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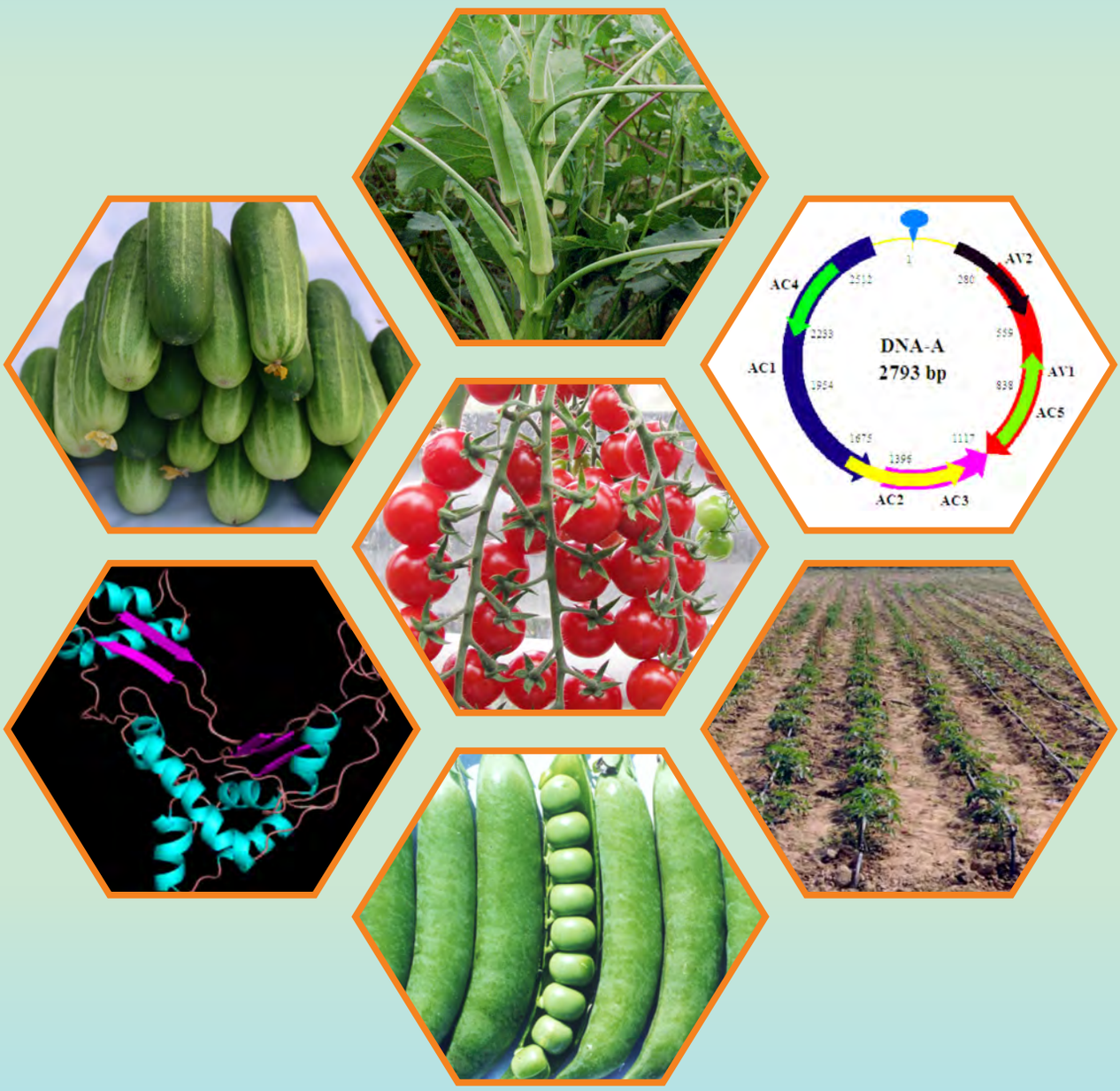
2014-15



भाकृअनुप
ICAR

ICAR-Indian Institute of Vegetable Research
(An ISO 9001: 2008 Certified Institute)
(Indian Council of Agricultural Research)
Varanasi – 221 305

INDIAN INSTITUTE OF VEGETABLE RESEARCH

Annual Report

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PREFACE

Vegetables are important constituents of nutritional and livelihood security due to their short duration, high yield, nutritional value, economic viability and ability to generate on-farm and off-farm employment. India contributes 14% of world's vegetable production with an area of 9.4 million hectares and the average productivity of 17.4 t/ha. Productivity of vegetables in India is seen to be lower than China (23.4 t/ha) and world average (19.6 t/ha) but India ranks first in production of okra in the world (73% of world production) and second in other vegetables such as brinjal (27.55%), cabbage (13%), cauliflower & broccoli (36%), onion (19.90%), potato (13%) and tomato (11%). As a result of huge spurt in vegetables produce (162.9 million t), India has become the second largest producer of vegetables in the world. However in spite of remarkable growth, the Indian vegetable sector is still facing severe constraints such as low crop productivity, uneven productivity across the countries, huge post-harvest losses, inadequacy of multipurpose varieties, limited irrigation facilities, climate change and underdeveloped infrastructure support like cold storages, markets, roads, transportation facilities, etc.

To address above issues, concerted efforts are needed in the direction to capitalize on our strengths and remove constrains to meet the goal of moving towards a formidable vegetable growth in India. In this endeavor, research efforts made by ICAR-IIVR through six mega programme of the institute viz., Integrated Gene Management, Seed Enhancement in Vegetables, Productivity Enhancement through Better Resource Management, Post Harvest Management and Value Addition, Prioritization of R&D Needs and Impact Analysis of Technologies Developed by ICAR-IIVR and Integrated Plant Health Management, along with promotion of developed technologies by the institute including Regional Station, Sargatia and 03 KVKs working under its administrative control will go a long way in achieving these goals and has also contributed significantly in improving the growth rates in vegetable supplies and per capita availability, halted the increase in vegetable prices, and reduced seasonality. Besides, 23 externally funded projects presently running in the institute immensely contributed in strengthening institute mega programme.

It gives me immense pleasure to bring out the Annual Report 2014-15 of this institute comprising significant highlight made under research, extension, AICRP (Vegetable Crops), 03 KVKs, and Regional Station, Sargatia, Kushinagar.

Rigorous support, constant encouragement and guidance provided by Dr. S. Ayyappan, Secretary (DARE) & DG, ICAR and Dr. N.K. Krishna Kumar, DDG (Horticultural Science), ICAR have opened a new vista for meeting the research and physical targets by the institute during 2014-15.

Contribution made by all the scientists, technical and office staffs of Vegetable Family are duly acknowledged for the cooperation, coordination, compilation of information and finally bringing out this document.

Varanasi
June 26, 2015

(Bijendra Singh)
Director

Contents

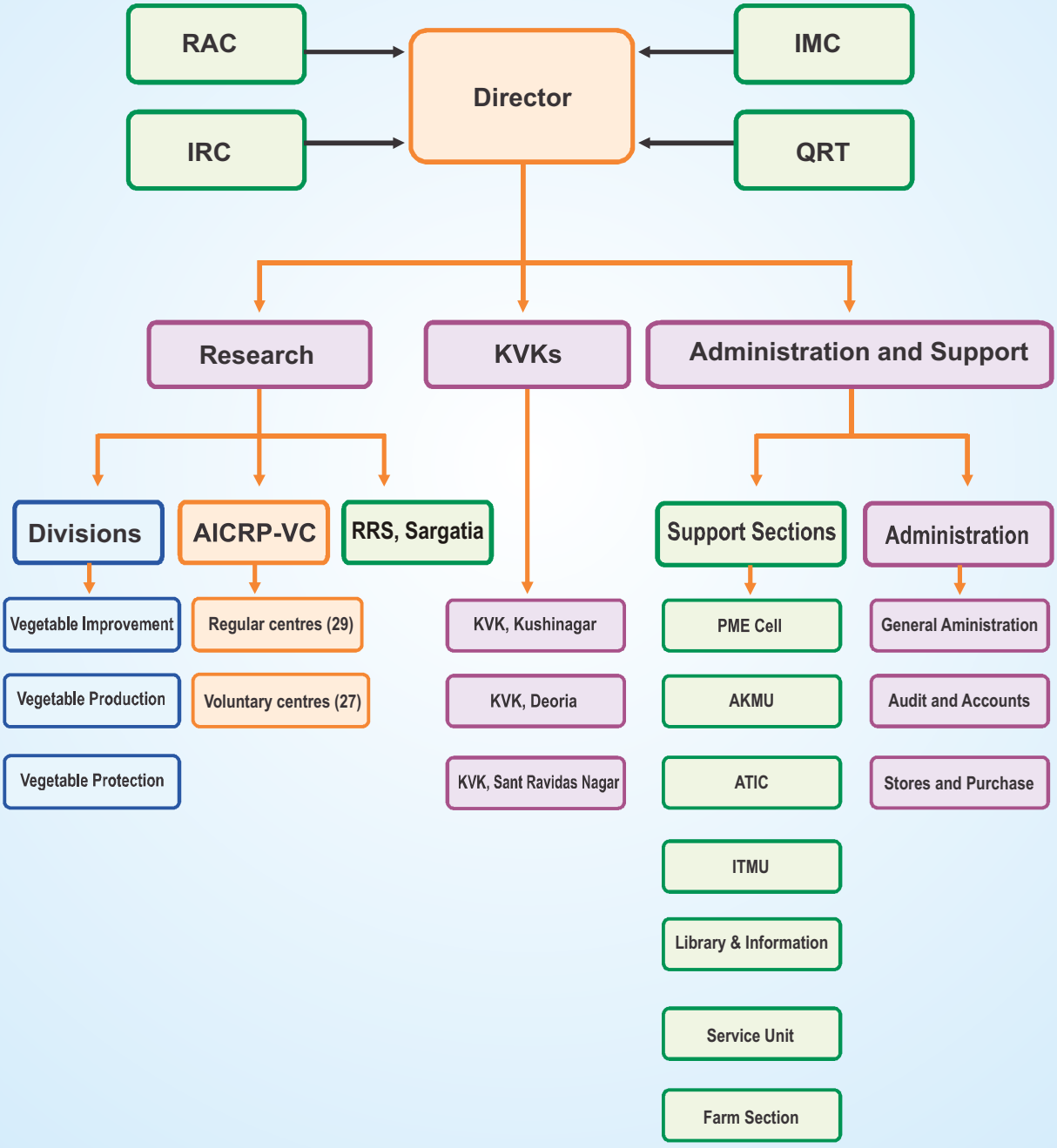
ABBREVIATIONS

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
EPF	Entomopathogenic Fungi
ESFB	Early Shoot and Fruit Borer
FLD	Front Line Demonstration
FRAP	Ferric Reducing Antioxidant Property
FSB	Fruit & 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 Betasatellite
ToLCuB	Tomato Leaf Curl Betasatellite
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
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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, Sant Ravidas Nagar
PME Cell
AKMU
ATIC
ITMU
Library & Information
Service Unit
Farm Section
General Aministration
Audit and Accounts
Stores and Purchase

EXECUTIVE SUMMARY

The research and development activities of 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 18 externally funded projects. In each mega-programme numbers of sub projects have been formulated with specific objectives.

Under the sub project "Management of vegetable genetic resources including under-utilized crops", a total of 113 accessions including cultivated species and their wild relatives in 57 major and minor vegetable crops were augmented through import and inland explorations. Besides, new collection, 4753 accessions of different vegetable crops are also maintained at the institute. A total of 924 accessions of different vegetables have also been shared with different organizations for research and demonstration purpose after signing of the Material Transfer Agreement (MTA).

In solanaceous vegetables, earlier isolated 20 higher β carotene segregating lines of tomato from crosses derived from *Solanum lycopersicum X S. pimpinellifolium,* 15 segregating lines were advanced from F6 to F7, and evaluated for further advancement. Cherry type tomatoes segregants from population of crosses derived from *Solanum lycopersicum* X *S. pimpinellifolium* or *S. habrochiates*, 16 segregants were advanced from F3 to F4.

Six reported PCR-based co-dominant markers for *Mi* gene in tomato were screened in resistant genotypes along with a susceptible genotype. Out of six markers, four (Aps, C8B, REX-1 and CT119) were cleaved amplified polymorphic sequences (CAPS) and other two (*Mi*23 and Pmi) were sequence characterized amplified regions (SCAR) markers. To reconfirm nematode resistance that was identified in last year, nine tomato genotypes (four resistant lines, three susceptible lines from the last year study and two advanced lines *viz.*, D-6-1-4-P2 and C-12-1-4-P2018) were screened against root knot nematodes (RKN) at two inoculation rates *viz.*, 2000 J_2 and 4000 J_2. Tomato accessions EC-786262 and EC-786267 were found highly resistant to RKN at both the inoculation rates. Under distant hybridization programme in brinjal, sixty interspecific crosses were attempted utilizing six cultivars (Pant Rituraj, PR-5, Kashi Uttam, Pusa Ankur, Pusa Upkar and ADM-190), and nine wild species *viz. S. undatum, S. ferox, S. sisymbrifolium, S. macrocarpum, S. lasiocarpum, S. aethiopicum, S. anguivi, S. villosum, S. xanthocarpum*. IVBHR-20 and IVBHR-21 were identified as promising hybrids in round fruited segments while under F_1 hibrid evaluation, IVBHL-20 and IVBHL-21 were found promising in (medium) long fruited segment. SSR primers (320) were screened for identification of polymorphic primers between parental lines of RILs in brinjal. A total of 40 primer pairs were identified polymorphic and 15 were used for genotyping of RILs. A total of 61 F_1 hybrids developed in chilli during 2013-14 were evaluated. F_1 hybrids, A7 x EC-519636 and A7 x VR339 involving cytoplasmic male sterile parents showed higher yield potential. In order to transfer genetic male sterility (GMS3, *ms-3*) in desirable backgrounds, BC1F1 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 was selfed for BC_1F_2. A total of 16 genotypes of sweet pepper were collected and evaluated for different agro-morphological traits *viz.* plant height, stem girth, number of fruits per plant, fruit length, fruit width, fruit weight and pericarp thickness.

Among leguminous vegetables, 14 dwarf and bush type cowpea advanced lines along with one national check (Kashi Kanchan) were evaluated for various growth characters, earliness, yield attributing traits, yield and resistance to cowpea golden mosaic virus during *kharif* 2014. Line 70-2 flowered earliest and took minimum days to 50% flower (32.2 DAS) followed by line 98-4 (33.1 DAS) and 96-4 (34.2 DAS). In pea, based upon the last year field screening to *Fusarium* wilt, eight genotypes including susceptible lines *viz.*, VRPE-29, VRPE-64, VRPE-60, VRPE-62, VRP-6, Kashi Mukti, Kashmiria and VRPE-25 were selected for artificial screening and further evaluation for the disease. The lines VRPE-60 and Kashmiria found tolerant upto some extent. Rest of the genotypes were severely affected by *Fusarium* wilt. In French bean, five advanced lines, 21 introduced genotypes and 44 germplasm, both bush and pole types, were evaluated under field conditions. Among bush type, nine genotypes namely VRFBB-2, VRFBB-67, VRFBB-91, VRFBB-95, FMGC6V-1129, FMGC6V-1176, FORC6V-1136, Paulista and Riveragro belonging to vegetable types were found to be potential yielder along with

good quality pod traits (pods cylindrical, free from fibre, slow seed development, tender and bright colour) while in pole type, three genotypes namely VRFBP-44, VRFBP-131 and IC595238 showed better yield potential for tender pod. Nutritionally, IC595238, a purple podded genotype, possesses 48% higher antioxidant activity than the green podded genotypes because of the presence of anthocyanin.

Among gourds, VRPG-103, VRPG-17, VRPG-05, VRPG-85 and VRPG-89 of pointed gourds were found promising for yield and fruit quality. A total 1500 cuttings of pointed gourd varieties Kashi Alankar and Kashi Suphal were produced for distributing to the farmers of Mirzapur and Varanasi district. A putative female specific marker *i.e.* 700 bp amplicon from UBC 834 was identified. This was further validated on a set of 19 accessions consisting of 10 male and 9 female clones. In sponge gourds, two open pollinated genotypes *viz.* VRSG-1-12 and VRSG-194, and two hybrid genotypes namely, VRSGH-1 and VRSGH-2 were found promising for horticultural traits. Interspecific cross combinations of *Luffa cylindrica* syn. *Luffa aegyptiaca* (VRSG-136 & VRSG-12) x *Luffa acutangula* var. Satputia syn. *Luffa hermaphrodita* (VRS-1) for generation of recombinant inbred lines (RILs) as well as inter specific hybrids were developed.

In the melons, pumpkins and cucumber, four advanced lines along with check PCUC-09 were been evaluated in cucumber for yield and its contributing traits in mottle green segment. Fruits of these lines were non-bitter in taste. The best performing line based on the fruit colour, appearance and yield was VRCU Sel.-06-01. In pumpkin, a total of 15 F_1 cross combinations have been developed for further evaluation. The selected F_1s VRPKH-12-04 and VRPKH-12-05 in long group and VRPKH-13-06 in round group have been found promising. These hybrids combination will be evaluated for further performance and stability. Five promising advanced lines and one check of *Cucurbita pepo* (summer quash) along with two segregating lines were evaluated. Among the evaluated lines, VRSS-10-66 and VRSS-06-12-01 was found promising. Ninety eight genotypes of watermelon including landrace, ecotypes and wild forms were planted, evaluated and maintained through selfing. VRW-1, VRW-2 and VRW-12 were found promising for earliness, yield and fruit quality. A red fleshed genotype VRW-9-4 and light yellow fleshed line VRW-12-3 were also identified for further evaluation. Advanced lines VRSWM-3-4-2 (yellow rind and yellow flesh), VRW-9 (red fleshed), VRW-12-3 (light yellow fleshed) and VRW-13-4 (red fleshed) were found promising for yield and quality. One hundred twenty F_6 generation of recombinant inbred lines of Kashi Madhu (desert melon) × B-159 (snap melon) were evaluated for various horticultural traits. Sex form of RIL families were either andromonoecious or monoecious. RIL-207 of musk melon has been identified for downy mildew disease resistance under field condition. This RIL will be further validated for downy mildew resistant under artificial condition.

In okra, Kashi Vardaan (VRO-25), a new okra variety was identified through XXXII AICRP (VC) Group Meeting for Zone IV (Uttar Pradesh, Bihar, Jharkhand and Punjab). Kashi Vardaan is an early, medium tall (120-125 cm) variety with short internodes along with single or double branch attached in narrow angle with main branch. It takes 42-44 days for first flowering. The fruits become available from 47-100 days after sowing and total yield is 150-155 q/ha. It was found resistant to yellow vein mosaic virus (YVMV) and okra enation leaf curl virus (OELCV) under field condition. Twenty four hybrids were evaluated in rainy season for yield and disease reaction. One line of susceptible check (Pusa Sawani) was sown after 5 lines of each hybrid. The hybrid 2015/OKHYB-3 was earliest and took 40 days for 50% flowering. Maximum number of fruits/plant was harvested from 2015/OKHYB-4 (18.6) followed by HOK-152 (18.5) while highest yield per plant was harvested from 2015/OKHYB-4 (205 g) followed by 2015/OKHYB-1 (184 g). A total of 240 lines including 30 released varieties, 32 advanced lines, 50 lines from IIHR and 128 accessions of wild species (*Abelmoschus angulosus, A. manihot, A. tetraphyllus, A. ficulneus, A. crinitus, A. moschatus, A. pungens* and *A. tuberculatus)* were screened during rainy season when maximum infestation of the diseases occurs. Among cultivated species, 36 lines (VRO-109, VROB-178, VROB,181, No. 315, VRO-112, AE-70, BC-1, VRO-104, 285-1-12-1-6-9-10, 294-61-3-1-5, 285-1-3a-1-17-1) were found resistant to YVMV, 4 lines (VRO-109, Okra-6, 299-2-9-1-6-4 and 285-1-12-2-4-17) were found resistant to both OELCV and YVMV. Among 128 wild accessions screened, 7 accessions [*A. manihot* (3), *A. moschatus* (1), *A. tuberculatus (1)*, *A. tetraphyllus (2)]* were found resistant to YVMV, 31 accessions [*A. moschatus* (9), *A. manihot* (6), *A. tetraphyllus* (12), *A. pungens* (2) were found resistant to OELCV while only 3 accessions [*A. manihot* (1) and *A. moschatus* (2)] found resistant to both YVMV and OELCV. In okra leaf curl virus infection, four types of symptoms were observed *i.e.* only enation leaf curl, petiole bending, vein twisting and stem bending. For confirmation whether these symptoms are of enation leaf curl virus or due to different viruses, above four types of symptomatic plants were selected for identification of viruses. The

total DNA was isolated and amplified using begomoviruses specific primes, cloned and sequenced. All the above four clones showed more than 96% nucleotide identity with okra enation leaf curl virus. So, petiole bending, vein twisting and stem bending are not a separate virus but these are symptoms of okra enation leaf curl virus only.

In cauliflower, 95 genotypes including 12 advanced lines were evaluated to screen out the promising lines for September, October and November maturity group. Among them, two genotypes *i.e.* VRCF-86 and VRCF-201 were the potential yielder in October maturity, and VRCF-50, VRCF-75, VRCF-37, VRCF-202 and VRCF-2 were found better for November maturity group.

