellaperumal, Neeraj Singh and Manjunatha T Gowda (*w.e.f.* 29.8.2015)

Annexure VI

Distinguished Visitors

Dr. S. Ayyappan Secretary DARE & Director General, ICAR, New Delhi	02.04.2015; 27.06. 2015; 06.11. 2015
Smt.Durgawati Devi,Gram Pradhan, Jayapur village,Varanasi	02.04.2015
Dr. Prem Narain Mathur Regional Representative Bioversity International for Central and South Asia, New Delhi	21.05.2015; 14.02.2016
Dr. AK Joshi Regional Coordinator, South East Asia, CIMMYT	21-24.05.2015
Dr T. Janakiram ADG (Horticultural Sciences), ICAR, New Delhi	24.05.2015
Sh. Radha Mohan Singh Union Minister for Agriculture & Farmers Welfare Government of India, New Delhi	20.06.2015; 27.06. 2015; 06.11. 2015
Sh. Virendra Singh, MP, Bhadohi	01.07.2015 ; 05.12.2015
Sh. Kalraj Mishra, Union Minister G.O.I, Ministry of Micro, Small & Medium Enterprizes and MP Deoria	06.07.2015
Sh. Ravindra Kushwaha	13.07.2015 ; 29.03.2016
Sh. Laxman Acharya, MLC, Varanasi	23.07.2015
Dr. Kirti Singh Ex-Chairman, ASRB, ICAR, New Delhi.	11.08.2015; 12-14.02. 2016
Dr. N.P. Singh Director, ICAR-CCARI, Goa	19.09.2015
Dr. Harikesh Singh Former Dean, Education, B.H.U, Varanasi	13.10.2015
Sh. G. Hari MP, AIDMK, Tamil Nadu	06.11.2015
Dr. Tapas Mandal MP, AITC, West Bengal	06.11.2015
Sh. Sanjay Shamrao Dhote MP, BJP, Maharastra	06.11.2015
Kuwar Pushpendra Singh Chandel MP, BJP, UP	06.11.2015
Sh. Shankarbhai N. Vegad MP, BJP, Gujarat	06.11.2015
Sh. Aditya K Joshi Joint Secretary (Fisheries), New Delhi	06.11.2015
Dr. N.P. Singh Director, ICAR-IIPR, Kanpur	7.11.2015; 12-14.02.2016
Prof. G. Kalloo Former DDG (Hort. & Crop Sciences), ICAR, New Delhi	07.11.2015 ; 30.01.2016 ; 12-14.2.2016
Dr. P. Parvatha Reddy Director (Retd.), IIHR, Bengaluru	20-21.12.2015
Dr. O.P. Dutta Director (Research), Bidadi, Bengaluru	20-21.12.2015
Dr. Kaushik Banerjee Principal Scientist, NRC for Grapes, Pune	20-21.12.2015
Dr. Sudha Mysore Principal Scientist, IIHR, Bengaluru	20-21.12.2015
Dr. Gopalji Trivedi Former Vice Chancellor, RAU, Pusa, Bihar	30.01.2016
Dr. A.K. Mehta Former ADG (Extension), ICAR, New Delhi	30.01.2016
Dr. R.P. Singh Director, Institute of Agricultural Sciences, BHU, Varanasi	30.01.2016
Dr. N.K. Krishna Kumar DDG (Horticultural Sciences), ICAR, New Delhi	12.02.2016 ; 21.05.2016
Dr D.P. Ray Ex- Vice Chancellor, QUA&T, Bhubaneshwar	12-14.02. 2016
Dr. R.R. Hanchinal Chairman, PPV&FRA, New Delhi	12-14.02. 2016
Dr. Brahma Singh Ex. Director, DRDO, New Delhi	14.02. 2016

Results Framework Document (RFD)
for
ICAR-Indian Institute of Vegetable Research
(2014-2015)

Address: Post Bag No. 01, Post Office-Jakhini (Shahanshahpur),
Varanasi-221 305 U.P.
Website: www.iivr.org.in

Section 1: Vision, Mission, Objectives and Functions

Vision

Vegetables for food and nutritional security, and sustainable inclusive growth.

Mission

To contribute significantly to the nutritional security of India through research, education and extension on vegetables in collaboration with national and international partners for enhancing productivity and profitability, achieving sustainable food, and alleviating rural poverty.

Objectives

1. Improvement of vegetable crops for high yield, quality and resistance to biotic and abiotic stresses.
2. Enhancing productivity and quality through efficient input management, plant health management including post-harvest management and value addition.
3. Dissemination of technology.

Functions

To plan, coordinate, implement and monitor R&D programmes for sustainable vegetable production and resource conservation.