Under transgenic and regeneration protocols sub-project, explants of okra *viz.* hypocotyls, cotyledons, cotyledonary petiole excised from aseptically *in vitro* grown okra cv Kashi Kranti, 5-15 days old seedlings were evaluated for regeneration responses. In all the tested combination, only callus and root were induced and no shoot induction were observed in any combination on hypocotyls or cotyledons. Callus induced in all combination NAA, BA and 2iP were light green, globular and friable while in NAA, TDZ and CPPU were dark green, compact and larger in size in comparison to both BA and 2iP. In bittergourd, callus regeneration was observed from cotyledon and leaf explants cultured on different combinations and concentration of BAP, TDZ, 2-iP, 4-CPPU with NAA and 2,4-D along with PVP. Leaf explants on different concentration of BAP alone showed green compact callus and with 2-iP and 4-CPPU callus were light green and fragile. Leaf explants shows better callusing than cotyledonary explants. NAA in combination with BA and TDZ induced green, globular and compact callus while the combination of 2, 4-D with TDZ and BAP induced green, nodular and compact callus. However, leaf explants on 0.5 mg/l TDZ with 50mg/ml PVP resulted in dark green compact globular callus and induced shoot formation. Shoot induction was also observed with cotyledonary nodal explants on 0.5mg/l TDZ with 50mg/ml PVP. Under Inplanta transformation in tomato, it was found that the *gus*-gene expression that was observed in the previous year was transient and not stable as there was no *gus* staining in the progeny plants. In other experiment, tomato seedlings were vaccuum infiltrated with the *Agrobacterium* for 5, 10, 20 and 30 min duration along with triton –X 100 at 0.004%. After 3 days seedlings were stained. Seedlings from 20 min treatment have shown staining.

Under the project, biotechnological interventions for improvement of selected vegetable crops, backcross populations for *S. lycopersicum* X *S. chilense* interspecific cross and marker assays on backcross progenies have been generated. Early backcross generations (BC1F2, BC2F1, BC2F2 and BC3F1) were generated for an interspecific cross Kashi Amrit X (*S. lycopersicum* VF36 X *S. chilense* LA1972). The cultivar Kashi Amrit was used as a recurrent parent in backcrossing program. A total number of 35 BC3F1 families, 150 BC2F2, 80 BC1F2 families were generated. For cloning, characterization and expression analysis of drought responsive transcription factor genes in tomato, eight drought responsive genes whose expression studies have been performed in earlier experiments, the sequences of 3 genes were found significantly different in *Solanum habrochaites* line EC 520061. This nucleotide sequence difference resulted a completely different protein structure when compared by "UCSF Chimera" program of 3D protein structure modeling. In another experiment, a total of 76 WRKY transcription factor gene sequences were screened from various databases of tomato (*Solanum lycopersicum*) *i.e.* Solgenome Network Database and NCBI Database. Further, q-PCR primers of these WRKY sequences were designed. With objectives of targeted breeding and brinjal improvement activities, two readily crossable species *Solanum melongena* and *S. incanum* were used as parental lines to develop mapping population.

Under the sub-project, genetic improvement of underutilized vegetables, including vegetable soybean, leafy and root vegetables, 19 advanced lines and 74 germplasms of tropical carrot were evaluated under field conditions. Thirty seven of Asiatic carrot (red & black) collections were further evaluated and maintained through sib mating. The genotype VRSCR-27 (red) and VRS BCr-NH-11 (black) were found promising for yield and quality. In radish, 23 advanced lines (coloured rooted) and 32 germplasm were evaluated during winter. Thirty one genotypes of radish (white, red and black) collections were also evaluated and maintained by selfing. The genotype VRRd E-14, VRRd-111 (white roots), VRRRd-7 (red) and VRSBRd-1 (black) were found promising for yield and quality. Promising satputia genotypes, long fruited (VRS-1, VRS-7, VRS-11, VRS-24) and VRS-9-1 (round fruited) were planted for further evaluation. Total of 59 accessions collected from different places were maintained. In ridge gourd, 50 genotypes were collected and evaluated for different horticultural traits, and maintained through selfing. Among them VRRG-3-6 was identified for more pistillate flowers. Genotypes VRSRG-6 and VRSRG-24 were also identified for high

yield and consumer preference. In long melon, 34 genotypes were collected and evaluated for different horticultural traits and maintained through selfing. The genotype VRSLM-27 and VRSLM-31 were found promising. A total of 21 genotypes of fenugreek were augmented and evaluated for different agro-morphological and biochemical traits. Wide range of variation was observed for plant height (59.6-75.67 cm), number of primary branches (4-6.33), days to flowering (64.5-72.6) and green yield (11.2-46.4 q/ha). The germplasm showed good variation for total carotenoid (14.03-26.33 mg/100 g fresh wt), total phenol (88.55-143.85 mg GAE/100g) and DPPH (8.69-13.46 µmol TE/g). Two genotypes of *bathua* namely VRCHE-4 (purplish-green leaves and stem) and VRCHE-2 (green leaves and stem) have been identified for multi-cutting purpose whose yield potential recorded about 320 q/ha and 295 q/ha, respectively in the four cuttings.

Under the mega programme: Seed enhancement in vegetables, the overall seed production programme (Breeder+TL) was undertaken for 24 varieties in 17 vegetable crops. The breeder seed production was undertaken for 16 varieties in 8 different vegetable crops *viz.* tomato, brinjal, chilli, cowpea, pea, bottle gourd, okra and radish. A total of 1150 kg breeder seeds were produced against the national indents of 1144.20 kg. In addition to national indent, 1747 kg breeder seeds of different varieties of IIVR were also produced. Conversion of ovules to seed in 14 tomato varieties and 5 chilli varieties were studied for two consecutive years. It was observed that it expresses variation depending upon variety. The priming of brinjal seed was done with three concentrations each of inert osmotica PEG 6000, mannitol and sorbitol. Distilled water was used as control. The duration of treatment was 24 to 168 hours (1-7days) in two replications at 25^{O}C. The treated seeds performing best in the lab conditions were evaluated under field conditions for two consecutive years. Plant population for CMS based chilli hybrid seed production have also been standardized.

In vegetable production trials, for growing seedlings in potting plugs, out of 46 different combinations, the mixture comprising of FYM with rice husk or vermicompost with rice husk (3:1) was found economical and suitable media as compared to cocopeat. Experiments on protected conditions revealed that the maximum yield of hybrid tomato and capsicum were recorded under low cost polyhouse. In precision farming trial, the performance of cowpea, okra and tomato were evaluated under different sowing or planting environments. Findings on sowing date revealed that cowpea sown on 26th March, okra sown on 22nd July and tomato transplanted on 3rd October have produced maximum biomass and yield. In another experiment various quantity of N was tried in tomato, and application up to 160 kg N/ha has noticed maximum fruit yield. Findings on adopting various tillage practices in vegetables indicated that conservation tillage with residue incorporation resulted maximum yields, soil organic carbon and cost-benefit ratio in cowpea, cabbage and tomato; whereas in chilli the maximum yields were obtained under conventional tillage practice.

In organic farming trials during *Zaid* season, the maximum yields of cowpea and okra was realized with the integrated application of FYM (10 t/ha) + poultry manure (2.5 t/ha) + *Rhizobium* / *Azotobacter* + PSB. The vitamin-C content was also higher in these crops under organic treatments. The lowest insect damaged pod of cowpea (15.5%) was observed in organic treatment against inorganic plots (39%). Soil carbon stock and carbon sequestration were improved significantly with different organic management systems.

Experiments related to enhancing water and nutrient use efficiency were carried out in several vegetable crops. Drip fertigation studies in tomato revealed that N fertigation @ 120 and 150 kg/ha has significantly enhanced the yield (40.10 and 43.97 tones/ha, respectively). The maximum nitrogen use efficiency was noticed with N fertigation at 120 kg/ha. Fertigation studies in cucumber revealed that the most of the growth and yield parameters were significantly higher under N at 150 kg/ha. In another trials, drip irrigation scheduled at 0.6 bars coupled with black polythene mulch resulted significantly higher fruit yield (90.17 tones/ha) and water use efficiency in tomato. Under IPNM study, the maximum fruit yield in bottle gourd (421.75 q/ha) was realized with application of FYM 8 t/ha + vermicompost 2.7 t/ha + poultry manure 2 t/ha (40 kg N from each), which was about 28% higher yields over recommended NPK. In a study on performance of vegetable crops under subsurface drip irrigation system (SDI) revealed that the yield of tomato increased with increasing level of water application from 50% ET (27.67 t/ha) to 100% ET (42.13 t/ha) through SDI. Water use efficiency (WUE) of tomato was found to be highest with 60% ET.

For enhancing shelf-life and retaining quality of bitter gourd, carnauba based commercial formulation '*Niprofresh*' as well as laboratory formulated edible coating were found effective. Recently, importance of the vegetable has increased due to their bioactive compounds. The process of encapsulation of black carrot anthocyanin using carrier matrix under freeze

drying condition was optimized. In a study on *in-vivo* effect of black carrot juice on rat, it was found that black carrot juice decreases concentrations of serum triglycerides level in dose and time dependent manner. It also reduces the fasting blood glucose concentration in steptozotocin induced diabetic rats, besides influences the intestine and blood *incretin*.

In a survey among the farmers of Bihar and UP about pesticide use, it was observed that at the grassroot level farmers lacks knowledge and awareness about the pesticide use. Under tribal sub programme (TSP), seeds of rainfed paddy, pigeon pea, wheat, chickpea, and kitchen garden vegetable seed packets, saplings of mango, guava, custard apple, bael, jackfruit and bamboo were distributed among the tribal beneficiaries.

Under the mega programme on Integrated plant health management, integrated module comprising spray of rynaxpyr 18.5 SC 0.5 ml/l followed by azadirachtin 0.15% 5ml/l, emamectin benzoate 5 SG 0.5 gm/l and *Bt* 1ml/l at 10 days interval during flowering and fruiting recorded 85.71% reduction in fruit damage by *Maruca vitrata* in cowpea with higher yield (118.62 q/ha). In cabbage, integrated module comprising spray of azadhiractin 0.3% 5ml/l, rynaxpyr 18.5 SC 0.15 ml/l, novaluron 10 EC 1.5ml/l, E benzoate 5 SG 0.35g/l at 10-15 days interval was highly effective with 68.17% reduction in DBM, *Plutella xylostella* population and recorded 91.67% increase in yield as compared to control. In brinjal, two rotational strategies *i.e.* spray of rynaxpyr 0.4ml/l followed by emamectin benzoate 0.4g/l, Spinosad 1.5ml/l, chloropyriphos 2ml/l and cypermethrin 0.5ml/l was most effective giving 94.92% protection of shoot damage and 72.90% protection of fruit damage with 91.29% yield increase and corresponding values for another strategy *i.e.* rynaxpyr followed by emamectin benzoate spray were 97.14, 75.43 and 54.50%, respectively.

Under toxicological investigation, occurrence of 4 genetic groups of *Bemisia tabaci* namely Asia I, Asia II-1 and Asia II-5 and China 3 were noted in Varanasi region. A new invasive group China-3 first time was recorded in India from Varanasi. Asia I constitute 39.39% followed by Asia II-5 (33.33%) and China 3 (21.21%). Sulfoxaflor 90g a.i/ha and Flupridifurone 250g a.i/ha exhibited 87.40 and 88.19% reduction, respectively. Cyantraniliprole 10 OD was 79.14, 64.34 and 30.74 times toxic to that of imidacloprid against *Myzus persicae, Lipaphis eryisimi* and *Aphis gossypii*, respectively. Cyantraniliprole 60 g a.i./ha caused 80, 86 and 75% mortality against *B. brassicae, L. erysimi* and *M. persicae*, respectively. Flea beetle was less susceptible to cyantraniliprole compared to commonly used insecticides. Sulfoxaflor 24 SC 90 g a.i/ha and flupridifurone 200 SL 250 g a.i./ha were effective with 87.40 and 88.19% reduction in leafhopper, whereas, Cyzapyr 10 OD 75 g a.i/ha effective with 97.81% reduction in whitefly.

Under biological control of insect pests, promising natural enemies like *Trathala flavo-orbitalis* from *Leucinodes orbonalis* infesting brinjal, *Aenasius arizonensis* from invasive mealy bug, *Phenacoccus solenopsis* infesting brinjal, tomato, okra, pointed gourd, chillies and *Apanteles paludicole* from *Sphenerches caffer* infesting bottle gourd were recorded. A parasitoid *T. flavo-orbitalis* parasitized *L. orbonalis* to a maximum of 17.25% during October 3rd week. A parasitoid *Aenasius arizonensis* showed variable response towards *P. solenopsis* infesting vegetables, being highest in tomato (28.23%) followed by okra (26.5%) and cucurbits (10.89%). Among different EPF tested alone and in 1:1 ratio with neem oil 1% against *Epilachna dodecastigmata*, *M. anisopliae* IIVR strain 5g/l had least LT_{50} of 60.86 hr compared to *L. lecanii* (65.95 hr). Neem oil took minimum 45.09 hr for 50% kill. *M. anisopliae* IIVR strain + neem oil took still lower time (33.85 hr) showing compatibility and synergistic action. When imidacloprid, thaimethoxam in combination with *B. bassiana* IIVR strain, *M. anisopliae* IIVR strain, *L. lecanii* tested at half of their recommended doses against *L. erysimi* indicated imidacloprid+*V. lecanii* with lowest LT_{50} value of 21.22 hr and highest co-toxicity coefficient value (1.42). Similarly, thiamethoxam + *V. lecanii* took lowest LT_{50} value as 11.39 hr with highest CTC value (1.90) showing synergism.

Under the management of fungal diseases, *Trichoderma* formulation (BATF43-1) and PGPR endophytic bacteria (H86NV) and Sel 7 were evaluated against damping off (*Pythium aphanidermatum*) and collar rot (*Sclerotium rolfsii*) in tomato. Tomato seeds (cv. Kashi Amrit) were treated with the bioformulation @ 10 g/kg of seeds or carbendazim @ 2g/kg. Root dipping with bioformulation @10% and soil drenching with chemical (Fosetyl Al / Copper hydroxide/ tebuconazole) @ 0.1% were also applied. Among the bioformulations, *Trichoderma* formulation BATF43-1 showed maximum damping off control (>60%) in tomato, and amongst chemicals, carbendazim seed treatment followed by drenching with Fosetyl Al recorded more than 80% control of the disease. In case of germination, BATF 43-1 recorded as the best treatment. Tebuconazole 0.025% caused 100% inhibition of mycelial growth of *Sclerotium rolfsii* and *Pythium aphanidermatum*. Under bioprospecting of microorganisms, the genomic DNA of selected

pathogen suppressing microbes was isolated, and the 16 srRNA region was amplified, cloned and sequenced. The isolates were identified as *Stenotrophomonas maltophila*, *Serratia marsecens* and *Alcaligenes* sp. *Isaria farinosa* was compatible with cyzpyre, flopyridifuron, sulflour, flonicamid, spiromesifen, difenthion, Imidacloprid, Thiomethoxam and acetamprid except dimethoate at recommended dose.

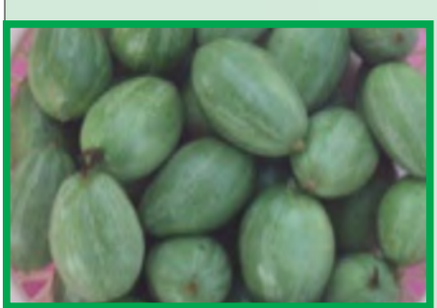
Under the management of important bacterial diseases, streptocycline 100 ppm gave the highest content of chlorophyll a, chlorophyll b, carotenoids, superoxide dismutase (SOD), proline, nitrate reductase and total protein component in tomato as compared to control followed by Copper hydroxide 2g/l water when applied for the management of leaf spot of tomato (*Xanthomonas axonopodis* pv *vesicatoria*). Combining biocontrol agent (*Bacillus subtilis*) and SAR inducers showed the best result against black rot of cabbage.

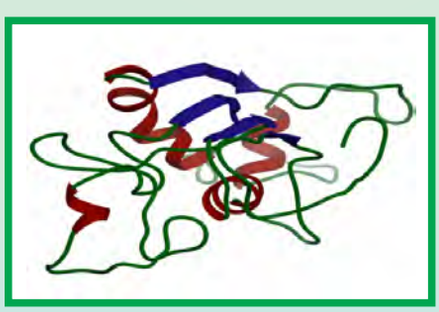
Under diagnostics of plant viruses, the complete genome (DNA-A) of virus isolate infecting squash was determined to be 2738 nts with a typical genome organization of other old world monopartite begomoviruses. Recombination analysis of Squash leaf curl China virus infecting squash indicated the evidence of recombination in SLCCNV infecting squash with most of the DNA fragments derived from TOLCNDV (U15015) and SLCCNV (KC857509) and emerged as a new strain of SLCCNV infecting squash. RDP analysis of DNA B like sequence isolated from squash indicated the evidence of recombination in DNA B like sequence suggestive of the most part of DNA B descended from BYVMV (HQ586007) and ToLCNDV (JN663848) infecting okra and chilli in India. In virus vector relationship study, the maximum transmission efficiency (100%) achieved using 6 insects/plant with 24 hr of AAP and IAP in Squash leaf curl virus. Young seedlings up to the age of two weeks were highly vulnerable to the virus, and afterwards their susceptibility to virus decreased.

In plant nematode management, hexane extract of *Calotropis procera* (1%) recorded high mortality (62.7%) followed by chloroform (51.3%), methanol (25%) and acetone (17.7%) over control. Methanol extract of *Datura metel* showed 36.3% mortality in *M. incognita* and 11.3% in *Rotylenchulus reniformis* under *in-vitro* condition. The bacterial isolate BG-11 reduced root galls up to 65.7% similar to the formulation of *B. subtilis* (IIHR strain).

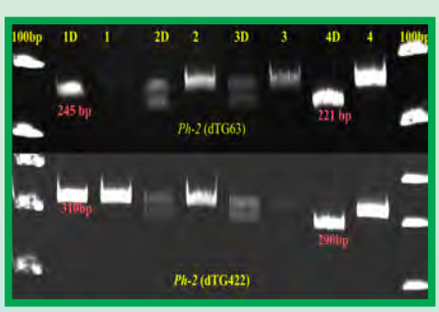
Under the pest dynamics study, the highest cucurbit fruit fly, *Bactrocera cucurbitae* was recorded during Nov. 1st week (287.67 nos/trap) followed by March last week (266.33). Large fluctuation in the incidence of shoot & fruit borer, *Leucinodes orbonalis* in brinjal was observed with two peaks; first during 16th SMW (27.67 moths/trap) and second in 09th SMW (33 moths/trap). Incidence of late blight in tomato (*Phytophthora infestans*) initiated when minium temperature starts <18-20 ^{0}C (44-45 Std wk) and progresses rapidly when >80% RH and <10-15 ^{0}C. (52 to 3rd std wks). Periodical incidence of black rot in cabbage (*Xanthomonas campestris pv. campestris*) observed for 14 weeks with maximum during February 3rd week (48.3%).

Research Achievements





Division of Vegetable Improvement



MEGA PROGRAMME 1: INTEGRATED GENE MANAGEMENT

Programme Leader: Major Singh

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

SK Tiwari, DR Bhardwaj, H Lal, N Rai, Sudhakar Pandey, Rajesh Kumar, SK Sanwal, HC Prasanna, PK Singh, T Chaubey, BK Singh, JK Ranjan, YS Reddy, P Karmakar, Pragya and Jyoti Devi

Status of germplasm collection

Six thousands five hundred ninety six accessions of 62 different major and minor vegetables crops are being maintained at ICAR-IIVR, Varanasi. 113 new accessions have been augmented to the pool in the institute during the year 2014-15. The institute is maintaining 317 accessions of 57 (8 in tomato, 13 in brinjal, 13 in chilli, 3 in French bean, 10 in okra, 1 in radish, 1 in pointed gourd, 1 in cucumber, 1 in *methi* and 8 in amaranth) related wild species in ten vegetable crops.

Maintenance, characterization and screening of germplasm, breeding stock and varieties

Brinjal: One hundred sixteen germplasm accessions were maintained and multiplied. Seeds of twelve related wild species of brinjal procured from AVRDC, Taiwan last year were multiplied for further use in breeding programme.

Chilli: Three hundred thirty five accessions of *Capsicum* species were maintained during 2014-15. These included nine sets of cytoplasmic male sterile lines, two genetic male sterile lines, 21 newly introduced chilli accessions, seven indigenous collections and the working collections of chillies. Morphological characterization as per the minimal descriptors of chilli was completed for 225 accessions for 42 traits. Genotypes BS-20 and BS-79 were found tolerant to leaf curl and insects under field condition.

Tomato: Fifty seven accessions of tomato including wild species i.e.; *Solanum neorickii* (2), *S. arcanum* (1), *S. lycopersicum* (1), *S. pimpinellifollium* (1), *S. habrochaites* (1), WIR 3928 and WIR 3957 are being maintained.

Cowpea: Twelve pole type cowpea genotypes collected from Mizoram were evaluated during *kharif*, 2014. Genotype MZCP-10 took minimal days to 50% flowering (42 DAS) followed by MZCP-9 (46 DAS). The maximum number of branches per plant was recorded in genotype MZCP-2 (4.4) followed by MZCP-5 (4.0). The longest peduncle was found in genotype MZCP-5 (27.0 cm) followed by MZCP-6 (26.2 cm). The maximum number of peduncles per plant was obtained from genotype MZCP-4 (8.3) followed by MZCP-5 (8.0). However, the maximum number of pods per plant was obtained from genotype MZCP-5 (9.6) followed by MZCP-12 (7.4). Similarly, longest and heaviest pod was obtained from genotype MZCP-15 (34.5 cm and 12.7 g) followed by MZCP-9 (32.2 cm and 12.5 g).

The maximum number of seeds per pod was recorded in genotype MZCP-4 (12.9) followed by MZCP-15 (12.7). The highest pod yield per plant was obtained from genotype MZCP-10 (84.4 g) followed by MZCP-9 (72.5 g). All genotypes exhibited red seed-coat colour and were susceptible to cowpea golden mosaic virus and *Cercospora cruenta* under field condition. A total of three hundred sixty two genotypes of cowpea were maintained.

Pea: A total of 22 peas genotypes belonging to early, mid and late maturity group were selected and analysed for the biochemical traits *viz.*, total phenol (mg GAE/100 g), total flavonoids (mg CE/100 g) and antioxidant activities. The genotype EC-9485 and VRP-233 bearing purple colour flower, recorded highest total phenol (128.64 and 104.01), flavonoids (45.84 and 36.84) and antioxidant activities (26.79 and 20.96) whereas the cultivar belonging to early group (VRP-100, VRP-101, VRP-25, VRP-5, VRP-6, AP-3 and Arkel, in general, possessed lower values for these traits. Phenol and flavonoid content had positive correlation with antioxidant activities.

Indian bean: A total of 25 pole type germplasm were maintained, documented and evaluated for early, yield and good pod quality (Table 1).

Table 1: Promising genotypes of Indian bean

Traits	Promising accessions
Early and high yield	VRSEM-101 (First picking : 129DAS; Yield: 5.3 kg/ plant), VRSEM-760 (First picking : 128 DAS; Yield: 5.2 kg/ plant)
DYMV tolerant lines (Under field condition)	VRSEM-12
Characterization on the basis of pod color	
Green with purple line	VRSEM-201, VRSEM-45, VRSEM-100 ; VRSEM-798
White	VRSEM-415, VRSEM-601, VRDB-1; VRSEM-90
Green	VRSEM-780, VRSEM-941 (B), VRSEM- 815; VRSEM-836

French bean: Sixty five accessions of French bean were evaluated for various traits of economic importance. A total of 13 new germplasm of *Phaseolus* (9 of *P. lunatus*, 2 of *P. coccineus* and one each of *P. acutifolius* and *P vulgaris*) were added to the genetic stocks from AVRDC, Taiwan.

Pointed gourd: One hundred thirty germplasm of pointed gourd were evaluated. Number of days required for the anthesis of the 1st flower ranged from 65 to 90 days with mean of 85.25 days; and number of node at 1st harvest varied from 5.75-12.25 with a mean of 9.56. There was considerable variation recorded among the clones for internode length (7.20 -15.15 cm), fruit length (4.25 -11.30 cm), fruit diameter (3.00-4.55cm), fruit weight (17.50-52.00 g), number of fruits per plant (75.00-315.00) and weight of fruit per plant (4.50-15.00 kg). Two clones of pointed gourd and one wild species of *Trichosanthes* were collected from West Bengal.

Sponge gourd: A total of 75 germplasm including new collection were evaluated. Among the 75 germplasm, 10 genotypes *viz.* VRSG-195, VRSG-77, VRSG-154, VRSG-9, VRSG-3-14, VRSG-2-13, VRSG-3-13, VRSG-11, VRSG-189 and EC-790313 were found promising for horticultural traits. Genotype VRSG- 195 produced highest number of fruits (12 fruits/plants) and yield (1.5 kg/plant) followed by VRSG-3-14. The genotype EC-790313 produced longest fruits (70.23 cm). Genotype VRSG-77, VRSG-154, VRSG-194 and VRSG-171 showed tolerance against downy mildew whereas VRSG-194, VRSG-195, VRSG-1-12 and VRSG-214 were free from virus disease symptoms under field conditions.

Cucumber: A total of 52 germplasm/genotypes 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 37.0 (VRCU-3) to 53.0 (VRCU-26) and number of days required for anthesis of 50% female flower ranged from 36.0 (VRCU-5) to 55.0 (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 g (VRCU-3) to 1137.28 g (VRCU-14-3).

Pumpkin: Twenty six germplasm were been evaluated for yield and quality attributes. A total of 100 lines including identified/released varieties were maintained as active collections. Variability for different characteristics was observed. Fruit yield per plant ranged between 1.88 kg per plant (VRPK-07) to 20 kg/plant (VRPK-10-8). Number of fruits per plant varied between 1.5 (VRPK-80) to 4.50 (VRPK-5-1). Individual fruit weight ranged from 0.47 kg (VR-87) to11.66 kg (VR-07-4) at mature stage. All the lines were maintained through selfing / sibbing for their further utilization. Forty six pumpkin genotypes were analysed for antioxidant activity i.e. total phenol, (mg/100g), CUPRAC (µmol TE/g) and FRAP (µmol TE/g). The maximum phenol content (40.04), CUPRAC (3.54) and FRAP (0.86) was recorded (Table 2).

Table 2: Descriptive statistics of 46 genotype of pumpkin for antioxidant activity

Statistics	Total phenol (mg/100g)	CUPRAC (µmol TE/g)	FRAP (µmol TE/g)
Minimum	4.62	0.29	0.06
Maximum	40.04	3.53	0.86
Overall mean	17.66	1.428	0.352
SE	1.31	0.1	0.02
Important genotypes	VRPK-Sel-10-01 VRPK-03	VRPK-Sel-11-6-5 VRPK-01	VRPK-Sel-11-6-5 VRPK-222-2-2
Kashi Harit (check)	30.94	1.77	0.73

Watermelon: Ninety eight genotypes of watermelon including land races, ecotypes and wild forms were planted, evaluated & maintained through selfing. VRW-1, VRW-2 and VRW-12 were found promising for earliness, yield and fruit quality. A red fleshed genotype VRW-9-4 and light yellow fleshed line VRW-12-3 has also been identified for further evaluation.

Muskmelon: One hundred fifty germplasm of muskmelon were maintained and twenty five germplasm of muskmelon were collected from Uttar Pradesh, Bihar, Jharkhand and Karnataka. Eighty diverse genotypes of muskmelon were evaluated for different horticultural traits. Fruit shape in evaluated germplasm were round, flattened, oblate, elliptical, pyriform, ovate and elongated. Exterior fruit colour varied from yellow to grey, while flesh colour ranged from white to orange. Vine length, number of primary branches varied from 85.00 - 200.50 cm and 2.76-5.00 with a mean value of 120.75 and 3.50, respectively. Days to first flower anthesis and node at which first productive flower appear ranged from 45 .00 – 70.00 and 5.00-10.00, respectively. On the other hand fruit length (9.55-32.25 cm) diameter (7.85 – 20.15 cm), fruit weight (150.00 – 1100.50 g), pericarp thickness (0.85-2.25 cm), total soluble solids (4.75-15.50 °Brix) and yield/plant (0.80 – 4.30 kg) also exhibited considerable variability. VRMM-12, VRMM-25 and VRMM-23 were found to be three best performing genotypes.

Other crops: A total 95 germplasm of cauliflower, 55 of radish, 5 of bathua, 21 of fenugreek were evaluated for various traits. A radish genotype VRRAD-130, with pink colour root, showed unique trait among tropical types having iciclical shape and coloured root, and possessed highest amount of total antioxidant activity i.e.; 150% higher than the white rooted varieties. While 93 accessions of carrot were evaluated and variation for shoot weight (22.6-91.8 g), shoulder diameter (2.6-4.9 cm), root length (12.4-24.0 cm), root weight (29.1-133.0 g) and harvest index (36.3-71.8 %) were recorded.

Phylogenetic analysis of indigenous vegetables: Phylogenetic relationships among sponge gourd, ridge gourd and satputia was carried on a set of 24 accessions including 9 accessions of ridge gourd, 2 of sponge gourd and 4 of satputia. Primers for DNA barcoding were used for this analysis.

Sharing of germplasm: Promising germplasm accessions and released varieties/hybrids were shared with various organizations for research, evaluation and demonstration purpose after signing of the Material Transfer Agreement (MTA). Details of the germplasm supplied along with the recipient organizations are given in Table 3.

Table 3: Crop-wise details of the germplasm shared with other organizations

Crop	Recipient organization
Tomato (314)	ICAR-IIHR, Bangalore (2), University of Agricultural Sciences, Bangalore (9), College of Horticulture, UHS Campus, Bangalore (258), Taikojen Seeds LLP, Kolkata (1), ICAR-CPRI, Shimla (3), SKUAS&T, Jummu (30), Kerala Agriculture University (8), Tamil Nadu Agriculture University, Coimbatore (12), National Institute of Plant Genome Research, New Delhi (1), Banaras Hindu University, Varanasi (39), SHIATS, Allahabad (20), University of Horticultural Sciences, Bagalkot (1), Babasaheb Bhimrao Ambedkar University, Lucknow (30)
Brinjal (136)	Central Agricultural University, Meghalaya (30), College of Horticulture, Hiriyur, Karnataka (25), ICAR-CPRI, Shimla (2), NDUA&T, Faizabad (20), Banaras Hindu University, Varanasi (30), Swarna Seeds, Kolkata (2), I&B Seeds Pvt. Ltd. (2), Babasaheb Bhimrao Ambedkar University, Lucknow (25)
Chilli (34)	I&B Seeds Pvt. Ltd. (1), Swarna Seeds, Kolkata (3), Centre of Biotechnology, Shiksha O Anusandhan University, Bhubaneswar (20), Bihar Agricultural University, Sabour (10)
Cucumber (10)	Dept. of Horticulture, H.N.B. Garhwal University, Srinagar (10)
Bitter gourd (69)	Dept. of Horticulture, H.N.B. Garhwal University, Srinagar (10), CHES (ICAR-IIHR), Bhuvneshwar (10), Banaras Hindu University, Varanasi (10), Regional Agricultural Research Station, Nandyal, Andhra Pradesh (20), Babasaheb Bhimrao Ambedkar University, Lucknow (18), Swarna Seeds, Kolkata (1)
Bottle gourd (21)	SKN College of Agriculture, Jobner (20), Swarna Seeds, Kolkata (1)
Okra (81)	College of Horticulture, University of Horticultural Sciences, Bagalkot (50), Swarna Seeds, Kolkata (3), I&B Seeds Pvt. Ltd. (3), Babasaheb Bhimrao Ambedkar University, Lucknow (25)
Muskmelon (6)	Dr. YSR Horticulture University, Kadapa, Andhra Pradesh (1), I&B Seeds Pvt. Ltd. (1), Tamil Nadu Agriculture University (4)
Pumpkin (2)	Swarna Seeds, Kolkata (1), I&B Seeds Pvt. Ltd. (1)
Pea (2)	I&B Seeds Pvt. Ltd. (2)
Cowpea (39)	NRCPB, New Delhi (5), Tamil Nadu Agriculture University (4), Swarna Seeds, Kolkata (2), I&B Seeds Pvt. Ltd. (3), Babasaheb Bhimrao Ambedkar University, Lucknow (25)
Indian bean (1)	Swarna Seeds, Kolkata (1)
French bean (26)	Centre of Biotechnology, Shiksha O Anusandhan University, Bhubaneswar (26)
Ridge gourd (31)	University of Horticultural Sciences, Bagalkot (25), Horticulture College & Research Institute, Dr. YSR Horticulture University, Venkataramannagudem (6)
Sponge gourd (2)	Swarna Seeds, Kolkata (1), I&B Seeds Pvt. Ltd. (1)
Carrot (35)	College of Horticulture, UHS, Bagalkot (35)
Radish (25)	Horticulture College & Research Institute, Dr. YSR Horticulture University, Venkataramannagudem (25)
Total	**924 accessions**

SUB PROJECT: 1.2: Genetic Improvement of Solanaceous Vegetables

Major Singh, N Rai, Rajesh Kumar, JK Ranjan, SK Tiwari, YS Reddy, RS Gujjar, AB Rai, M Loganathan, B Mahesha, C Sellaperumal, TK Koley and Satyendra Kumar Singh

TOMATO

Examination of molecular markers for use in marker assisted selection (MAS) in tomato for Root Knot Nematode (*Mi*), late blight (*Ph-2*) and *Fusarium* wilt (*I, I-2* and *I-3*): Six reported PCR-based co-dominant

markers for *Mi* gene were screened in resistant genotypes along with a susceptible genotype. Out of six markers, four (Aps, C8B, REX-1 and CT119) were cleaved amplified polymorphic sequences (CAPS) and other two (Mi23 and Pmi) were sequence characterized amplified regions (SCAR). Aps marker did not result in any PCR amplification and the banding pattern for C8B was not consistent among the resistant genotypes used. Remaining four markers gave banding pattern, which was in accordance with the reported literature (Fig. 1).

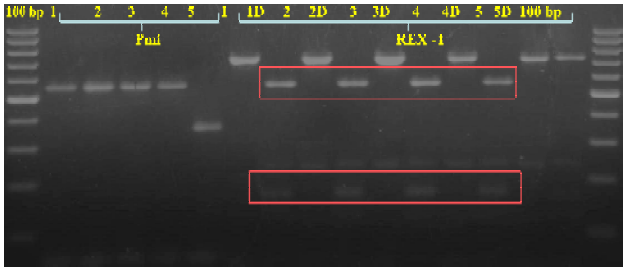


Fig. 1: 1, 2, 3 and 4 are resistant genotypes; 5 is susceptible genotype; D in case of REX-1 indicates after digestion with restriction enzyme

Two reported CAPS markers (dTG63 and dTG422) for *Ph2* were screened in *Ph-2* containing genotypes, in a susceptible genotype and in hybrids with single dose of *Ph-2*. The banding pattern in the markers was in accordance with the elsewhere reports (Fig. 2).

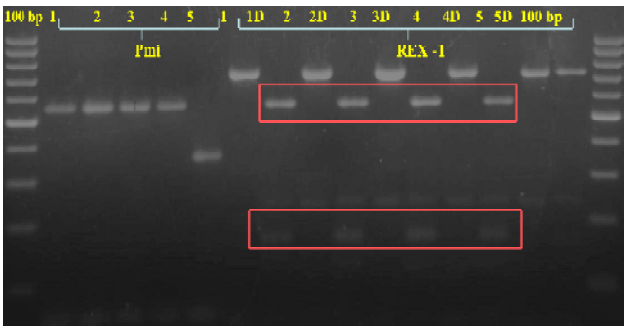


Fig. 2: Ph-2 containing genotype, 2 and 3 - Ph-2 in heterozygous condition and 4 is a susceptible genotype. D - after digestion with restriction enzyme

Four reported PCR-based co-dominant markers for *I-3* gene were examined. Among them two markers *viz*, P7-43B and PTG-190 are CAPS markers and other two *viz*, P7-43D F1/R1 and P7-43D F3/R1 are SCAR markers. Other than P7-43B, all other markers gave banding pattern that was similar to reported literature. In addition, one dominant SCAR marker At2 for *I* gene and one dominant SCAR marker Z1063 for *I-2* gene were tested and the banding pattern was according to reported literature (Fig. 3).

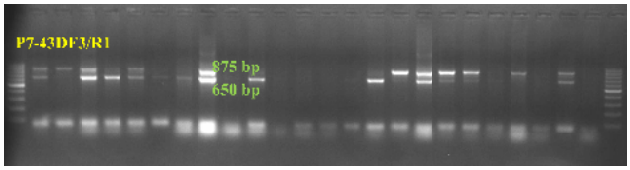


Fig. 3: Banding pattern of P7-43F3/R1 SCAR marker observed in tomato accession EC-786272

The above marker information was used to select individual plants of respective genotypes to be used in crossing programme and for purification of respective tomato accession.

Screening against root knot nematode (*Meloidogyne incognita)* and leaf minor (*Liriomyza trifolii*): Nine tomato genotypes (four resistant lines, three susceptible lines) and two advanced lines viz., D-6-1-4-P2 and C-12-1-4-P2018) were screened at two inoculation rates *viz*, 2000J_2 and 4000 J_2. Tomato accessions EC-786262 and EC-786267 were found highly resistant to root knot nematode at both the inoculation rates. Twenty one tomato genotypes were screened against leaf minor damage under screen house conditions. Among them EC-520078 was the most tolerant one.

Field evaluation of F_1s against early blight and late blight: Three F_1s of WIR 3928 were made with Kashi Amrit (DVRT-1), Kashi Vishesh (H86) and Hawaii 3998. These F_1s have shown resistance to early blight under field conditions. Twenty five tomato hybrids were evaluated for horticultural and blight resistance under field conditions. Among them, two hybrids with *Ph2* gene in heterozygous condition found resistant to late blight.

Generation advancement for high yield good quality and least ToLCV incidence

Forty seven segregants were advanced from F_9 to F_{10} and 13 segregants were selected. While, sixty one segregants were advanced from F_8 to F_9 and 14 segregates were selected. Similarly four segregants were advanced from F_6 to F_7 and 02 segregates were selected. Ten segregants were advanced from F_5 to F_6 and 6 were selected.

Development of cherry tomato: Sixteen segregating populations derived from *Solanum lycopersicum* × *S. pimpinellifolium and S. habrochiates* were advanced from F_3 to F_4.

Development of beta carotene rich varieties/lines: Fifteen segregating lines obtained from cross *Solanum lycopersicum* × *S. pimpinellifolium* evaluated for beta carotene. The genotype TBCL-29 (35.53 mg/g) contained highest beta carotene followed by TBCL-1 29 (32.20 mg/g).

BRINJAL

Evaluation of hybrids: Forty four F_1 hybrids were evaluated for earliness, yield and quality traits. Based on yield and other parameters IVBHR-20 (Fig. 4) and IVBHR-21 were identified as promising hybrids in round fruited segments, while IVBHL-20 (Fig. 4) and IVBHL-21 were found promising in long (medium) fruited segment.

IVBHR-20 IVBHL-20

Fig. 4: Fruit appearance of IVBHR-20 (round) and IVBHL-20 (medium long)

Hybridization and generation advancement: Under distant hybridization programne, sixty interspecific crosses were attempted utilizing six cultivars (Pant Rituraj, PR-5, Kashi Uttam, Pusa Ankur, Pusa Upkar and ADM-190) and nine wild species viz: *S. undatum, S. ferox, S. sisymbrifolium, S. macrocarpum, S. lasiocarpum, S. aethiopicum, S. anguivi , S. villosum* and *S. xanthocarpum*. Among cultivated lines, 70 cross combination in round purple and 42 cross combination in purple long segment has been attempted utilizing promising parental line. Six promising advanced lines (3 round and 3 long fruited) in F_7, F_8 and F_{10} generations were selected for high yield and better fruit quality. A total of 277 segregating populations (F_2-27, F_3-36, F_4-14, F_5-43, F_6-30, F_7-53, F_8-34, F_9-20, F_{10}-14, F_{11}-06) were advanced to subsequent higher generation.

Genotyping of 114 RILs: SSR primers (320) were screened for identification of polymorphic primers between parental lines of RILs. 40 primer pairs were identified polymorphic and 15 were used for genotyping of RILs (Fig. 5).

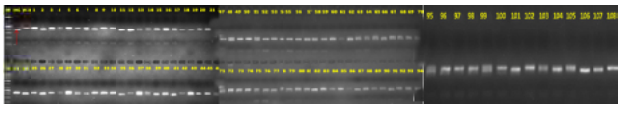


Fig. 5: Polymorphism pattern generated by SSR primer emh02E08 (166). Lane M: 100 bp ladder, Lane 1: Ramnagar giant (*S. melongena*), Lane 2: W_4 (*S. incanum*)

Maintenance breeding: Seeds of Kashi Sandesh (400g), Kashi Taru (500g), Kashi Komal (200g), Kashi Prakash (400g) and Kashi Uttam (500g) was multiplied for distribution and multi-location demonstration / evaluation by public and private organizations. Parental line of hybrids *viz*- PR-5 (250g), CHBR-2 (150), Pant Rituraj (200g), Uttara (150g) Punjab Barsati (150g), ADM-190 (150g) and IVBL-22 (300g) were also multiplied.

CHILLI AND CAPSICUM

CHILLI

Evaluation of intra and inter-specific F_1 hybrids: A total of 61 F_1 hybrids were evaluated. Parents involved in crosses are with resistance to diseases such as anthracnose, leaf curl and with high yield potential and pungency. F_1 hybrids, CCH-10 and CCH-11 (Fig. 6) involving cytoplasmic male sterile parents showed higher yield potential. *Per se* performances of the crosses were estimated and selected combinations for different traits are given in Table 4.

Table 4: Promising F_1 hybrids for different yield traits in chilli

Traits	F_1 hybrids
Fruit length (cm)	A2 x Japani Longi (11.9), Pusa Jwala x CM-334 (10), A2 x Kashi Anmol (9.4), A2 x PBC-904 (9.4)
Fruit diameter (cm)	PT-12-3 x NG-6 (3), A2 x VR-339 (1.4), A2 x Punjab Lal (1.3)
Plant height (cm)	MS-12 x PBC-904 (71), A1 x VR-339 (63.67), A2 x VR-339 (55.7)
Fruits per plant	A2xVR-339 (191), MS12 x PBC-904 (121), A2 x K. Chanchal (115)
Fruit yield (q/ha)	A2 x Kashi Anmol (150), A2 x VR-339 (145), A1 x VR-339 (143)

CCH-10 CCH-11

Fig. 6: CCH 10 & CCH-11, CMS-based F_1 hybrids with high yield potential

Estimation of capsaicin in green and red chillies: High variation in terms of capsaicin content in green as well as red chilli fruits was observed. In general, pungency was predominant in red chilli fruits, ranging from Byadagi Dabbi (0.13%) to GKC 29 (1.54%). The difference in capsaicin content from red to green was

highest in EC 519636 (37500 SHU) followed by PBC-142 (19500 SHU) and CCH-5 (18000 SHU) (Table 5). Chilli fruits containing 0.5 % capsaicin are ideal for edible purpose in vegetables.

Table 5: Capsaicin content in red and green chilli fruits

Genotype	Green chilli		Red chilli		SHU (Diff.)
	Capsaicin %	SHU	Capsaicin %	SHU	(Red – Green)
VR-339	1.25	187500	1.3	195000	7500
Kashi Gaurav	0.84	126000	0.89	133500	7500
Pusa Jwala	0.62	93000	0.65	97500	4500
F5-112	0.63	94500	0.69	103500	9000
Kashi Anmol	0.55	82500	0.6	90000	7500
Kashi Surkh	0.77	115500	0.84	126000	10500
CCH-7	0.15	22500	0.19	28500	6000
GKC-29	1.54	231000	1.61	241500	10500
AKC-89/38	1.24	186000	1.31	196500	10500
CSB-8	0.49	73500	0.57	85500	12000
PBC-367	0.63	94500	0.69	103500	9000
VNS-4	0.86	129000	0.91	136500	7500
Kashi Early	0.77	115500	0.82	123000	7500
Dabbi	0.13	19500	0.21	31500	12000
PBC-142	0.54	81000	0.67	100500	19500
Kashi Tej	0.61	91500	0.68	102000	10500
EC-519636	0.72	108000	0.97	145500	37500
CCH-5	0.31	46500	0.43	64500	18000

Transfer of male sterility: In order to transfer genetic male sterility (GMS3, *ms-3*) 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 was selfed for BC_1F_2. These seeds will be grown and BC_2F_1 will be developed in the next growing season. 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.