Section – 2: *Inter se* priorities among key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target/Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1.	Enhancing productivity and quality through efficient input management, plant health management including post-harvest management and value addition	38	Development of efficient production technologies	Technologies for improving input use efficiencies in field and protected cultivation	Number	12	6	5	4	3	2
			Development of eco-friendly protection technologies	Characterization and documentation of pathogens including PCR based diagnostics	Number	8	62	52	42	32	22
				Identification of effective components of pest management and development of IPM/ IDM technologies	Number	10	5	4	3	2	1
			Post-harvest management and value addition	Technology for value addition including increasing the shelf life of vegetables	Number	8	7	6	5	4	3
2.	Improvement of vegetable crops for high yield, quality and resistance to biotic and abiotic stresses	28	Collection, conservation, evaluation and utilization of germplasm	Addition of new germplasm and identification of germplasm for specific traits	Number	12	240	200	160	120	80
			Development of varieties/ hybrids	Identification and validation of markers, mapping of QTLs and genes	Number	09	8	7	6	5	4
				Development of advance lines/ identification/ release of varieties/ hybrids	Number	7	6	5	4	3	2
3.	Dissemination of technology	14	Popularization of IIVR varieties/ hybrids	Breeder's seed production	Kg	06	2880	2400	1920	1440	920
			Popularization of vegetable technologies	Organization of training/ demonstration/ exhibition/Kisan mela/consultancies provided	Number	08	112	100	88	76	64

S. No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target/Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
	*Publication/Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	Number	3	5	4	3	2	1
			Timely publication of the Institute Annual Report (2013-2014)	Annual report published	Date	2	30.06.2014	02.07.2014	04.07.2014	07.07.2014	09.07.2014
	*Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90
	*Efficient functioning of the RFD system	3	Timely submission of Draft RFD for 2014-2015 for approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014
			Timely submission of results for 2013-2014	On-time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014
	*Enhanced transparency / Improved service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Redness Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
	*Administrative reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014	Nov.5 2014
			Implementation of agreed milestones of approved Mitigating strategies for reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section – 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 12/13	Actual Value for FY 13/14	Target Value for FY 14/15	Projected Value for FY 15/16	Projected Value for FY 16/17
1.	Enhancing productivity and quality through efficient input management, plant health management including post harvest management and value addition	Development of efficient production technologies	Technologies for improving input use efficiencies in field and protected cultivation	Number	6	6	5	5	5
		Development of eco-friendly protection technologies	Characterization and documentation of pathogens including PCR based diagnostics	Number	43	46	52	55	56
			Identification of effective components of pest management and development of IPM/IDM technologies	Number	1	4	4	5	5
		Post-harvest management and value addition	Technology for value addition including increasing the shelf life of vegetables	Number	3	6	6	7	7
2.	Improvement of vegetable crops for high yield, quality and resistance to biotic and abiotic stresses	Collection, conservation, evaluation and utilization of germplasm	Addition of new germplasm and identification of germplasm for specific traits	Number	350	125	200	210	220
		Development of varieties/hybrids	Identification and validation of markers, mapping of QTLs and genes	Number	9	4	7	7	7
			Development of advance lines/identification/release of varieties/ hybrids	Number	2	2	5	6	7
3.	Dissemination of technology	Popularization of IIVR varieties/hybrids	Breeder's seed production	Kg	2542	2350	2400	2450	2450
		Popularization of vegetable technologies	Organization of training/ demonstration/ exhibition/Kisan mela/consultancies provided	Number	182	80	100	105	105
	*Publication/Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	Number	3	3	4	6	7
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	-	-	July 2, 2014	-	-
	*Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	-	-	96	-	-

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 12/13	Actual Value for FY 13/14	Target Value for FY 14/15	Projected Value for FY 15/16	Projected Value for FY 16/17
	*Efficient functioning of the RFD system	Timely submission of draft RFD for 2014-2015 for Approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
	*Enhanced transparency / Improved service delivery of Ministry/Department	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
	*Administrative reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov. 2, 2014	-	-
		Implementation of agreed milestones of approved Mitigating strategies for reduction of potential risk of corruption (MSC)	% of implementation	%	-	-	90	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

Section - 4 (a): Acronyms

Sl.No.	Acronym	Description
1.	R&D	Research and Development
2.	QTLs	Quantitative Trait Loci
3.	IPM	Integrated Pest Management
4.	IDM	Integrated Disease Management
5.	INM	Integrated Nutrient Management
6.	IIVR	Indian Institute of Vegetable Research
7	PCR	Polymerase Chain Reaction
8.	DNA	Deoxyribo Nucleic Acid
9.	GOI	Government of India
10.	MOA	Ministry of Agriculture
11.	DAC	Department of Agriculture and Cooperation
12.	SAUs	State Agricultural Universities
13.	NHB	National Horticulture Board
14.	NHM	National Horticulture Mission
15.	APEDA	Agricultural and Processed Food Products Export Development Authority
16.	KVKs	Krishi Vigyan Kendras
17.	NGOs	Non-Government Organizations