Screening for virus resistance: Different chilli genotypes were screened for tolerance/resistance to various viruses through double antibody sandwich – ELISA test. It was found that the natural interspecific derivative lines of chilli showed more resistance towards different viruses *viz.*; capsicum chlorosis, cucumber mosaic and groundnut bud necrosis viruses. The genotypes BS-35, CM-334, IIVRC-452 and Japani Longi were free from all these three viruses under the test and these are being utilized for development of prebred lines of chilli.

Screening for thrips and mites tolerance: A set of 130 lines were screened for reaction to thrips & mites based on percent leaf curl damage of the plants. Seven genotypes showed less than 5% damage on leaves while 52 lines were categorized under 6-20% damages (Table 6). A cross between Kashi Anmol and Japani Longi was advanced to F_2 generation and single plants selections were made based on symptom appearance for further advancement for line development.

Table 6: Screening of chilli against thrips and mites infestation

S.N	Scale	Genotype
1	Damage < 5%	LCA-353, PT-14-1, PT-279, PT-285, PT-70, BS-20, BS-79
2	Damage 6-20%	CO-5677, IIHR-29, PBC- 374, SM-12, Dabbi, PBC-776, C00-765, BS-5 (Yellow), SDA-205, SDA-204, JCA-283
3	Damage 21-40%	IIHR-22, C0-5778, C0-5484, IIHR-25, PDG-66, PDG-2, JCA-9 + DN PT-4, Roshani, SM-14, C0-4
4	Damage 41-60 %	LCA-424, PT-12-3, EC-454591, SB-12667, SP-12, PT-57, VRCH-1, PT-166, PT-336, PT-125, PT-323,
5	Damage 61-80%	PDC-49 A, SP-38 , SP-16 DN, SP-143 A , PT-290, PT-248, LCA-301 (7)
6	Damage > 80%	NG-4, Co-5677, SM-2

Line development: From the segregating lines i.e.; 102 combinations in F_2 generation, 65 families in F_3, 107 in F_4, 73 families in F_5, 8 families in F_6 and 11 families in F_7 were advanced. In F_2 generation, derivatives of PBC 904 and NG lines expressed promise for tolerance to flood, leaf curl, thrips and mites along with high pungency. Similarly in F_5 generation, derivatives of Kashi Sinduri x AKC-89/38 for morphological attributes and anthracnose, PT-12-3 x Bhut Jolokia for morphological, capsaicin and leaf curl disease and Kashi Sinduri x BS-35 for LCV, anthracnose and capsaicin were advanced to subsequent generations.

Genotyping of mapping population: The $F_{2:3}$ populations consisting of 229 individual genotypes derived from a cross between Kashi Sinduri and AKC 89/38 to be used for generating the genetic map and QTL analysis. Out of 545 simple sequence repeat primers, 57 were found polymorphic and of these, 36 were genotyped among the 229 individuals of mapping population derived from Kashi Sinduri and AKC 89/38 (Fig. 7).

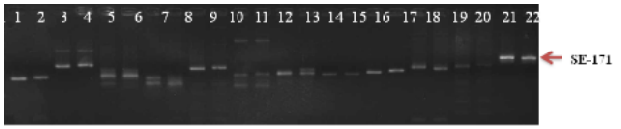


Fig. 7: Genotyping of $F_{2:3}$ individuals with polymorphic SSR 'SE-171'

CAPSICUM

A total of 16 genotypes of *capsicum* were evaluated for different agro-morphological traits. Among evaluated traits, plant height ranged from 27 .4 to 46.2 cm, whereas stem girth from 0.72 to 1.3 cm. Similarly, number of fruits per plant, fruit length, fruit width, fruit weight and pericarp thickness ranged from 2.0 to16.2, 2.3 to 7.0 cm, 3.2 to 6.3 cm12 to 52.2 g and 2 to 4.0 mm respectively. On the basis of above traits genotype EC-458206, PT 12 -3 and GPC-6 were found promising. Sixteen crosses were made to generate F_1 hybrids for evaluation and generate segregating

PT 12 -3 EC458206 GPC-6

Fig. 8: Promising germplasm of *Capsicum*

population (Fig. 8).

SUB PROJECT: 1.3: Genetic Improvement of Legume Vegetables

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COWPEA

Evaluation of advanced breeding lines: Fourteen dwarf and bush type advance lines along with one national check (Kashi Kanchan) were evaluated. Line 70-2 flowered earliest and took minimum days to 50% flowering (32.2 DAS) followed by line 98-4 (33.1 DAS) and 96-4 (34.2 DAS). The maximum number of branches plant^{-1} was recorded in line 112-4 (4.6) followed by 68-2 and 79-4 (4.5). The longest peduncle was found in Kashi Kanchan (39.5 cm) followed by line 71-1 (35.8 cm) and 112-4 (35.2 cm). The maximum number of peduncles plant^{-1} was obtained from line 112-4 (31.4) followed by line 79-4 (29.3) and 98-4 (29.2). However, the maximum number of pods plant^{-1} was recorded in line 112-4 (32.2) followed by line 96-4 (29.8) and 102-1 (29.5). The longest pod was obtained from line 112-4 (33.3 cm) followed by line 121-3 (32.2 cm). Similarly, the heaviest pod was recorded in line 67-1 (13.5 g) followed by line 112-4 (13.0 g). The maximum number of seeds pod^{-1} was observed in line 67-1 (14.4) followed by line 112-4 (13.8). The highest pod yield plant^{-1} was recorded in line 112-4 (398.5 g) followed by 98-4 (371.2 g) and 102-1 (365.7 g).

Hybridization and advancement of generations: Backcrossing of F_1s with recurrent parental lines was carried out and 24 BC_1F_1 were made. A total of 296 segregating populations (F_2-35, F_3-35, F_4-65, F_5-46, F_6-47, F_7-56, F_8-10, and F_9-2) were advanced to subsequent higher generation.

Maintenance breeding of cowpea varieties: The maintenance breeding of cowpea varieties *viz*. Kashi Shyamal, Kashi Gauri, Kashi Unnati, Kashi Kanchan and Kashi Nidhi were done through single plant selections.

Cowpea entries in AICRP (VC) Trial: Two advanced lines (VRCP-10 and VRCP-11) were included in AVT-II of AICRP (VC) trial. The seeds of aforesaid materials and Kashi Kanchan (national check) were multiplied for their multi-location testing.

PEA

Artificial screening of pea against *Fusarium* wilt: Based upon the last year field screening for *Fusarium* wilt, eight genotypes including susceptible lines *viz*., VRPE-29, VRPE-64, VRPE-60, VRPE-62, VRP-6, Kashi Mukti, Kashmiria and VRPE-25 were selected for artificial screening and further evaluation for the disease. The lines VRPE-60 and Kashmiria found tolerant upto some extent only and rest of the genotypes were severely affected by *Fusarium* wilt.

Evaluation of advanced lines (mid maturity): Among the mid maturity group, three lines *viz*., PC-531 × VRP-270, PC-531 × AP-1 and PC-531 × DARL-404 were found promising based upon the shape, colour, pod number, pod length pods / plant and yield (Table 7).

Table 7: Promising advance lines for mid group

Traits	PC-531 × VRP-270	PC-531 × AP-1	PC-531 × DARL-404
Day to 50% flowering	52	50	48
Pods/plant	17	14.5	15.3
Length (cm)	8.56	9.02	9.60
Yield/plant (g)	168	152.5	164.0

Field screening for peas *Alternaria* blight in early maturity group: A severe infection of *Alternaria* blight on pea was noticed during January 2015 (Fig. 9). A total of 42 genotypes belonging to early maturity group

were screened for the *Alternaria* leaf spot incidence. The genotype VRPE-60 (17.14%), VRPE-14 (18.18%), VRPE-54 and VRPE-17 (20% each) were recorded with minimum PDI. On contrary, VRPE-25 (71%) was worse affected by the pathogen.

Fig. 9: Pea pod and leaf affected by *Alternaria* blight

Screening of late maturity pea germplasm for *Alternaria* blight: A total of 314 lines were screened under field conditions for the disease incidence in which 12 lines were categorized as resistant, 60 lines as moderately resistance, 88 lines as moderately susceptible, 139 lines as susceptible and 15 lines as highly susceptible for *Alternaria* blight. However, none of the genotype showed highly resistance symptoms.

Generation advancement of breeding material: Among total 88 peas advanced lines, 12 line were advanced to F_3, 24 to F_4, 4 to F_5, 9 to F_6, 12 to F_7, 7 to F_8, 5 to F_9, 1 to F_{10}, 11 to F_{11}, 1 to F_{12} and 2 to F_{13}.

Maintenance breeding of pea varieties: The maintenance breeding was done through true to type single plant selection of pea varieties *viz.*, Kashi Nandini, Kashi Uday, Kashi Mukti, Kashi Samridhi and Kashi Shakti.

FRENCH BEAN

Five advanced lines, 21 introduced genotypes and 44 germplasm of French bean, both bush and pole types, were evaluated under field conditions. Among bush type, nine genotypes belong to vegetable types were found to be potential yielder along with good quality pod traits (pods cylindrical, free from fibre, slow seed development, tender and bright colour) such as VRFBB-2, VRFBB-67, VRFBB-91, VRFBB-95, FMGC6V-1129, FMGC6V-1176, FORC6V-1136, Paulista and Riveragro; while in pole type, three genotypes namely VRFBP-44, VRFBP-131 and IC-595238 showed better yield potential for tender pod (Fig. 10). Nutritionally, IC595238, a purple podded genotype, possesses 48% higher antioxidant activity than the green podded genotypes because of the presence of anthocyanin in pods. A genotype 'VRFBB-91' has been identified for earliness, short duration (80-85 days), better pod quality and 115-120 q/ha yield potential.

Fig. 10: French bean genotype VRFBB-91-pods and seeds

INDIAN BEAN

Generation advancement: Thirty eight segregating populations of different generations 19 (F_5 to F_6); 26 (F_6 to F_7), 19 (F_3- F_4), and 7 (F_2 to F_3) derived from Pole x bush were advanced and SPS were done for further generation advancement.

Evaluation of advanced lines: Six advanced lines of F_6 and F_7 were tested with national released check for bush type varieties for yield and quality traits. The performance is given in Table 8.

Table 8: Performance of Indian bean lines for yield and contributing traits

Genotype	DFF	DFPS	Plant height (cm)	Pod length (cm)	Per pod weight (g)	Pod shape	Yield / plant (g)
VRBSEM-1	35	43	59.7	5.2	5.0	Slightly curved	750 .00
VRBSEM-3	54	63	44.3	9.5	10.0	Straight	1100.00
VRBSEM-8	55	64	42.4	10.2	9.0	Slightly curved	750.00
VRBSEM-9	52	64	43.2	8.6	12.5	Curved	680.00
VRBSEM-10	51	60	45.8	11.1	15.5	Slightly curved	850.00
VRBSEM-14	52	64	54.4	12.6	15.0	Straight	820.00
VRBSEM-15	40	53	72.4	13.3	12.0	Slightly curved	800.00
Arka Jay (NC)	51	61	61.2	9.5	5.0	Slightly curved	265.00
Konkan Bhushan	43	51	70.2	6.8	5.5	Straight	286.00
Ganesh	39	58	65.4	7.2	6.0	Slightly curved	264.00
Pawan	37	45	62.3	6.6	5.5	Straight	225.00

DFF: Days to first flowering; DFPS: Days to first pod setting

SUB PROJECT: 1.4: Genetic Improvement of Gourds

DR Bhardwaj, Sudhakar Pandey, T Chaubey, PK Singh, V Venkatravanappa, S Saha and Pradip Karmakar

POINTED GOURD

Identification of promising clones: Among the

evaluated clones VRPG-103, VRPG-17, VRPG-05, VRPG-85 and VRPG-89 found to be promising for yield and fruit quality (Fig. 11). A unique clone (VRPG-103) bearing fruits in cluster have been identified during field evaluation of pointed germplasm. The occurrence of single fruit, double fruited cluster, triple fruited cluster and cluster with four fruit were 21.80%, 49.75%, 17.20% and 11.25%, respectively. Some other important clones with high yield and attractive fruits have also been found.

Fig. 11: Promising clones of pointed gourd

VRPG-89: VRPG-89 has been identified during field evaluation of pointed gourd germplasm. It is a unique, less seeded clone having only 4-8 seeds/fruit and more pulpy. The fruits of this clone are light green in colour with longitudinal white strip. Average fruit weight, fruit length and fruit diameter ranged from 40 to 45 g, 8.50 to 9.50 cm and 3.50 to 3.75 cm, respectively. The average yield per vine varied from 11.00 kg/vine to 13.00 kg/vine. The yield potential (tender fruits) of VRPG-89 was 300 to 310 quintal/ha with 2500 plant population. Fruits of this clone are suitable for confectionary purpose as well as for stuffing purpose (Fig.12).

Fig. 12: Fruits of VRPG-89

Intra specific hybridization using elite female and male clones: Twelve combinations of intra specific crosses were made using elite female and male clones and seeds were harvested. Seeds of all cross combination were sown in nursery during July-August. After germination and emergence of seedling, healthy plant were planted in poly tube for better growth and development and finally two month old seedlings were planted in the main field.

Production of planting material and clonal multiplication of selected clones: About 1500 cuttings of pointed gourd varieties Kashi Alankar and Kashi Suphal were produced for distributing to the farmers. Beside this, approximately 100 numbers of planting materials were produced for VRPG-103, VRPG-05, VRPG-89, VRPG-17 and VRPG-85.

Identification of female specific sex-linked IISR marker in pointed gourd: A study was undertaken to identify the sex linked markers in pointed gourd using inter simple sequence repeat (ISSR) primers. Initially, genomic DNA from two plants of each male and female were used to screen 44 ISSR primers. A putative female specific marker of 700 bp amplicon from UBC 834 was identified. This was further validated on a set of 19 accessions consisting of 10 male and 9 female clones. This, ISSR primers could be used as an effective tool for early sex diagnosis in pointed gourd.

Identification of seedless clone of pointed gourd through molecular marker: One seedless clone VRPG-105 was identified. Identification of seedless plant at early stage can only be done through molecular markers and will pave the way for the development of seedless cultivar in pointed gourd. A study was undertaken to identify molecular markers linked to either seedless or seeded line in pointed gourd using RAPD primers. Initially, genomic DNA from two plants of each seedless and seeded were used to screen 60 RAPD primers. A putative female specific marker of 750 bp amplicon from OPC-07 was identified as linked to seeded clone. This was further validated on a set of 15 clones consisting of 6 seedless and 9 seeded clones. Thus, RAPD primers could be used as an effective molecular tool for early identification of seedless plant in natural population.

SPONGE GOURD

Promising genotypes/hybrids identified for multi-location testing: Two open pollinated genotypes viz. VRSG-1-12 and VRSG-194 and two hybrid genotypes namely, VRSGH-1 and VRSGH-2 was found promising for horticultural traits. Genotype VRSG-1-12 has fruit length 25.3 cm, fruit width 3.15 cm, 18.5 fruits per plant,

average fruit weight 120 g and 2.22 kg fruits yield/ plant whereas VRSG-194 has fruit length 22.4 cm, fruit width 3.28 cm, 17.25 fruits per plant, average fruit weight 115 g and 1.99 kg fruits yield/ plant. Hybrid VRSGH-1 possessed fruit length 23.5 cm, fruit width 3.60 cm, 19.85 fruits/plant, average fruit weight 140g and fruit yield of 2.78 kg/plant (Fig. 13). Hybrid, VRSGH-2 has fruit length 20.7 cm, width 3.20 cm, number of fruits/plant 23.25, average fruit weight 110 g and 2.56 kg fruit yield/plant.

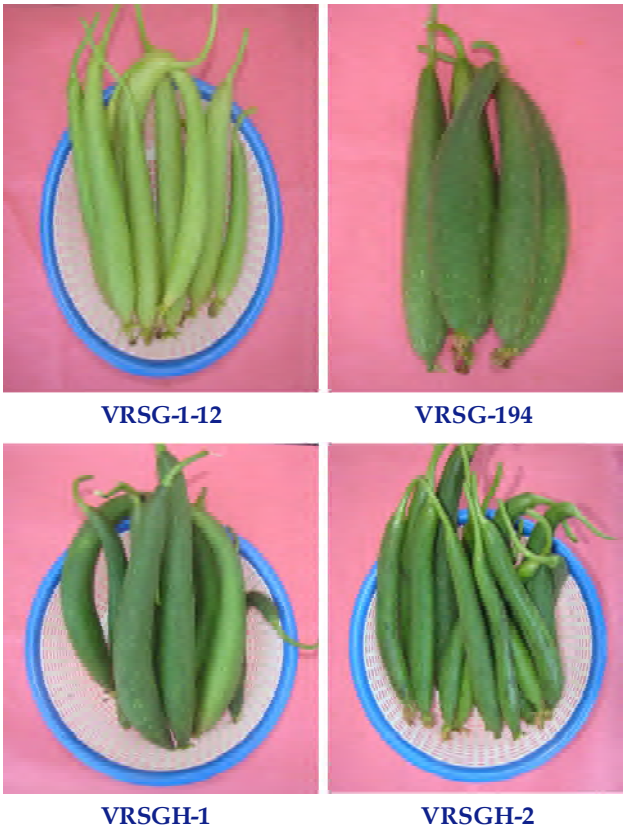


Fig. 13: Promising genotype/hybrid of sponge gourd

Promising inter specific hybrids developed: Inter specific cross combinations of *Luffa cylindrica* syn. *Luffa aegyptiaca* (VRSG-136 & VRSG-12) *x Luffa acutangula* var. satputia syn. *Luffa hermaphrodita* (VRS-1) for generation of recombinant inbred lines (RILs) as well as inter specific hybrids were developed. Inter specific hybrid, VRSG-136 x VRS-1 produced first male flower at 4.66 nodes and female flowers at 7.33 nodes. Fruits get ready for harvest at 42 days after sowing. It has fruit length 22.0 cm, 19 fruits/plant, average fruit weight 130 g and 2.47 kg fruit yield/plant. Hybrid VRSG-12 x VRS-1 exhibited first male flower at 11th nodes and female at 9th nodes. It takes 58 days for first fruit harvest from date of sowing. It possessed 19 cm fruit length, 16 fruits/plant, average fruit weight 150 g and fruit yield per plant is 2.40 kg.

Generation advancement: Thirty two F_5 poulation, 28 F_3 and 29 F_2 populations of sponge gourd were advanced to F_6, F_4 and F_3, respectevely. Under the RILs development programme, population of *Luffa cylindrica* syn. *Luffa aegyptiaca* × *Luffa acutangula* var. Satputia syn. *Luffa hermaphrodita* advanced from F_1 to F_2 (160 plants).

BOTTLE GOURD

Germplasm management: Seven genotypes were evaluated for desirable horticultural traits. Among them 5 genotypes VRBG-47-1, VRBG-47-2, IC594544, VRBG-19 and VRBG-19-1 were noted promising.

Evaluation of hybrids: Nineteen hybrids were evaluated and among them VRBG-3 x VRBG-5, VRBG-8 x VRBG-6, DVBG-2 x VRBG-1, IC594544 x IC594545, VRBG-7 x VRBG-27, IC594545 x IC594544 and VRBG-34 x VRBG-7 (round) were found promising.

Advancement of generation: F_1 (19), F_2 (4) F_3 (6), and F_4 (7) were advanced to next generation.

BITTER GOURD

Germplasm management: During the year total 9 genotypes were evaluated for quality & horticultural traits. Among light green fruited types VRBTG-2, VRBTG-5, VRBTG-7 (Stuff type) and in dark green types DRAL-41(protuberant type), DRB-1001, and DRB-1002, DRB-1003 were found very promising with respect to earliness and yield. Genotypes RS-636, Kalyanpur Barahmasi, and SDCL-146 were found higher yielder and continue for longer period.

Field screening of bitter gourd against begomovirus: A total of 28 genotypes were screened against begomovirus in the open field and pot condition. None of the lines found resistance while, two lines (HABG-1and Sel.-2) expressed symptomless carrier.

Development and evaluation of hybrids: During the year 21 hybrids using diverse parents were developed and evaluated for horticultural traits. Among them 10 hybrids VRBTG-3 x VRBTG-47, VRBTG-545 x VRBTG-21, VRBTG-36 x VRBTG-10, VRBTG-566-W x VRBTG-555-W, VRBTG-10 x VRBTG-17, VRBTG-100 x VRBTG-4, VRBTG-3 x VRBTG-545, VRBTG-33 x VRBTG-23, VRBTG-5 x VRBTG-3 and VRBTG-5 x VRBTG-568 were found promising.

Advancement of generation: During the year, F_2 (9) and F_3 (3) were advanced for next generation.

Phenotypic response to low temperature/winter season: This experiment was laid out with the objectives to evaluate 15 bottle gourd genotype to observe the phenotypic response to low temperature/winter season. The experiment was laid on 10 September, 2014. The flowering in crop started from last week of October. The anthesis of female flower was maximum during first week of flowering. The cropping duration of crops

was upto February, 2015. Variations in the population were recorded for fruit shape and colour and a total of 30 single plant selections were made. The genotype KD-02 was found highly resistant to downy mildew and DR-01 was highly susceptible. The genotype VRBG-15-05 and KL-02 was also showed tolerant reactions to downey mildew.

ASHGOURD

Multiplication and maintenance of seeds of released varieties: Two kg seeds of Kashi Dhawal and Kashi Ujwal were produced and SPS were selected for maintenance of the variety.

SUB PROJECT: 1.5: Genetic Improvement of Melons, Pumpkins and Cucumber

Sudhakar Pandey, DR Bhardwaj, PK Singh, B Mahesha M Loganathan, Pradip Karmakar and TK Koley

CUCUMBER

Development of hybrids and double hybrids: The parents for hybrid development have been selected based on the variability and purity. A total of 10 F_1 cross combinations were developed for further evaluation. Variability in cucumber is very low as studied evident by the studies with molecular markers. Therefore, 12 double hybrid combinations selecting diverse parents for yield, quality and disease resistance were evaluated.

Evaluation of advance lines: A total of 4 advanced lines along with checks PCUC-09 have been evaluated for yield and its contributing traits in mottle green segment. Fruits of these lines were non-bitter in taste. The best performing lines based on the fruit colour, appearance and yield were VRCU Sel.-06-01 followed check PCUC-09 (Table 9).

Table 9: Yield and contributing traits of advance lines

Hybrids	Fruit length	Fruit diameter	No. of fruit/ plant	Average fruit weight (g)	Yield/ plant (g)
VRCU-Sel-09-36	14.00	3.25	6.25	115.00	700.00
VRCU-Sel-07-01	12.00	3.50	5.85	95.00	550.75
VRCU-Sel -06-01	16.00	4.75	6.30	130.00	800.00
VRCU.Sel.12-01	15.00	3.85	6.00	100.50	600.00
PCUC-09	19.25	4.65	6.65	120.00	750.00

Evaluation of hybrids: A total of 15 hybrids were evaluated for yield and its contributing traits in mottle green segment. These hybrids were non-bitter in taste. The best performing hybrids based on the fruit colour, appearance and yield were VRCUH-13-03 followed by VRCUH-13-02 and VRCUH-12-08 (Table 10).

Table 10: On farm trial performance of selected cucumber hybrids in mottle green segments

Hybrids	Days to 50% female flowering	No. of fruits/ plant	Fruit length (cm)	Fruit diam-eter (cm)	Average fruit weight (g)	Yield/ plant (g)
VRCUH-12-01	48	5.00	14.50	4.20	120.00	640.00
VRCUH-12-02	46	4.43	13.50	3.50	100.00	542.86
VRCUH-12-03	47	4.50	15.40	3.20	125.00	587.50
VRCUH-12-04	48	4.63	13.50	2.80	120.00	595.00
VRCUH-12-06	50	4.67	15.90	3.00	100.00	566.67
VRCUH-12-08	48	4.75	18.90	4.20	150.00	662.50
VRCUH-12-09	52	4.38	17.30	4.20	145.00	599.38
VRCUH-13-19	46	4.63	15.20	4.60	141.00	629.13
VRCUH-13-03	44	4.25	16.80	3.40	156.00	695.00
VRCUH-13-04	43	4.75	16.40	3.80	135.00	636.25
VRCUH-13-05	44	4.17	17.80	3.10	140.00	563.33
VRCUH-13-06	48	4.33	14.70	2.90	150.00	600.00
VRCUH-13-07	52	4.25	17.90	2.60	120.00	550.00
VRCUH-13-10	58	4.38	13.40	2.50	134.00	584.25
VRCUH-13-02	52	4.80	18.60	4.20	160.00	688.00

Advancement of segregating generations: A total of 13 F_2s and 4 F_3s were evaluated, selfed and further 10 F_3s and 5 F_4s were selected based on fruit characters to advance as next generation.

PUMPKIN

Development of hybrids and evaluation: A total of 15 F_1 cross combinations were developed for further evaluation. The selected F_1s, VRPKH-12-04 and VRPKH-12-05 in long group and VRPKH-13-06 in round group have been found promising. These hybrids combination will be evaluated for further performance and stability.

Advancement of breeding material: A total of 16 segregating lines which includes F_2 (14), F_3 (13), F_4 (4), F_5 (9), F_6 (8) and F_7 (8) were evaluated, selfed and further selection were made to advance as next generation.

Evaluation of advanced lines: Five advanced breeding lines were evaluated for important horticultural traits. Maximum yield per plant was reported in VRPK-222-2-1 (15.12 kg/ plant) followed by VRPK-05-01 (13kg/ plant), whereas maximum individual fruit weight was

observed in VRPK Sel-11-01 (6.75 kg) followed by VRPK-01 (5.10 kg) at green stage. On the basis of overall performance VRPK-222-2-1 and VRPK-05-01 was found promising.

Maintenance and evaluation of advanced lines of summer squash: Five promising advanced lines, and one check of *Cucurbita pepo* (summer quash) and two segregating lines were evaluated. Among the evaluated lines, VRSS-10-66 and VRSS-06-12-01 were found promising.

Multiplication and maintenance of seeds of released variety

Kashi Harit: Five kg seeds of Kashi Harit variety of pumpkin was multiplied and SPS were selected for maintenance of the variety.

Kashi Subhangi: One kg seeds of Kashi Subhangi variety of summer squash was multiplied and SPS were selected for maintenance of the variety.

WATERMELON

Advanced lines VRSWM-3-4-2 (yellow rind and yellow flesh), VRW-9(red fleshed),VRW-12-3(light yellow fleshed) and VRW-13-4 (red fleshed) were found promising for yield and quality. Earlier identified yellow rinded, red fleshed genotype VRW-3 (Kashi Pitambar) was identified for release through Institutional variety and technology release and management committee.

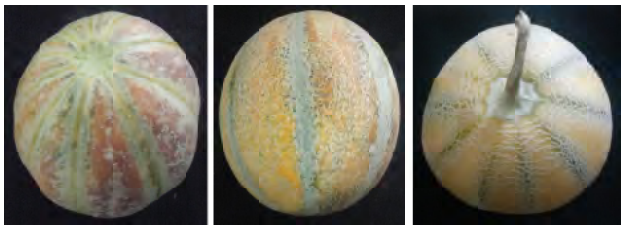
MUSKMELON

Promising genotypes of muskmelon

VRMM-12: The first productive flower appears 45-50 day after sowing on 5-6th nodes. Fruit flesh is creamish white in colour with strong musky flavor and sweetness. The average fruit weight, pericarp thickness, total soluble solids and yield/plant were 400g to 450 g, 2.00 to 2.15 cm, 14-15 °Brix and 2.80 kg, respectively (Fig. 14).

VRMM-25: The anthesis of first female flower takes place 50-55 day after sowing on 8-9th nodes. The fruits are oval round in shape. The average fruit weight of this line was 600-800g. Fruit flesh is crispy and yellowish orange in colour with musky flavor and sweetness (TSS 11.50-13.20°Brix) (Fig. 14).

VRMM-23: The first productive flower appears 50-60 day after sowing on 6-7thnodes. The fruits are flattish round in shape, yellowish cream in colour with greenish striped along the longitudinal grooves and having netted fruit surface (Fig. 14). Fruit flesh is cream in colour with musky flavor and TSS ranged from 10-11°Brix. The average fruit weight, pericarp thickness and yield/plant were 300g to 400 g, 2.00 to 2.15 cm and 2.80 kg, respectively (Fig. 14).



VRMM-12 VRMM-25 VRMM-23

Fig. 14: Promising genotype of muskmelon.

Evaluation of RILs (F_6) derived from Kashi Madhu × B-159 for horticultural traits: One hundred twenty F_6 generation of recombinant inbred lines of Kashi Madhu (desert melon) × B-159 (Snapmelon) evaluated for various horticultural traits. Sex form of RILs families was either andro-monoecious or monoecious. RILs families were almost stable for different morphological characters. Fruit shape of the RILs were round, flattened, oblate, elliptical, pyriform, ovate, and elongated. Exterior fruit colour ranged from dark yellow to whitish yellow. Fruit flesh colour of the RILs varied from white to yellow. Mean and range for different quantitative traits are presented in the Table 11. All the traits evaluated showed appreciable variation. From these RILs, there is a strong possibility to select round fruited monoecious line for further use in hybrid breeding programme.

Table 11: Horticultural traits of RILs (F_6) Kashi Madhu × B-159

Traits	Range	Mean
Vine length (cm),	90-210	115.25
Number of primary branch	2.75-5.32	3.50
Days to first productive flower anthesis	45.25-65.15	55.00
Fruit Length (cm)	12.50-35.50	20.50
Fruit diameter (cm)	7.36-16.10	10.86
Fruit weight (g)	150.25-1500.00	565.27
Total soluble solids (°Brix)	4.55-13.10	9.75
Yield/plant (kg)	0.50-3.0	1.75

Identification of downy mildew resistant lines: From F_6 RILs of Kashi Madhu × B-159. B-159, RIL 207 was free from downy mildew disease under field condition. This line will be further validated for downy mildew resistant under artificial condition.

SUB PROJECT: 1.6: Genetic Improvement of Okra

SK Sanwal, B Singh, V Venkatravanappa and J Halder

Evaluation of hybrids: Twenty four hybrids were evaluated in rainy season for yield and disease reaction with susceptible check (Pusa Sawani). The percent disease incidence in susceptible check varied from 67-84% for YVMV and 35-48 % for OELCV. All the crosses mentioned in the table are resistant to both YVMV and OELCV (Table 12).

Screening of advanced lines, breeding materials and wild species to okra enation leaf curl virus (OELCV) and YVMV: A total of 240 lines including 30 released varieties, 32 advance lines from IIVR, 50 lines from IIHR and 128 accession of wild species (*Abelmoschus angulosus, A. manihot, A. tetraphyllus, A. ficulneus, A. crinitus, A. moschatus, A. pungens,* and *A. tuberculatus)* were screened during rainy season. Susceptible check (Pusa Sawani) was sown after 5 lines of each genotype/ lines. Percent incidence of YVMV and OELCV was recorded at 30, 60 and 90 days after sowing. Among cultivated species 36 lines (VRO-109, VROB-178, VROB, 181, No. 315, VRO-112, AE-70, BC-1, VRO-104) were found resistant to YVMV, 4 lines (VRO-109, Okra-6, 299-2-9-1-6-4 and 285-1-12-2-4-17) found resistant to both OELCV and YVMV.

Among 128 wild accessions screened, 7 accessions [*A. Manihot* (3), *A. moschatus* (1), *A. tuberculatus (1), A. tetraphyllus (2)]* were found resistant to YVMV, 31 accessions [*A. moschatus* (9), *A. manihot* (6), *A. tetraphyllus* (12), *A. pungens* (2)] were found resistant to OELCV while only 3 accessions [*A. manihot* (1), *A. moschatus* (2)] found resistant to both YVMV and OELCV.

Evaluation of advanced lines: A total of 32 advanced lines were evaluated for yield and disease reaction. Among these, the advance line VRO-109 and Okra-6 were found promising for all the characters (Table 13).

Estimation of yield loss due to enation leaf curl virus: The healthy and disease infected plants of three advanced lines (VROB-180, VRO-112 and VRO-108) were selected at two stages *i.e.;* 30-35 days after sowing (DAS) and 50-55 DAS. Experimental data revealed that the virus caused yield loss ranging from 52-90 percent depending upon the age of the plant at the time of infection. Plants infected at 30-35 days after sowing caused 85-90 % yield loss while plants infected at 50-55 DAS caused 52-63 % yield loss depending on the genotype (Table 14). Infected plants had less number of fruits, stunted growth, small inter-nodal length and higher stem diameter. Fruits from infected plants were small, deformed and unfit for marketing.

Physiological response of enation leaf curl virus infected and healthy leaves of okra: The physiological response of enation leaf curl virus-infected okra leaves was studied by comparing the biochemical and physiological parameters of virus infected plants with healthy plants. Two advance lines VRO-112 and VRO-108 were selected for this purpose. The total chlorophyll content was reduced by 49 (VRO-108) to 61 % (VRO-112) and carotenoid concentrations in infected leaves was significantly reduced by 54% (VRO-112) and 49% (VRO-108), respectively. The photo chemical efficiency measured as the Fv/Fm ratio was 0.525 in VRO-112 and 0.535 in VRO-108 in healthy leaves while in infected leaves it was 0.495 and 0.528, respectively. Hydrogen peroxide (H_2O_2), a harmful byproduct of many normal metabolic processes was found more in infected leaves of both the lines. Catalase and Peroxidase enzymes catalyze the decomposition of H_2O_2, to water and oxygen. When enzyme activity was expressed on H_2O_2 oxidized min^{-1} mg^{-1} protein, a marked reduction in catalase (36-37%) and peroxidase

Table 12: Performance of superior hybrids in okra

Hybrids	Code	Days to 50% flowering	Fruits/ plant	Fruit yield/ plant (g)	YVMV (%)	OELCV (%)
SB-8 x VRO-102	2015/OKHYB-1	45	16.4	184	4.2	7.80
SB-8 x VRO-101	2015/OKHYB-2	46	17.2	170	0.0	6.50
VRO-6 x VRO-107	2015/OKHYB-3	40	17.4	174	9.0	9.60
VRO-101 x SB-2	2015/OKHYB-4	45	18.6	205	11.0	2.80
747-3-1 x SB-2	2015/OKHYB-5	46	14.0	168	7.0	0.00
HOK-152 (C)	HOK-152 (C)	52	18.5	172	6.4	4.50
CD at 5%	CD at 5%	3.90	1.32	7.86	2.66	0.54

Table 13: Characteristics of promising lines VRO-109 and VRO-112

Advance line	Days to first flowering	Node to first flower	Fruit colour	Fruit length (cm)	Fruit diameter cm)	Fruits/ plant	Fruit yield (q/ha)	Resistant to
VRO-109	39-42	4-5	Dark green	10-12	1.4-1.5	16-19	140-145	YVMV & OELCV
VRO-112	37-39	3-4	Green	12-13	1.3-1.4	18-20	150-155	YVMV & OELCV

Table 14: yield loss due to ELCV at different stage of infection

Characters	VROB-180		VRO-112		VRO-108	
	Healthy plant	Infected plant	Healthy plant	Infected plant	Healthy plant	Infected plant
Yield loss when plant affected by OELCV at early stage (30-35 DAS)						
Fruits/plant	19.06	3.3	17.80	2.8	17.2	1.7
Yield/plant (g)	193.0	28.5	187.8	32.50	182.0	18.4
% yield reduction		**85.23**		**82.69**		**89.89**
Yield loss when plant affected by OELCV at 50-55 DAS						
Plant height (cm)	100.35	75.5	115.75	82.5	102.75	78
Stem diameter (cm)	1.58	1.69	1.62	1.66	1.43	1.92
Internodel length	7.25	6.85	7.5	6.8	10.02	6.97
Fruit length (cm)	10.44	7.56	8.13	7.04	9.95	6.9
Fruit diameter (cm)	1.71	1.64	1.83	1.61	1.6	1.27
Fruits/plant	18.25	8.95	18.6	7.7	16.5	6.45
Yield/plant (g)	187.95	90.35	196.5	86.97	177.45	65.20
% yield reduction		**51.93**		**55.75**		**63.26**

activities (62-65 %) was observed in infected leaves. Superoxide dismutase enzynmes that catalyze the dismutation of the superoxide (O_2^d) radical into either ordinary molecular oxygen(O_2) or hydrogen peroxide (H_2O_2) found more in healthy leaves as compared to infected leaves. Lipid peroxidation in which free radicals steal electrons from the lipids in cell membranes resulting in cell damage was higher in infected leaves of both the varieties.

Identification of viruses through PCR based diagnostics: In okra leaf curl virus infection, four types of symptoms were observed i.e. only enation leaf curl, petiole bending, vein twisting and stem bending. Confirmation was done whether these symptoms were of enation leaf curl virus or due to different viruses. Above four types of symptomatic plants was selected for identification of viruses. All the above four clones showed more than 96% nucleotide identity (Fig. 15) with Okra enation leaf curl virus. So, petiole bending, vein twisting and stem bending may not be due to separate viruses but might be symptoms of Okra enation leaf curl virus (Fig. 16).

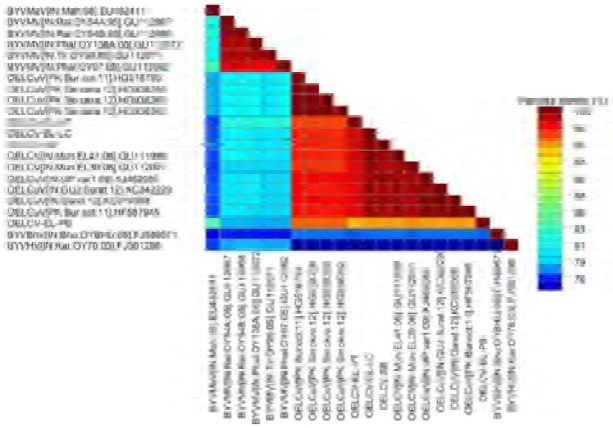


Fig. 15: Graphical representation of percentage pairwise genome scores and nucleotide identify plot of full genomes of OELCuV and other begomoviruses

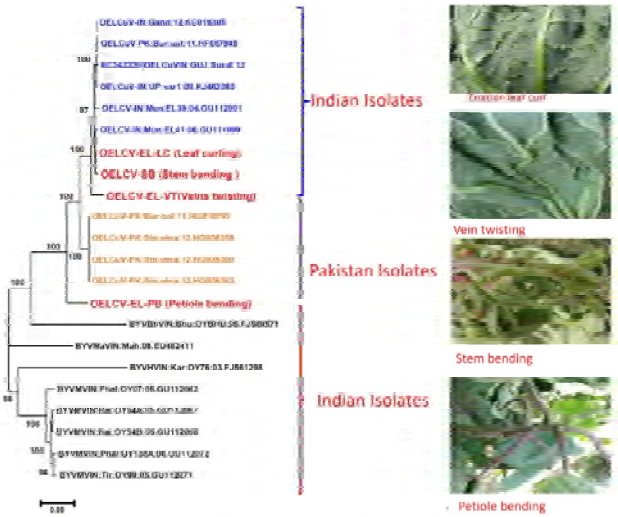


Fig. 16: Phylogentic tree of complete nucleotide sequences of DNA-A of OELCuV.

Physical and biochemical basis of resistance against leaf-hopper in okra genotypes: 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 *Amrasca biguttula biguttula* 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 reaction as compared to tolerant genotype VROB-181 which had 11.85, 9.17 and 9.95 trichomes per cm^2, respectively. 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, 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 of breeding material: 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.

Kashi Vardaan (VRO-25): A new okra variety identified through XXXII AICRP (VC) group meeting for zone no. 4 (Uttar Pradesh, Bihar, Jharkhand and Punjab). The length and diameter of the fruit is 10-11 cm and 1.65 cm, respectively at marketable stage. The fruits are available from 47-100 days after sowing and total yield is 150-155 q/ha. It is found resistant to yellow vein mosaic virus (YVMV) and okra enation leaf curl virus (OELCV) under field condition.

Maintenance breeding of released varieties of okra: The maintenance breeding of okra released varieties *viz.*; Kashi Kranti, Kashi Pragati, Kashi Sathdhai, Kashi Lila and Kashi Vibhuti were done through true to type single plant selection.

SUB PROJECT: 1.7: Genetic Improvement of Cauliflower

BK Singh, PK Singh and Jyoti Devi

Ninety-five genotypes, including 12 advanced lines, were evaluated for September, October and November maturity group. Among them, two genotypes i.e. VRCF-86 and VRCF-201 were the potential yielder in October maturity, and VRCF-50, VRCF-75, VRCF-37, VRCF-202 and VRCF-2 found to be better for November maturity group. A male sterile line identified and crosses made with VRCF-86, VRCF-50 (Fig. 17) and VRCF-2 to transfer male sterility system.

Promising genotypes VRSCF-7 (Early), VRSCF-6 (mid) and VRSCF PK-77 of mid late maturity group were planted along with some other promising genotypes. Cauliflower genotypes VRSCF-9, VRSCF-27 and VRSCF-32 are in final year of AICRP (VC) testing and

VRCF-86 VRCF-50

Fig. 17: Promising genotype of cauliflower

VRSCF PK-77 has entered in AVT-I AICRP (VC) testing. A white petaled genotype VRSCF-29 was identified, which can be used in breeding programme.

SUB PROJECT: 1.8: Transgenic and Regeneration Protocols

JK Ranjan, Major Singh, YS Reddy, RS Gujjar and SG Karkute

Development of regeneration protocol in okra: Explants *viz.;* hypocotyls, cotyledon, cotyledonary petiole were excised from aseptically *in vitro* grown okra cv. Kashi Kranti and 5-15 days old seedlings were evaluated for regeneration responses. For each treatment 20 explants were cultured on MS medium supplemented with different concentration (0.1-5.0) of NAA individually or in combination with BA, 2iP, 4-CPPU and with TDZ. In all the tested combinations only callus and root were induced, no shoot induction were reported in any combination on hypocotyls or cotyledons. Callus induced in all combination NAA, BA and 2iP were light green, globular and friable while in NAA, TDZ and CPPU were dark green, compact and larger in size in comparison to both BA and 2iP. The root induction was higher and prominent in 2iP and NAA combination among all the tested combinations. However meristematic tissue isolated from two days old excised embryo shows multiple shoot induction on 4-CPPU and NAA supplemented combinations (Fig. 18).

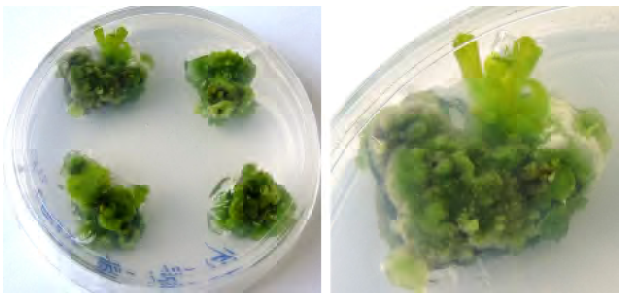


Fig. 18: Multiple shoot induction on meristematic tissue on MS with 1.0 mg/l 4CPPU and 0.2 mg/l NAA

Regeneration studies in bitter gourd: Bitter gourd seeds were germinated on half-strength MS medium.