Section - 4 (b): Description and definition of success indicators and proposed measurement methodology

S. No.	Success indicator	Description	Definition	Measurement	General comments
1.	Technologies for improving input use efficiencies in field and protected cultivation	Nutrient management/water management/cultivation/resource conservation packages are evaluated for improving input use efficiency	Nutrient management/water management/cultivation/resource conservation packages refers to the management and maintenance of soil/water/plant/inputs/ecosystem at an optimum level for enhancing the input use efficiency	Number of technologies tested/validated/developed for improving input use efficiencies in vegetable crops	To ensure higher productivity/profitability and sustainability of vegetable production systems
2.	Characterization and documentation of pathogens including PCR based diagnostics	Identification of pathogen through both conventional and molecular techniques are done for accurate and speedy identification of causal organisms based on that specific measures can be used for specific disease control	Accurate diagnosis of pathogen is the first step in any pest/disease management programme. This refers to apart from identification through conventional method, utilization of advanced biotechnological tools for accurate and speedy identification of pathogens	Number of pathogens identified/characterized and diagnostics developed	Precision and accurate identification of the pathogen for which pin pointed control measures can be used to avoid unnecessary/unwarranted control measures for sustainable vegetable production
3.	Identification of effective components of pest management and development of IPM/IDM technologies	Different IPM/IDM components like use of semi-chemicals/cultural control/ biopesticides/chemicals are evaluated for ecofriendly pest management	IPM/IDM technology refers to use of integrated control methods for pest and disease and improving environmental health and sustaining high productivity	Number of effective components identified and IPM/IDM technologies developed	To ensure less use of harmful pesticides for quality vegetable production and environmental safety
4.	Technology for value addition including increasing the shelf life of vegetables	Edible coating such as carnauba wax, steeping preservation with hurdle concept and suitable packaging materials are evaluated for extending the shelf life of fresh vegetables. Osmo-air drying, development of fermented vegetable product and nutraceutical rich functional foods are carried out for various value added processed vegetables	Shelf life extension refers to methods for delaying postharvest senescence and maintenance of quality of vegetable for longer period. Value addition refers to the processing methods involving dehydration, concentration, fermentation, *etc* to develop stable products for various value added processed vegetables	Number of technologies for value addition including increasing the shelf life of vegetables tested/validated/developed	The extension of shelf life and value added products would reduce the huge postharvest losses in terms of both quality and quantity and generate employment to rural men and women
5.	Addition of new germplasm and identification of germplasm for specific traits	Germplasm is the basic requirement to develop improved varieties	Germplasm are the basic raw materials of actual or potential value for crop improvement	Number of new germplasm collected and identified for specific traits	Germplasm of different vegetable crops including underutilized genetic resources is collected for utilization/sharing to develop improved/elite lines with specific traits and to enhance the gene pool

S. No.	Success indicator	Description	Definition	Measurement	General comments
6.	Identification and validation of markers, mapping of QTLs/genes	Markers are short DNA sequence developed/validated through mapping QTLs/genes for specific traits and can be used in marker-assisted selection in vegetable breeding programme	Molecular markers are DNA sequences also called tags for particular traits in any species which can be used for improvement of existing/new varieties	Number of markers identified/validated	Markers are used for identifying traits of interest and can be used for the development of improved vegetable varieties and also to study the inter-relationships of individuals
7.	Development of advance lines/identification/release of varieties/ hybrids	Varieties/hybrids are identified/ developed through adopting breeding procedures involving selected germplasm	Varieties are genotypes commonly cultivated by the growers	Number of advance lines/varieties/hybrids identified/developed	Vegetable varieties are developed for different attributes after multi-location testing under different ecological conditions
8.	Breeder's seed production	Breeder seeds are required to be produced to maintain the quality of seeds	Breeder seeds are the first link in National Seed Production chain which are essential for production of foundation and certified seed down the chain	Quantity of seeds produced	The quantity of breeder seeds produced may vary depending upon the indents from GOI
9.	Organization of training/ demonstration/ exhibition/kisan mela/consultancies provided	Organize training/ demonstrations/ exhibition on improved production and protection technologies in vegetable crops for farmers and other stakeholders	To enable dissemination of technologies for enhancing technology adoption	Number of trainings/ demonstration/exhibition organized/conducted	To enhance the productivity through wider adoptability of improved technologies in vegetable crops for livelihood and nutritional security