Cotyledon and, leaf explants from 8-12 days old seedlings were evaluated for regeneration response. For culture initiation and regeneration, explants were cultured on MS medium containing different combinations and concentrations (0.2 - 5.0 mg l^{-1}) of plant growth regulators. Callus regeneration was observed from cotyledon and leaf explants cultured on different combinations and concentration of BAP, TDZ, 2-iP, 4-CPPU with NAA and 2,4-D along with PVP. Leaf explants on different concentration of BAP alone showed green compact callus and with 2-iP and 4-CPPU callus were light green and fragile. Leaf explants shows better callusing than cotyledonary explants. The NAA in combination with BA and TDZ induced green, globular and compact callus while the combination of 2, 4-D with TDZ and BAP induced green, nodular and compact callus. However, leaf explants on 0.5 mg/l TDZ with 50mg/ml PVP resulted in dark green compact globular callus and induced shoot formation. Shoot induction was also observed with cotyledonary nodal explants on 0.5mg/l TDZ with 50mg/ml PVP (Fig. 19). The root induction frequency was higher with 2, 4-D but rooting was prominent with NAA. Higher concentration of plant growth regulators than the above induced enlarged and fragile callus.

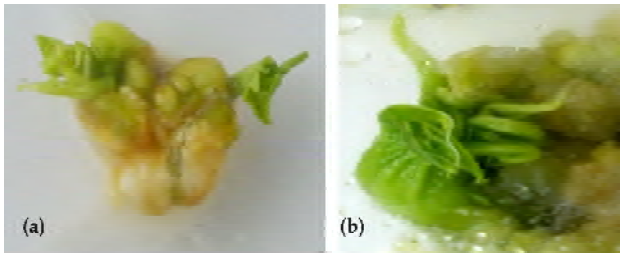


Fig. 19: Multiple shoots regeneration in bitter gourd (a) 0.5 mg l^{-1} TDZ +50 mg ml^{-1} PVP (cotyledonary node); (b) 0.5 mg l^{-1} TDZ + 50 mg ml^{-1} PVP (leaf explant)

***In planta* transformation in tomato:** In an effort to develop *in planta* transformation protocol germinating tomato seeds were treated with *Agrobacterium tumefaciens* strain EHA – 105 harboring the binary vector. Plasmid pPIPRA539 was used as a vector system for *in planta* transformation. Plasmid pPIPRA539 contains the *gus* gene linked to the CaMV 35S promoter. Hundred seedlings were treated with agroinoculum at 0.004 percent concentration of surfactant triton – X 100. Out of 100 treated seedlings 16 grown into plants. Flowers from these plants were performed with GUS histochemical test. Flowers of initial inflorescence from 4 plants got stained (sepals and petals didn't stained). Other flowers and leaves didn't stained. Seeds from initial truss were collected and were grown for GUS histochemical test (Fig. 20). It was found that the *gus*-gene expression observed in

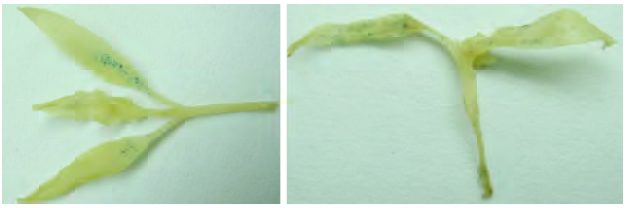


Fig. 20: GUS assay in tomato seedlings

the previous year, was transient and not stable as there was no gus staining in the progeny plants. In other experiment, tomato seedlings were vacuum infiltrated with the *Agrobacterium* for 5, 10, 20 and 30 min duration along with triton –X 100 at 0.004%. After, 3 days seedlings were stained. Seedlings from 20 min treatment have shown staining.

SUB PROJECT: 1.9: Biotechnological interventions for improvement of selected vegetable crops

HC Prasanna, Major Singh, SK Tiwari, Sudhakar Pandey, Rajesh Kumar, M Loganathan, Pradip Karmakar RS Gujjar and SG Karkute

Generation of backcross populations for *S. lycopersicum* x *S. chilense* interspecific cross and marker assays on backcross progenies: Early backcross generations (BC_1F_2, BC_2F_1, BC_2F_2 and BC_3F_1) were generated for an interspecific cross Kashi Amrit X (*S. lycopersicum* VF36 X *S. chilense* LA1972). The cultivar Kashi Amrit was used as a recurrent parent in backcrossing program. A total number of 35 BC_3F_1 families, 150 BC_2F_2, 80 BC_1F_2 families were generated. These populations are being utilized under the externally funded projects and will be handled using the resources available in these projects. In addition, clones of interspecific hybrid and 120 BC_1F_1 plants were also maintained regularly in tissue culture facility through cuttings (Fig. 21).

As many as 150 CAPS markers previously identified to be polymorphic between recurrent parent and *S. chilense* were used for performing marker assays on BC_1F_1 clones. This has been completed on 45 samples using few markers. Again, the marker assays will be performed using the resources available in externally funded projects.

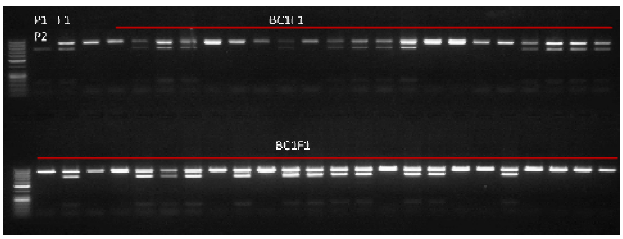


Fig. 21: Electrophoretic separation of CAPS marker amplified using C2At5g61910 and digestion by *Hinf*I

Cloning, characterization and expression analysis of drought responsive transcription factor genes in tomato: Among the eight drought responsive genes whose expression studies have been performed in earlier experiment, the sequences of 3 genes were found significantly different in *Solanum habrochaites* line EC 520061. This nucleotide sequence difference resulted a completely different protein structure when compared by "UCSF Chimera" program of 3D protein structure modeling (Fig. 22).

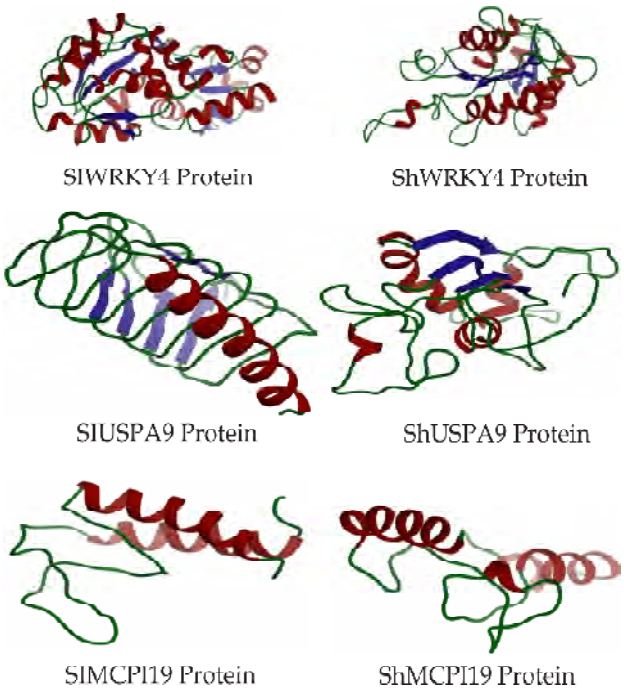


Fig. 22: 3D Protein Structure comparison of three drought responsive genes (*SlWRKY4*, *SlUSP9* and *SlMCPI19*) in *Solanum lycopersicum (Sl)* and *Solanum habrochaites (Sh)*

Screening drought responsive WRKY genes: In another experiment, a total of 76 WRKY transcription factor gene sequences were screened from various databases of tomato (*Solanum lycopersicum*) i.e.; Solgenome Network Database and NCBI Database. Further, Q-PCR primers of these WRKY sequences were designed. In the mean time, multiple sequence alignment of all the WRKY proteins was performed using already available programmes on the web (i.e. CLUSTAL-W) so as to test out the similarities among WRKY proteins. Plants of *Solanum habrochaites* line EC-520061 (wild tomato) were grown and subjected to artificial drought stress. Q-PCR amplification was performed using control and drought stressed RNA of *Solanum habrochaites* line EC-520061. Real time PCR results showed the amplification/expression of only 71 WRKY sequences (out of 76) in the wild tomato line. Out of these 71 WRKY TF genes, only 13 genes documented considerable up-regulation during artificially imposed drought stress.

De novo transcriptome sequencing of *Solanum melongena* (c.v. Ramnagar Giant) and related wild species *S. incanum*: With objectives of targeted breeding and brinjal improvement activities, two readily crossable species *Solanum melongena* and *S. incanum* were used as parental lines to develop mapping population. To accelerate breeding programs and to obtain more genetic information for developing biotic and abiotic stress resistance lines and fruits of public choice, RNA-seq libraries from different tissues of both plant were deep sequenced and assembled into a representation of a high quality *de novo* transcriptome assembly. A total of 1,45,512 transcripts with 21,914 unique genes for *Solanum melongena* c.v. Ramnagar Giant and 1,44,948 transcripts with 21,706 unique genes for *S. incanum* were obtained. About 99.99% of HQ bases (›20) from all the tissues could be read into full transcriptome. Several SSR and SNP-primers have been designed to study molecular signatures and polymorphism patterns related to physiological and morphological characteristics of the plants. Functional annotations based on sequence similarity to known plant dataset with available information in public domain revealed distribution of functional categories for both species very similar to that of tomato and potato genome. The assembled and annotated information will be used for the further study of developmental, defence and metabolic pathways of *S. melongena* and *S. incanum* and in understanding the mechanisms behind other physiological characteristics to accelerate research on these non-model plants.

3-D structure modelling of SlWRKY 4 protein cloned from drought tolerant tomato: Understanding the interaction of WRKY proteins with other proteins/ligands in plant cells is of utmost importance to develop plants having tolerance to biotic and abiotic stresses. The *SlWRKY4* protein was cloned from a drought tolerant wild species of tomato (*Solanum habrochaites*) and the secondary structure and 3D modelling of this protein were predicted using Schrodinger Suite-Prime. Predicted structure was also subjected to plot against Ramachandran's conformation, and the modelled structure was minimized using Macromodel. Finally, the minimized structure was simulated in the water environment to check the protein stability. The behaviour of the modelled structure was well-simulated and analyzed through RMSD and RMSF of the protein. Present work provides modelled 3D structure of SlWRKY4 that will help in understanding mechanism of gene regulation by further *in silico* interaction studies (Fig. 23).

Fig. 23: 3-D structure of SlWRKY 4 protein

SUB PROJECT: 1.10: Genetic improvement of underutilized vegetables, including vegetable soybean, leafy and root vegetables

PK Singh, DR Bhardwaj, Pragya, SK Tiwari and BK Singh

CARROT

Nineteen advanced lines and seventy four germplasm of tropical carrot were evaluated. The evaluated genotypes varied considerably for shoot weight (22.6-91.8 g), number of leaves/ plant (4.6-14.4), leaf length (21.9-71.6 cm), shoulder diameter (2.6-4.9 cm), root length (12.4-24.0 cm), root weight (29.1-133.0 g) and harvest index (36.3-71.8 %). Among them, nine genotypes were found to be potential yielder (>80 g root weight) along with better quality traits (self-coloured and small core, smooth root, fewer secondary roots and lesser root scars) such as VRCAR-91-1 (orange coloured root); VRCAR-185, VRCAR-109, VRCAR-112, VRCAR-149 and VRCAR-80 (red coloured root); VRCAR-107-2 and VRCAR-171-1 (purple-red coloured root) and VRCAR-125 (black coloured root).

Thirty seven of Asiatic carrot (red & black) collections were further evaluated and maintained through sib mating. The genotype VRSCR-27 (red) and VRS BCr-NH-11 (black) were found promising for yield and quality.

RADISH

Twenty-three advanced lines (coloured rooted) and thirty-two germplasm of radish were evaluated. Among them eight genotypes were found to be good yielder (>80 g root weight) along with better quality traits (uniform root shape, smooth root, fewer secondary roots and soft leaf) such as VRRAD-130 (pink exterior and xylem); VRRAD-143 and VRRAD-131-2 (pink exterior); VRRAD-130-2, VRRAD-130-3 VRRAD-131 and VRRAD-135 (purple exterior); and VRRAD-150 (white exterior) which have been advanced for next generation. The genotype VRRAD-130 showed unique trait among tropical radish having iciclical shape and coloured root, and possessed highest amount of total antioxidant activity (FRAP activity 5.66 ìmol/g) which is about 150% higher than the white rooted varieties. Generation has been advanced to BC_1F_1 stage in five backgrounds (2 in white rooted, 1 in purple rooted and 2 in pink rooted) for transferring CMS system.

Thirty one genotypes of radish (white, red and black) collections were further evaluated and maintained by selfing. The genotype VRRd E-14, VRRd-111 (white roots), VRRRd-7 (red) and VRSBRd-1 (black) were found promising for yield and quality.

SATPUTIA

Satputia genotypes long fruited (VRS-1, VRS-7, VRS-11, VRS-24) and round fruited (VRS-9-1) were planted for further evaluation. Total of 59 accessions collected from different places were maintained. Seeds of Kashi Khushi also produced.

RIDGE GOURD

Fifty genotypes were collected, evaluated for different horticultural traits and maintained through selfing. Among them VRRG-3-6 was identified for more pistillate flowers. Genotypes VRSRG-6 and VRSRG-24 were also identified for high yield and consumer preference.

LONG MELON

Thirty four genotypes were collected, evaluated for different horticultural traits and maintained through selfing.. The genotype VRSLM-27 and VRSLM-31 were found promising. The genotypes VRSLM-13-1 and VRSLM-16 were identified for early and higher yield.

IVY GOURD, SNAKE GOURD, ROUND MELON, FABABEAN, KAKROL AND KARTOLI

Fifteen of snake gourd, eighteen of Ivy gourd, thirty of faba bean, twenty nine germplasm of *M. dioca*, twenty of round melon, fifty four of *M. chochinchinensis*/ *M. subangulata ssps. renigera* were collected, evaluated and are being maintained at SPC, Sargatia. In Ivy gourd promising clone VRSIG-9 (Kashi Bharpoor), in Kakrol VRSG-1 (Kashi Gautam) and Kartoli VRSMD-9 (Kashi

Haritika) were proposed for release through Institutional variety and technology release committee.

LEAFY VEGETABLES

Fenugreek (*Trigonella foenun-graecum*): A total of 21 genotypes of fenugreek were augmented and evaluated for different agro-morphological and biochemical traits. Wide range of variation was observed for plant height (59.6-75.67 cm), number of primary branches (4-6.33), days to flowering (64.5-72.6) and green yield (11.2-46.4 q/ha). The germplasm showed good variation for carotenoid (14.03-26.33 mg/100 g fresh wt), total phenol (88.55-143.85 mg GAE/100g) and DPPH (8.69-13.46µmol TE/g).

Bathua (*Chenopodium album*): Two genotypes of bathua namely VRCHE-4 (purplish-green leaves and stem) and VRCHE-2 (green leaves and stem) have been identified for multi-cutting purpose whose yield potential recorded about 320 q/ha and 295 q/ha, respectively in the four cuttings. Moreover, total measured plant growth for VRCHE-4 was 40 cm, 124 cm, 153 cm, 169 cm & 205 cm, and for VRCHE-2 was 35 cm, 106 cm, 128 cm, 153 cm & 181 cm, respectively at 85 days, 100 days, 115 days and 150 days after sowing.

MEGA PROGRAMME 2: SEED ENHANCEMENT IN VEGETABLES

Programme Leader: P.M. Singh

Rajesh Kumar, T Chaubey, Sudhir Singh, T. Kole, S. Saha, J. Halder, PK Singh, RN Prasad, SK Sanwal, N Rai, SK Tiwari, PS Naik and Manimurugan, C

Conversion of ovules to seeds: Conversion of ovules to seed in 14 tomato varieties and 5 chilli varieties was studied for two consecutive years. It was observed that it expresses variation depending upon variety. The average values have been depicted in tables 15 & 16.

Table 15: Effect of varieties on conversion of ovules to seed in tomato

Name of Varieties	Fruit shape	No. of locules	Av. normal seeds (%)
Kashi Amrit	Flat round	5-6	92
Kashi Vishesh	Oblong	4-5	88.5
Kashi Hemant	Round	3-4	88
Arka Alok	Oval round	3-4	89.5
Arka Abha	Oval round	3-4	80.5
Pusa Upma	Oblong	3-4	91
Solan Gola	Oval round	2	91
Roma	Oblong	3-4	89.5
Hisar Lalit	Oval round	3-4	89.5
Hisar Arun	Flat round	4-5	89.5
Punjab Bahar	Oval round	3-4	89.5
Punjab Chhuhara	Pear shape	2	88.5
Punjab Keshari	Flat round	4-5	89.5
Swarna Lalima	Flat round	5-6	94

*Based on two year's data

Table 16: Effect of varieties on conversion of ovules to seed in chilli

Name of Varieties	Fruit wt. (g)	Fruit length (cm)	No. of locules	Av. normal seeds (%)
K. Anmol	4.42	7.18	3.00	99
PT-12-3	2.98	5.24	2.80	89.5
Taiwan-2	1.00	2.88	2.00	95
P. Jwala	5.14	12.30	2.60	92.5
K. Sinduri	11.90	12.34	2.20	88.5

Studies on pollen storability: The pollen from brinjal varieties (Kashi Taru, Kashi Prakash, Pant Rituraj & Punjab Barsati) were collected and stored under different conditions *viz.* at ambient temperature, in refrigerator, in deep freezer at -20°C and at -80°C, for testing the viability at periodic intervals in lab (Table 17, 18 & Fig. 24).

Table 17: Pollen viability of brinjal varieties during storage

Varieties	Initial viability	
	Ist Year	IInd Year
Pant Rituraj	93.27	97.44
Punjab Barsati	85.33	95.83
Kashi Taru	90.34	100.00
K.Prakash	88.14	96.89

Fig. 24: Flower pollination by stored pollen and fruit set.

Seed quality enhancement through priming: The priming of brinjal seed was done with three concentrations each of inert osmotica PEG 6000, mannitol and sorbitol. Distilled water was used as control. The duration of treatment was 24 to 168 hours (1-7 days) in two replications at 25°C. The treated seeds performing best in the lab conditions were evaluated under field conditions for two consecutive years (Table 19).

Table 18: Effect of storage conditions on pollen viability (%) in brinjal

Varieties	Ambient Temperature								Refrigerator							
	After 3 months		After 6 months		After 9 months		After 12 months		After 3 months		After 6 months		After 9 months		After 12 months	
	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II
Pant Rituraj	92.1	95.2	74.8	96.3	65.6	94.4	55.1	88.5	70.3	97.0	72.5	96.3	64.6	94.0	65.1	92.5
Pb Barsati	84.8	95.8	72.3	95.8	72.3	91.9	61.1	88.5	68.2	95.4	71.8	93.2	66.5	90.3	57.5	88.6
Kashi Taru	86.1	96.3	73.1	96.3	67.9	91.0	56.5	91.6	72.4	100.0	84.2	96.6	70.8	95.8	60.8	93.6
K.Prakash	87.6	95.6	72.0	92.1	69.2	93.2	59.6	86.1	83.6	96.6	68.6	94.9	62.9	95.2	55.5	89.8

Varieties	-20°C								-80°C							
	After 3 months		After 6 months		After 9 months		After 12 months		After 3 months		After 6 months		After 9 months		After 12 months	
	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II	Yr. I	Yr. II
Pant Rituraj	72.9	97.0	70.1	97.0	65.0	97.0	59.2	95.2	79.6	97.6	77.5	97.6	60.7	--	68.0	--
Pb. Barsati	78.0	95.0	71.1	95.3	69.1	93.6	68.0	91.0	80.2	95.6	65.9	95.6	65.0	--	55.7	--
Kashi Taru	87.2	99.2	74.9	98.3	68.3	96.6	58.9	96.9	89.4	100.0	83.7	100.0	62.3	--	67.7	--
K.Prakash	80.7	96.2	66.4	95.8	63.0	94.9	56.5	95.6	81.5	97.0	71.1	96.3	63.3	--	61.2	--

Table 19: Field evaluation of brinjal raised from primed seeds

Chemical	Priming days	No. of fruits/plant	Yield (q/ha)	
			Yr. I	Yr. II
PEG -2 MPa	2	28	364.57	351.72
	4	25	332.61	325.23
	7	23	304.21	293.84
Sorbitol 4%	2	32	403.52	390.47
	4	27	354.21	312.50
	7	25	298.50	282.90
Mannitol 4%	2	30	389.35	337.53
	4	28	342.58	297.48
	7	24	302.30	288.61
Control	-	26	346.50	300.35

Standardization of plant population for CMS based chilli hybrid seed production: The cytoplasmic male sterile (CMS) line (CCA 4267) and its restorer line (Pusa Jwala) were raised in the three ratios - 1 (CMS): 1 (restorer); 2 (CMS): 1 (restorer) and 3 (CMS): 1 (restorer) in order to examine the maximum seed yield from the CMS-based hybrid Kashi Surkh (CCH-2) in chilli. The observations recorded revealed that under the 1:1 ratio, total number of seeds per fruit were 47.25 with 5.75 g weight. Similarly, under 2:1, 28.12 seeds/fruit were recorded with 4.83g seed weight per fruit. Under 3:1 ratio, only 21.61 seeds per fruit were observed. Thus, in order to get higher seed yield, a ratio of 2 (cms line):1 (restorer line) may be followed (Table 20).

Table 20: Effect of plant population on seed quality of CMS based hybrid

Planting ratio	Fruit length	Fruit dia.	Fruit wt. (g)	No. of fruits/ plant	No. of seeds/ fruit	Total No. of seeds/ plant
1::1	7.66	1.28	5.75	7.1	47.25	335.48
2::1	8.33	1.39	4.83	15.70	28.12	441.40
3::1	9.70	1.40	5.24	11.60	21.61	250.68

Vegetable seed production: At ICAR-IIVR farm, the overall seed production programme (Breeder + TL) was undertaken in 24 varieties of 17 vegetable crops. The breeder seed production was undertaken for 16 varieties in 8 different vegetable crops viz. tomato, brinjal, chilli, cowpea, peas, bottle gourd, okra and radish. A total of 1150 kg breeder seeds were produced against the National indents of 1144.20 kg from Deputy Commissioner (Seeds). In addition to National indent, 1747 kg breeder seeds of different varieties of ICAR-IIVR were also produced.

Division of Vegetable Production

MEGA PROGRAMME-3: PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCES MANAGEMENT

Programme Leader: SNS Chaurasia

SUB PROJECT 3.1: Technologies for Protected and Off season Vegetable Production

SNS Chaurasia, RN Prasad, RB Yadava, Sudhir Singh, DK Singh, Anant Bahadur, TD Lama, TK Koley, MH Kodandaram, S Saha and Vanitha SM

Standardizing locally available growing medium for raising nursery in plug tray: Locally available potting materials were used for raising nursery alone or in 46 different combinations under low tunnel polyhouse. The periodic observations were recorded. The maximum plant height and biomass was recorded in the treatment wherein cocopeat and vermicompost was mixed in 3:1 ratio. However, the seedlings with FYM + Rice husk (3:1) or Vermicompost + Rice husk (3:1) were noted economically feasible in comparison to cocopeat. The seedling vigour and easy removal from the potting plugs was also better under these treatments (Fig. 25).

Fig. 25: Sedling from cocopeat+ vermicompost (3:1) & vermicompost + rice husk (3:1)

Performance of tomato under low cost protected structure: The experiment was conducted to develop package and practices for growing tomato under different low cost protected structure. The tomato variety Tolstoi (Indeterminate) was undertaken for the study. First the nursery was raised under low net house conditions and transplanted in low cost net house, poly house and compared with open field conditions and sprayed with water soluble liquid fertilizers two sprays as common and 3rd, 4th and 5th as treatments. The growth, yield and quality parameters were recorded and analysed statistically. The maximum plant height, average fruit weight and yield was recorded under poly house conditions with 4 sprays of WSF at 10 days interval, 30 days after transplanting followed by net house conditions. Quality parameters of tomato such as lycopene, ascorbic acid and antioxidant activity were evaluated for protected as well as open field condition (Fig. 26 & Table 21).

Fig. 26: Tomato cv. Tolstoi grown under polyhouse condition

Raising capsicum under low cost net house conditions: Based on the previous year data about the performance of capsicum under different growing structure, the seedlings of capsicum were raised in plug trays under protection from white flies and transplanted under net house condition during Rabi season of 2014. The growth yield and quality parameters were recorded. The hybrid Swarna (yellow

Table 21: Performance of tomato under low cost protected structure

Foliar sprays of WSF (19:19:19)	Poly house Conditions				Net house Conditions				Open Field Conditions			
	Plant height (cm)	Av. fruit wt (g)	Yield (kg/pl)	Yield (q/ha)	Plant height (cm)	Av. fruit wt. (g)	Yield (kg/pl)	Yield (q/ha)	Plant height (cm)	Av. fruit Wt (g)	Yield (kg/pl)	Yield (q/ha)
3	145.7	62.7	3.05	381.25	126.5	60.7	2.38	297.50	102.5	55.4	2.01	251.25
4	152.2	69.7	4.75	593.75	135.7	65.5	3.67	458.75	110.2	58.2	2.69	336.25
5	158.5	68.6	3.86	482.50	147.5	64.3	2.85	356.25	122.3	57.6	2.49	311.25

Fig. 27: Capasium *cv.* Swarna grwon under Polyhouse condition

coloured) and Indra (red coloured) performed better and gave maximum fruit yield (1.275 and 0.934 kg/plant, respectively). The number of fruits, plant height and average fruit weight were recorded maximum under Swarna (Fig. 27 & Table 22).

Table 22: Performance of capsicum under net house

Var./ Hybrids	Plant height (cm)	Fruits/ plant (No.)	Average fruit weight (g)	Yield (kg/plant)
Swarna	70.6	8.5	150.0	1.275
Indra	67.6	6.9	135.5	0.934
Cab-1201	55.2	5.7	91.7	0.522

SUB PROJECT 3.2: Precision Farming in Vegetable Crops

RN Prasad, RB Yadava and TD Lama

Field experiments were conducted during Zaid and Kharif 2014 and Rabi 2014-15 to study the performance of cowpea, okra and tomato under different sowing/planting environments. In cowpea, the maximum yield of 141.45q/ha,130.27q/ha and 125.62q/ha was obtained in Kashi Nidhi, Kashi Kanchan and Kashi Unnati respectively with second date of sowing i.e. on 26th March. Similarly, in okra, the maximum yield of 142.62q/ha,121.37q/ha and 126.54q/ha was obtained in Kashi Pragati, Kashi Vibhuti and Kashi Kranti, respectively with first date of sowing i.e. on 22nd July. In case of tomato, the maximum yield 460.3q/ha, 482.7q/ha and 410.4q/ha was obtained in Kashi Amrit, Kashi Anupam and Kashi Vishesh, respectively on first date of transplanting (3rd October) (Table 23). However, the above ground biomass accumulation was higher in the second transplanted crop (Fig. 28). The biomass production and yield in cowpea, okra and tomato crops were found to be closely related to the accumulation of growing degree days (GDD). Quantitative relationships of GDD with biomass production and yield were developed (Table 24). The coefficient of determination ranged from 0.65 to 0.88 in cowpea, 0.67 to 0.87 in okra and 0.74 to 0.88 in tomato suggesting that these equations so developed can be used satisfactorily for prediction of biomass production and yield in cowpea and tomato using GDD.

Table 23: Yield of cowpea, okra and tomato under different sowing/planting environments

Variety	Ist sowing/ transplanting	IInd sowing/ transplanting	IIIrd sowing/ transplanting
Cowpea			
	11.03.2014	**26.03.2014**	**10.04.2014**
Kashi Nidhi	131.64	141.45	114.54
Kashi Kanchan	123.73	130.27	108.27
Kashi Unnati	121.26	125.62	102.56
Okra			
	22.07.2014	**07.08.2014**	**22.08.2014**
Kashi Pragati	142.62	133.52	108.45
Kashi Vibhuti	121.37	114.34	94.61
Kashi Kranti	126.54	117.32	96.37
Tomato			
	03.10.2014	**18.10.2014**	**04.11.2014**
Kashi Amrit	460.3	445.4	287.52
Kashi Anupam	482.7	465.2	292.73
Kashi Vishesh	410.4	405.6	260.84

Table 24: Relationships between growing degree days (GDD), biomass accumulation and yield in cowpea and tomato

Cowpea	
Biomass = 0.053GDD – 28.75	R^2 = 0.88
Yield = 0. 066GDD + 7.191	R^2 = 0.65
Okra	
Biomass = 0.076GDD - 81.33	R^2 = 0.87
Yield = 0. 047GDD +44.59	R^2 =0. 67
Tomato	
Biomass= 0.0152GDD-34.26	R^2= 0.89
Yield= 0.865GDD+26.21	R^2=0.74

Studies on the effect of N levels on growth and yield of tomato: An experiment was conducted second year 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 2014-15. The data presented in Fig. 34 reveal that there was an increasing trend in growth, biomass accumulation, Chlorophyll Content Index and yield of tomato up to 160 kg N/ha. The maximum values with these characters were found to be 33.57g/plant Biomass, Chlorophyll Content Index 62.15 and yield 482.21 q/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. 29).

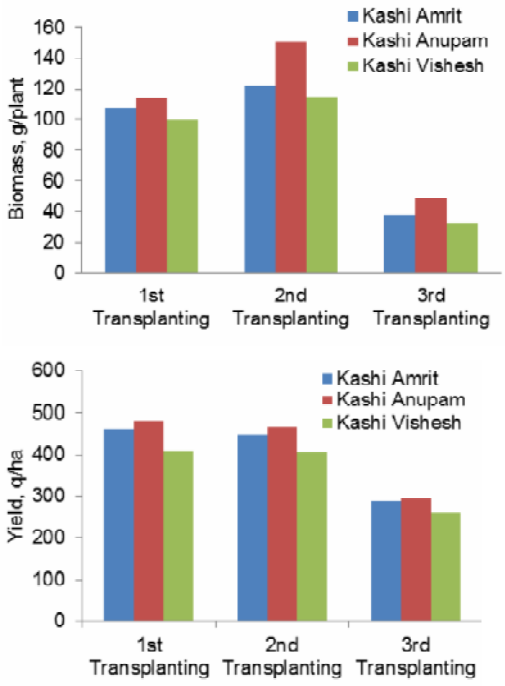


Fig. 28: Above ground biomass accumulation and yield of tomato cultivars on different dates of transplanting

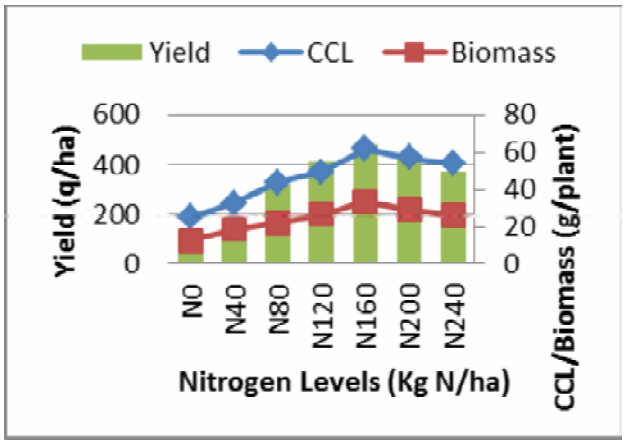


Fig. 29: Effect of nitrogen fertilization levels on yield, biomass and chlorophyll content index (CCI) of tomato

Studies on Weed Control: An experiment was conducted during kharif - 2014 to control the weeds especially Motha (*Cyperus rotundus*) at IIVR farm. Four concentrations of glyphosate (2, 4, 6 and 8%) were sprayed. The data revealed that the dry matter production per unit area was least (20.14g/m^2) with the use of glyphosate @ 8%, whereas in control it was maximum (76.56 g/m^2). Further, it is interesting to note that the regeneration of weeds started after 87 days of spraying of glyphosate @ 8%. The major weeds observed in the field were *Cyperus rotundus, Cynodon dactylon, Phylanthus niruri, Asphodelus fistulosus, Trianthema sp., Parthenium hysterophorus L.* and *Chicorium intybus.*

SUB PROJECT 3.4: Impacts of Organic Management Systems on Vegetable Productivity, Quality and Soil Health

RB Yadava, TD Lama, RN Prasad, Sudhir Singh, DK Singh, Jaydeep Halder, Manjunath, M and C Sellaperumal

Effect of different organic treatments on crop yields

***Zaid*-2014:** Cowpea (var. Kashi Kanchan) and okra (Kashi Kranti) were grown under nine different organic management treatments (**T1**-FYM @ 20 t/ha; **T2**-Poultry manure @ 5 t/ha; **T3**-Vermicompost @ 7 t/ha; **T4**- FYM @ 10 t/ha+ poultry manure @ 2.5 t/ha; **T5**-FYM @10 t/ha+ vermicompost @ 3.5 t/ha; **T6**-poultry manure @ 2.5 t/ha + vermicompost @ 3.5 t/ha; **T7**-FYM @ 10 t/ha+ poultry manure @ 2.5 t/ha + Biofertilizers (*Rhizobium / Azotobacter* + PSB); **T8**-FYM @10 t/ha + vermicompost @ 3.5 t/ha + Biofertilizers; **T9**- poultry manure @ 2.5 t/ha + vermicompost @ 3.5 t/ha + Biofertilizers) along with an inorganic control receiving only N, P, K through inorganic fertilizers, and an absolute control receiving no fertilizers/ manures. The results presented in Fig. 30 & 31 reveal that the maximum yields of cowpea (78.5q/ha) and okra (85.3q/ha) were recorded with the integrated application of 10 t/ha FYM+2.5 t/ha poultry manure + *Rhizobium / Azotobacter* + PSB whereas, the minimum yields (cowpea-21.2 q/ha and okra-36.6 q/ha) were recorded under absolute control.

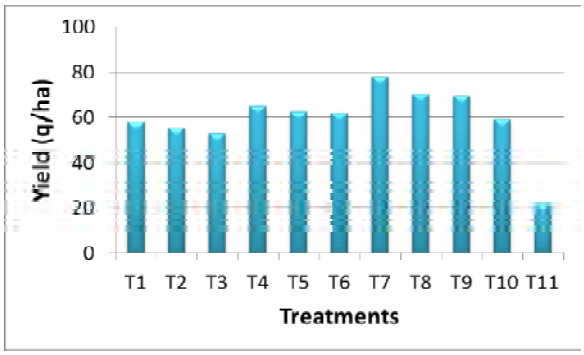


Fig. 30: Response of cowpea to different treatments

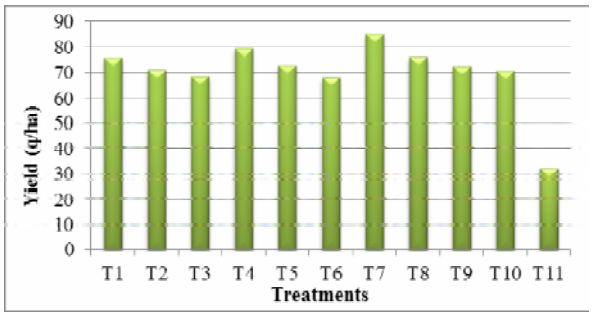


Fig. 31: Response of okra to different treatments

***Kharif* 2014:** During *kharif* season, cowpea (var. Kashi Kanchan) was grown under different organic management systems. The results presented in Fig. 32 reveal that combined application of organic manures along with bio-inoculation with *Rhizobium* and PSB was more effective as compared to other treatment combinations. The maximum yield (94 q/ha) was recorded with the application of FYM @ 10 t/ha + poultry manure @ 2.5 t/ha + bio-inoculation with *Rhizobium* and PSB. The lowest yield (30.9 q/ha) was obtained under absolute control.

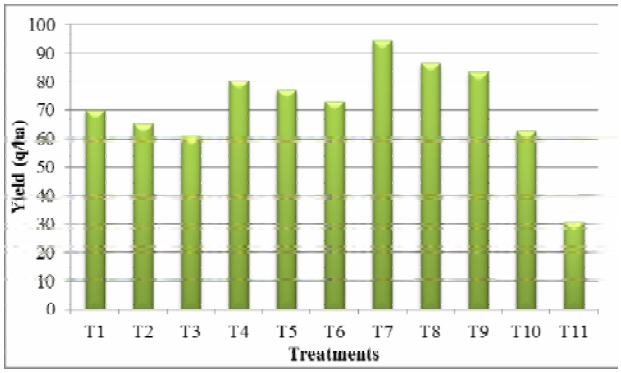


Fig. 32: Response of cowpea to different treatments during *kharif* season

***Rabi* 2014-15:** Cabbage (var. Golden Acre) and tomato (var. Kashi Vishesh) were planted under nine different organic treatments along with one inorganic and one absolute control during *Rabi* season. The data presented in Fig. 33 indicate that combined use of organic manures in 1:1 ratio was superior to their single application. The bio-inoculation with Azotobacter and phosphate solubilizing bacteria further improved the beneficial effects of combined use of organic manures. The maximum yield of cabbage (388.3 q/ha) was recorded with the application of FYM @10 t/ha + poultry manure @ 2.5 t/ha + *Azotobacter* + PSB. The lowest yield was recorded (186.7 q/ha) under absolute control where no manure/ fertilizer was used.

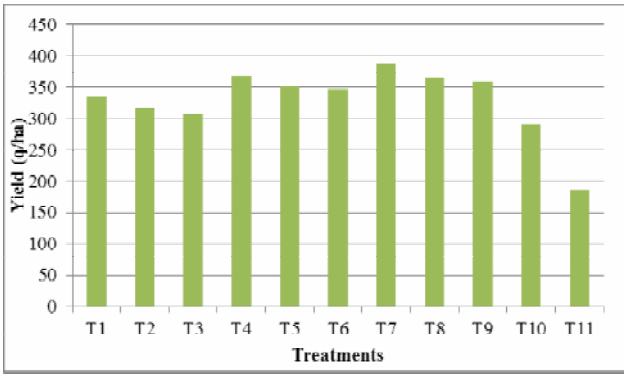


Fig. 33: Yield of cabbage in relation to different treatments

Effect of different organic treatments on incidence of cowpea pod borer: The incidence of major borer pest of cowpea *viz*., spotted pod borer *Maruca vitrata* (Pyralidae: Lepidoptera) was recorded in different organic treatments and compared with plots with recommended dose of inorganic fertilizers (Fig. 34). It is evident that lowest pod damage (15.45%) was observed in the Vermicompost @ 7 t/ha treated plots followed by T_4 (16.75% pod damage) where FYM @ 10 t/ha + Poultry manure @ 2.5 t/ha were applied. Interestingly, inorganic plots suffered highest pod damaged (39.05%) than any of the organic plots.

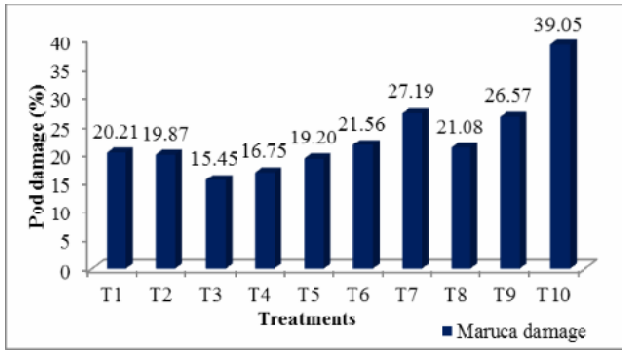


Fig. 34: Cowpea pod damage by *M. vitrata* as affected by different organic treatments

Effect of different organic treatments on root-knot nematode (*Meloidogyne incognita*) population: Population density and fluctuation of root knot nematode was studied under different organic management systems during *Rabi* 2014-15. The data recorded on percentage increase or decreases over initial population are presented in Table 25. The reduction in population of *M. incognita* was recorded in the range of 7.0 to 19.1% in tomato and 9.1 to 23.4% in cabbage over initial population. Among different treatment combinations tested, combined application of poultry manure @ 2.5t/ha + vermicompost @ 3.5t/

Table 25: Effect of different organic treatments on nematode infection in vegetables

Treatments	Tomato			Cabbage		
	P(i)	P(f)	% increase (+) or decrease (-)	P(i)	P(f)	% increase or decrease
T1	210.0	196.3	(-) 7.0	189.0	168.3	(-) 12.3
T2	215.0	192.3	(-) 11.8	196.0	171.0	(-) 14.6
T3	191.0	176.7	(-) 8.1	195.2	179.0	(-) 9.1
T4	189.2	168.3	(-) 12.4	199.0	169.5	(-) 17.4
T5	210.2	184.6	(-) 13.9	190.0	162.0	(-) 17.3
T6	183.2	162.5	(-) 12.7	205.0	176.0	(-) 16.5
T7	180.0	153.5	(-) 17.3	187.5	152.5	(-)23.0
T8	209.0	181.0	(-) 15.5	201.0	165.0	(-) 21.8
T9	180.5	151.5	(-) 19.1	210.0	170.2	(-) 23.4
T10	215.3	250.2	(+) 13.9	211.3	200.0	(-) 5.7
T11	204.0	225.0	(+) 9.3	202.0	194.0	(-) 4.1

ha + bio-fertilizers recorded maximum reduction in nematode population under tomato (19.1%) and cabbage (23.4%), whereas under inorganic and absolute control conditions there was slight increase in nematode population in tomato and comparatively very less reduction under cabbage over the initial population.

Effect of different organic treatments on quality of vegetables: The quality of vegetables was evaluated in terms of colour, texture and vitamin-C content. It was observed that there was no consistent trend in colour and texture under different treatments. In cowpea, the green colour (a value) varied from -6.26 to -6.97 under different treatments. The texture measured with needle probe (P2N) varied from 5.20 N to 5.65 N. In case of okra, the colour and texture ranged from -5.55 to -5.80 and 1.92 N to 2.07 N, respectively. The vitamin-C content in both the crops was found to be higher under organic treatments as compared to inorganic system. In cowpea it ranged from 11.50 mg/100 g under absolute control to 14.50 mg/100 g with the combined application of FYM @ 10t/ha+ poultry manure @ 2.5t/ha + biofertilizers. Similarly, in okra, it varied from 10.70-13.45 mg/100 g.

During *Rabi* season, the colour of cabbage varied from -14.02 to -15.13 whereas the texture ranged from 5.88 N to 6.11 N. The vitamin-C content varied from a minimum of 30.98 mg/100 g under absolute control to 34.50 mg/100 g under integrated use of FYM @10t/ha+ poultry manure @2.5 t/ha + biofertilizers.

Effect of different organic management systems on soil properties

Carbon stock and carbon sequestration: The analysis of soil samples reveal that soil carbon stock and carbon sequestration were influenced significantly with different organic management systems. The carbon stock ranged from a minimum of 0.916 Mg/ha under absolute control to a maximum of 1.217 Mg/ha with the use of FYM @ 20 t/ha. The carbon sequestration under different organic management systems was found to be maximum (301.0 kg/ha/yr) under FYM @ 20t/ha whereas, it was lowest (42.6 kg/ha/yr) under inorganic control (Fig. 35).

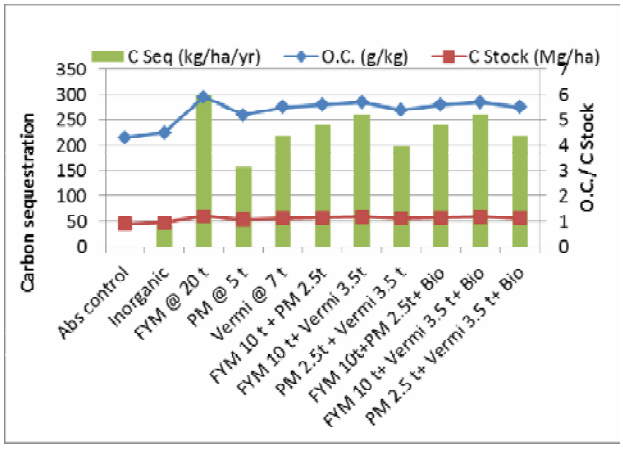


Fig. 35: Soil carbon stock and carbon sequestration under different treatments

Soil microbial activity: The total soil microbial activity in relation to different organic management systems was determined in terms of FDA (Fluorescein diacetate) hydrolysis. The results revealed that it was minimum (1.046 µ g/g soil) under inorganic system. Under organic management systems it varied from 1.16 to 1.37 µ g/g soil (Fig. 36).