Section-5: Specific performance requirements from other departments that are critical for delivering agreed results

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
State Governments	Andaman & Nicobar Islands, North Eastern Hilly States	Departments	State Biodiversity Authority/ Forest Department	Addition of new germplasm and identification of germplasm for specific traits	Permission for survey and collection of germplasm	Without permission it is illegal to enter the reserved forest for collection	Number of permission letters issued	Less number of germplasm accessions will be collected
State Governments	All states	Departments	Directorate of Extension, MOA/ Development Departments	Organization of training/ demonstration/ exhibition/kisan mela/consultancies provided	Sponsoring farmers/extension personnel for training	If trainees are not deputed, they cannot be imparted training	Number of candidates sponsored	Less number of trainings will be conducted
DAC	All states	Departments	Department of Agriculture & Cooperation, MOA	Breeder's seed production	Quantity of breeder seed	The target of breeder seed depends on quantity required	Requirement in Kg	Production may be increased or decreased

Section – 6: Outcome/Impact of activities of Department/Ministry

S. No.	Outcome/Impact	Jointly responsible for influencing this outcome/ impact with the following department(s)/ ministry(ies)	Success Indicators	Unit	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1.	Production of quality seed of vegetable crops, development of improved varieties and technologies including value added products	DAC/ SAUs/ NHB/NHM/ APEDA/ State line departments / KVKs/ NGOs etc.	Increase in production of vegetable crops	%	2.5	2.5	3.0	3.0	3.0
			Popularization of varieties/hybrids in terms of increase in breeder's seed production	Quintals	23.0	23.5	24.0	24.5	24.5
			Increase in awareness of stakeholders through training and demonstrations	%	45	50	40	40	40

Classification of Success Indicators according to its category

S. No.	Success Indicator(s)	Input	Activity	Internal Output	External Output	Outcome	Measures Qualitative Aspects
1.	Technologies for improving input use efficiencies in field and protected cultivation	False	True	False	False	False	False
2.	Characterization and documentation of pathogens including PCR based diagnostics	False	False	True	False	False	False
3.	Identification of effective components of pest management and development of IPM/IDM technologies	False	True	False	False	False	False
4.	Technology for value addition including increasing the shelf life of vegetables	False	True	False	False	False	False
5.	Addition of new germplasm and identification of germplasm for specific traits	False	True	False	False	False	False
6.	Identification and validation of markers, mapping of QTLs and genes	False	False	True	False	False	True
7.	Development of advance lines /identification/release of varieties/ hybrids	False	False	True	False	False	True
8.	Breeder's seed production	False	False	False	False	True	True
9.	Organization of training/ demonstration/ exhibition/Kisan mela/consultancies provided	False	True	False	False	False	False

Past achievements of the Success Indicators at IIVR, Varanasi

S. No.	Success indicator (s)	Past achievement of the Success Indicators					Mean of the achievements	Projected value of the success indicator for 2014-2015 as approved RFD 2013-2014
		n^{th} year	IV 2010-2011	III 2011-2012	II 2012-2013	I 2013-2014		
1.	Technologies for improving input use efficiencies in field and protected cultivation	-	-	5	6	7	6	6
2.	Characterization and documentation of pathogens including PCR based diagnostics	-	-	190	43	46	93	52
3.	Identification of effective components of pest management and development of IPM/IDM technologies	-	-	1	1	4	2	4
4.	Technology for value addition including increasing the shelf life of vegetables	-	-	8	7	7	7.33	6
5.	Addition of new germplasm and identification of germplasm for specific traits	-	-	89	295	147	177	135
6.	Identification and validation of markers, mapping of QTLs and genes	-	-	4	9	5	6	5
7.	Development of advance lines Identification/release of varieties/ hybrids	-	-	3	2	4	3	2
8.	Breeder's seed production	-	-	2300	2542	1836	2226	2375
9.	Organization of training/ demonstration/ exhibition/kisan mela/consultancies provided	-	-	130	93	90	104.33	95

Annual achievements (Performance evaluation) in respect of RFD 2014-15

Name of the responsibility Sub-centre	Total Composite Score	Rating of the RSC
ICAR-IIVR, Varanasi	91.32%	Very Good

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
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INDIAN INSTITUTE OF VEGETABLE RESEARCH

ICAR-Indian Institute of Vegetable Research

(An ISO 9001: 2008 Certified Institute)

Post Bag 01, PO- Jakhini (Shahanshahpur)
Varanasi -221 305
www.iivr.org.in

army printing press
www.armyprintingpress.com
Lucknow (0522) 2483164