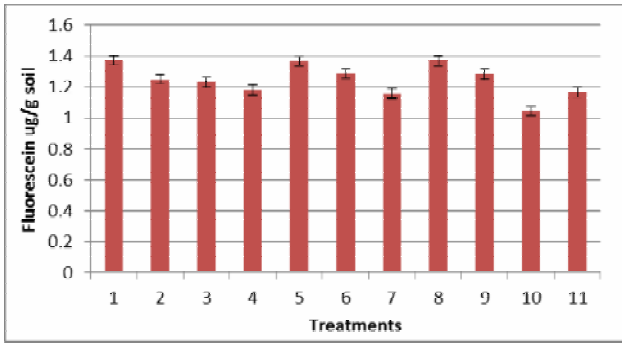


Fig. 36: Total microbial activity under different organic management systems

SUB PROJECT 3.5: Improving Soil Health and Carbon Sequestration in Vegetable Production System through Conservation Tillage and Residue Incorporation

TD Lama, RB Yadava, Anant Bahadur, DK Singh, Vanitha SM and M Manjunath

During *Zaid* 2014, the highest yield of cowpea was obtained in plots under conservation tillage (10.5

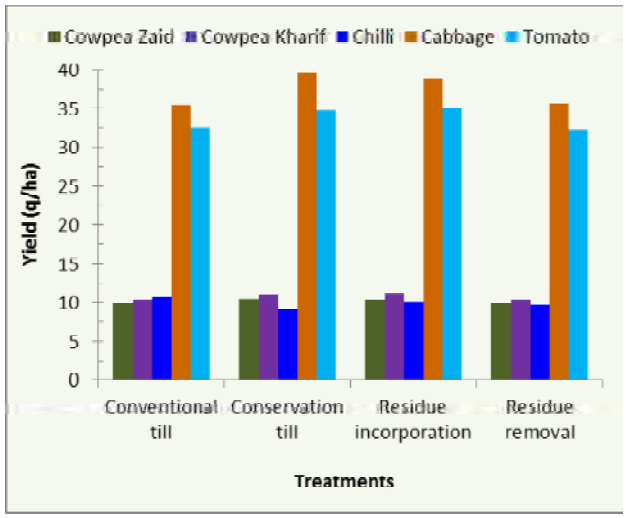


Fig. 37: Crops yields as influenced by tillage systems and residue management

t/ha), while in conventional tillage it was 0.99 t/ha. Similarly, during Kharif season, cowpea yield was higher in conservation tillage (11.0 t/ha) followed by conventional tillage (10.4 t/ha). Yields of cabbage and tomato crops were higher in conservation tillage (39.6 and 34.7 t/ha, respectively) as compared to conventional tillage (35.1 and 32.5 t/ha, respectively). In chilli, the yield was higher under conventional tillage (10.7 t/ha) as compared to conservation tillage (0.91 t/ha). In all the crops, higher yields were obtained in plots where residues were incorporated (Fig. 37).

The soil organic carbon (SOC) concentration, SOC stock, carbon pools and soil carbon sequestration were higher under conservation tillage and residue incorporation (Table 26). The total microbial activity assessed in terms of fluorescein diacetate hydrolytic activity (FDHA) in the soil samples from different treatments revealed that the microbial activity was higher under under conservation tillage (0.99 µg fluorescein/g soil) and residue incorporation (0.98 µg fluorescein/g soil). The soil penetration resistance in different treatments varied from 0.10-5.58 MPa.

Table 26: Effect of tillage, residue management and cropping system on SOC, SOC stock, SOC pools and SOC sequestration

Treatments	SOC (g/kg)	SOC stock (Mg/ha)	Labile C (g/kg)	Non-labile C (g/kg)	Soil C sequestration (kg/ha/yr)
Cowpea-Cabbage-Cowpea	4.80	1.15	0.60	4.19	148.57
Chilli-Cowpea	4.74	1.14	0.60	4.14	134.42
Tomato-Cowpea	4.77	1.15	0.60	4.17	142.82
Conventional tillage	4.66	1.12	0.59	4.07	115.45
Conservation tillage	4.88	1.17	0.61	4.26	168.42
Residue incorporation	5.01	1.20	0.63	4.38	199.57
Residue removal	4.53	1.09	0.57	3.96	84.31

The energy use efficiency and benefit-cost ratio in all the crops was higher under conservation tillage than conventional tillage due to reduced input use particularly, energy and capital inputs (Table 27). However, with residue incorporation the energy use efficiency was lower due to increase in energy input resulting from addition of crop residues.

SUB PROJECT 3.7: Enhancing Water and Nutrient use Efficiency in Vegetable Crops

Anant Bahadur, DK Singh, TD Lama, RN Prasad and SNS Chaurasia

Drip fertigation study in tomato: Drip fertigation study was conducted in tomato cv. Kashi Aman with objective to optimize the dose of N (through urea) for fertigation. Drip study revealed that N fertigation @ 150 kg/ha has significantly enhanced the most of the vegetative growth parameters such as, leaf area (6292.3 cm^2/plant), total dry matter (322 g/plant), total root length (6718.7 cm), root volume (27.55 cm^3), chlorophyll content index (23.23) and photochemical efficiency of PS II (0.620). However, as for as yield was concerned significantly higher number of fruits (22 and 23.7/plant), fruit weight (75 and 79.3 g), yield (1.51 and 1.66 kg/plant, and 40.10 and 43.97 tones/ha, respectively) were reported with N fertigation at 120 kg or 150 kg/ha. These two treatments showed superiority in performance over both N_1 and N_4 treatments; however they were statistically *at par* to each other. The maximum nitrogen use efficiency (3.34 q yield/kg of N) was registered with fertigation of N at 120 kg/ha, and the lowest NUE was recorded under N 180 kg/ha (1.76 q yield/kg of N) (Table 28).

Drip fertigation study in cucumber: Drip fertigation study was conducted in cucumber during Spring-summer season of 2014. In this study 3 levels of N fertigations were compared with conventional fertilization (120:60:60 kg NPK/ha as soil application). Most of the growth and yield parameters were found significantly higher under N at 150 kg/ha. N use efficiency were maximum i.e.15.2 and 14.9 kg/kg of N, respectively under N 100 and 120 kg/ha. The total N

Table 27: Energy output-input and benefit-cost (B:C) ratio under different tillage and residue management treatments

Treatments	Cowpea *Zaid*		Cowpea *Kharif*		Chilli		Cabbage		Tomato	
	Energy Use Efficiency	B:C Ratio	Energy Use Efficiency	B:C Ratio	Energy Use Efficiency	B:C Ratio	Energy Use Efficiency	B:C Ratio	Energy Use Efficiency	B:C Ratio
Conventional tillage	4.86	2.40	4.47	2.33	0.87	1.60	2.40	2.58	2.27	2.71
Conservation tillage	5.43	2.85	4.61	2.80	0.79	1.32	2.79	3.12	2.79	2.32
Residue incorporation	1.48	2.71	1.60	2.59	0.69	1.51	1.52	3.01	1.35	2.53
Residue removal	8.82	2.54	7.47	2.54	0.96	1.41	3.68	2.69	3.71	2.50

Table 28: Effect of drip N-fertigation on plant growth and yield attributes of tomato

Nitrogen fertigation	Leaf area (cm^2)	Total dry matter (g)	Total root length (cm)	Total root volume (cm^3)	CCI	Chlorophyll fluorescence (Fv/Fm)	Fruit no./ plant	Fruit weight (g)	Fruit yield /plant (kg)	Fruit yield (t/ha)	fNUE (q yield/ kg of N)
N_1 90 kg	3505.0	151.5	4856.0	16.47	14.53	0.480	15.7	68.3	1.10	28.93	3.21
N_2 120 kg	5216.3	259.7	5665.0	21.71	16.93	0.591	22.0	75.0	1.51	40.10	3.34
N_3 150 kg	6292.3	322.0	6718.7	27.55	23.23	0.620	23.7	79.3	1.66	43.97	2.93
N_4 180 kg	9480.0	301.1	5739.0	22.30	26.63	0.643	17.7	69.7	1.19	31.67	1.76
SEm ±	**208.45**	**6.11**	**176.25**	**1.15**	**0.63**	**0.017**	**0.64**	**1.86**	**0.12**	**1.68**	
CD 0.05	**615.54**	**18.36**	**530.02**	**3.48**	**1.72**	**0.053**	**1.83**	**5.77**	**0.31**	**5.03**	

content in various plant parts of cucumber varied 1.15 to 4.41% with maximum uptake under highest dose of N fertilizer applied (150 kg N/ha) (Table 29 & Fig. 38).

Drip irrigation and mulching study in tomato: Tensiometer based drip irrigation study was carried out in hybrid tomato during 2013-14. Two types of mulches *viz.*, black polythene and paddy straw mulches were used. Experimental findings revealed that drip irrigation scheduled at 0.6 bars coupled with black polythene mulch has resulted maximum and significantly higher number of fruits (20.3 ±1.56/plant), fruit weight (124.0 g), fruit yield (2.56 kg/plant and 90.17 tones/ha) and water use efficiency (31.64 q yield/ha/cm of water). The lowest WUE of 15.10 q yield/ha/cm of water was recorded with drip irrigation at 0.4 bars and without mulch. Weed growth was also noticed lowest under black polythene mulch (7.77 g DW/ m^2) as comparison to without mulch (120.47 g DW/ m^2). Frequent irrigation (0.4 bars) noticed higher weed biomass (70.88 g/ m^2) than drip irrigation at 0.6 bars (44.56 g/ m^2) or 0.8 bars (32.36 g/ m^2) (Fig. 39 & Table 30).

Fig. 39: Drip irrigation in tomato

Table 29: Effect of N fertigation on growth and yield attributes of cucumber

Nitrogen fertigation	Vine length (cm)	Total dry matter (g)	No. of fruits/ plant	Fruit yield (t/ ha)	WUE (kg yld./ cm of water)	fNUE (kg yld./ kg of N)	Nitrogen content (%)		
							Vine	Leaf	Fruit
F_1 (N 100)	121.3	114.4	5.5	15.18	60.0	15.2	1.43^{bc}	3.17^{c}	1.27^{b}
F_2 (N 120)	130.0	121.5	8.5	17.85	70.6	14.9	1.58^{b}	3.93^{b}	1.51^{a}
F_3 (N 150)	141.3	140.9	9.3	19.38	76.6	12.9	1.79^{a}	4.41^{a}	1.56^{a}
Control	167.3	152.2	6.5	15.30	44.7	12.8	1.34^{c}	3.05^{c}	1.15^{c}
SEm±	8.35	-	0.70	0.55					
CD 0.05	26.71	-	2.23	1.77					

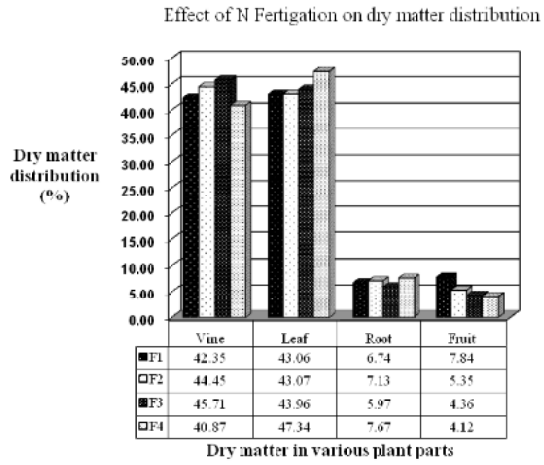


Fig. 38: Drip irrigation in cucumber

Table 30: Effect of tensiometer based drip irrigation scheduling and mulching on yield attributes of tomato

Treatment*	No. of fruits/ plant	Fruit weight (g)	Fruit yield/ plant (kg)	Fruit yield tones/ha	Weed dry biomass (g)	WUE (Q/ha/ cm water)
$I_1 M_0$	14.0	104.67	1.66	55.85	173.00	15.10
$I_1 M_1$	16.7	111.00	2.29	76.32	11.27	20.63
$I_1 M_2$	17.3	110.67	2.06	71.14	28.37	19.23
$I_2 M_0$	16.0	106.00	1.52	52.87	105.67	18.55
$I_2 M_1$	20.3	124.00	2.56	90.17	8.37	31.64
$I_2 M_2$	18.7	116.67	2.06	72.21	19.60	25.34
$I_3 M_0$	11.3	93.33	1.06	38.71	82.73	17.59
$I_3 M_1$	14.0	104.00	1.20	42.43	3.67	19.29
$I_3 M_2$	14.7	101.67	1.28	45.41	10.67	20.64
SEm±	**1.56**	**4.58**	**0.12**	**4.35**	**5.96**	-
$CD_{0.05}$	**4.74**	**13.89**	**0.36**	**13.20**	**18.07**	-

* I_1, I_2 and I_3 represent drip irrigation at 0.4, 0.6 and 0.8 bars, whereas M_0, M_1 and M_2 denote without mulch, black polythene mulch and paddy straw mulch, respectively.

Table 31: Effect of IPNM on fruit production in bottle gourd

Treatment details	Fruit No./ plant	Fruit length (cm)	Fruit wt. (g)	Yield/ plant (kg)	Fruit yield (q/ha)
T_1 = FYM 25 t/ha (120 kg N)	6.7	34.33	914.3	8.34	330.35
T_2 = Vermicompost 8 t/ha (120 kg N)	7.3	31.70	945.0	8.77	347.44
T_3 = Poultry manure 6 t/ha (120 kg N)	5.7	36.67	908.7	7.22	290.25
T_4 = FYM 8t/ha + Vermicompost 2.7t/ha + Poultry manure 2t/ha (40 kg N from each)	9.7	39.83	993.3	10.34	421.75
T_5 = T_1 + ½ Rec. NPK	8.3	38.43	957.7	9.59	378.05
T_6 = T_2 + ½ Rec. NPK	7.3	33.37	895.7	8.70	351.27
T_7 = T_3 + ½ Rec. NPK	6.0	35.60	854.0	6.25	242.10
T_8 = T_4 + ½ Rec. NPK	6.3	31.40	863.3	7.18	279.00
T_9 = Rec. NPK (120:60: 60 kg/ha)	7.0	36.00	920.7	8.33	329.85
SEm ±	**0.21**	**1.21**	**23.66**	**0.29**	**12.27**
CD 0.05	**0.65**	**NS**	**74.23**	**0.87**	**38.63**

IPNM study in bottle gourd: IPNM trial was conducted in Kharif season bottle gourd cv. Kashi Ganga. In this trial, three organic sources *i.e.* FYM, vermicompost and poultry manure were used alone or in various combinations including recommended NPK. Maximum number of fruits (8.3/plant), fruit weight (993.3) and fruit yields (10.34 kg/plant and 421.75 q/ha) was recorded in T4 that comprises combined soil application of FYM, vermicompost and poultry manure ensuring 40 kg N from each sources. This treatment combination has registered about 28% higher yields over recommended NPK (T_9) (Table 31).

SUB PROJECT 3.8: Performance of Vegetable Crops under Subsurface Drip Irrigation System

DK Singh, Anant Bahadur and SNS Chaurasia

Response of tomato (Kashi Vishesh) was studied under varying levels of water application through subsurface drip irrigation (SDI) with lateral placed at 10 cm depths below soil surface. Water was applied to the crop based on 50% ET, 60% ET, 80% ET and 100% ET through SDI and 100% ET through surface drip. A total of 116, 139, 186 and 232 mm depth of water were applied for 50, 60, 80 and 100% ET, respectively. It was observed that yield of tomato increased with increasing level of water application from 50% ET (27.67 t/ha) to 100% ET (42.13 t/ha) through SDI (Fig. 40). The yield increased by 16.9% at 100% ET however, it declined by 6.0-23.2% with water application at water level of 60%-50% ET as compared with surface drip (36.03 t/ha) (Fig. 41). The yield at 60% ET and 80% ET was 33.93 t/ha and 40.37 t/ha, respectively. Water use efficiency (WUE) of tomato was found to be 238.5, 243.8, 217.5 and 181.6 kg/mm, respectively under 50, 60, 80 and 100% ET. WUE of tomato under surface drip was 155.3 kg/mm.

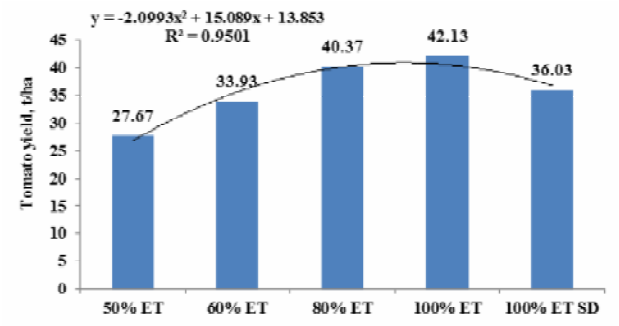


Fig. 40: Yield of tomato at varying level of water application

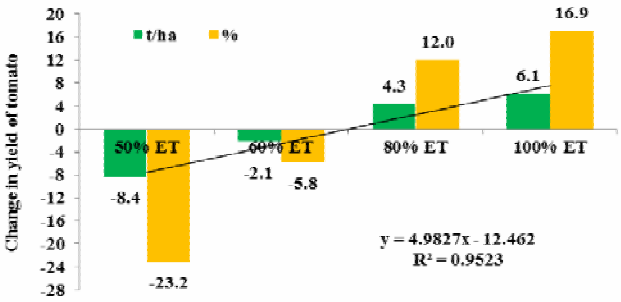


Fig. 41: Change in yield of tomato under varying level of water application

MEGA PROGRAMME 4: POST HARVEST MANAGEMENT AND VALUE ADDITION

Programme Leader: Sudhir Singh

SUB PROJECT 4.1: Studies on Carnauba Wax Edible Coating on Nutritional and Sensory Qualities of Bitter Gourd (*Momordica chrantia*)

Sudhir Singh and TK Koley

The effect of carnauba wax in bitter gourd was assessed with addition of various additives such as sodium alginate (SA) and carboxy methyl cellulose (CMC) on functional quality during storage with or without polypropylene pouches packaging and storage at ambient storage at 25 ^{0}C and refrigerated storage at 10 ^{0}C and relative humidity of 91% (Max) and 52% (Min). Minimum PLW (10.5%) in bitter gourd occurred with commercial Niprofresh based carnauba wax emulsion which was followed by PLW (15.4%) after 6 days of ambient storage temperature in SA added carnauba wax emulsion. The changes in moisture and PLW loss were of lower magnitude in bitter gourd fruits during packaging and storage at 10 °C as compared to without packaging and storage of bitter gourd fruits at 25°C. Similarly minimum decrease (93.56-51.54 mg/100g) in total phenol content (TPC) was obtained with commercial Niprofresh carnauba wax emulsion while maximum loss (93.56-40.21 mg/100g) occurred in fully control bitter gourd after 6 days of ambient storage. The decrease in antioxidant activity was also minimum (18.4%) with Niprofresh carnauba wax coating while the addition of SA and CMC in formulated carnauba wax coating in bitter gourd had also resulted in appreciable losses of 47.13 and 54.59%, respectively. The losses in ascorbic acid and electrolyte leakage also followed the similar trends with maximum losses in fully control bitter gourd and minimum losses with the commercial Niprofresh and formulated carnauba wax based edible coating. It can be concluded that commercial Niprofresh and formulated carnauba wax coating are effective in shelf life extension and retention of functional qualities for longer time as compared to fully control bitter gourd. There had been moisture adsorption on carnauba wax coated followed by polypropylene pouches coated bitter gourd fruits during refrigerated storage as a result fungal spoilage was started after 16 days of storage (Fig. 42a,b to 51a,b).

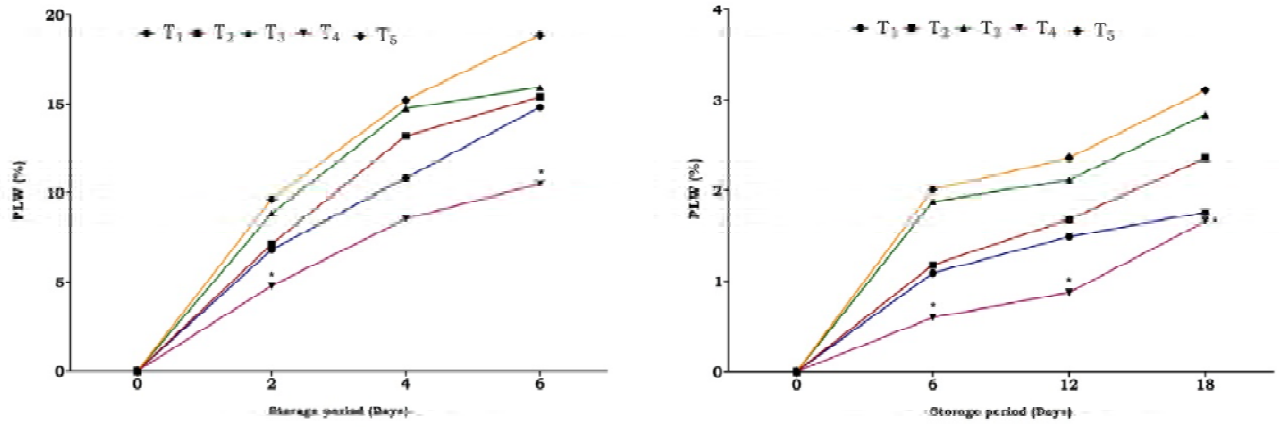


Fig. 42 (a & b): Changes in PLW during storage

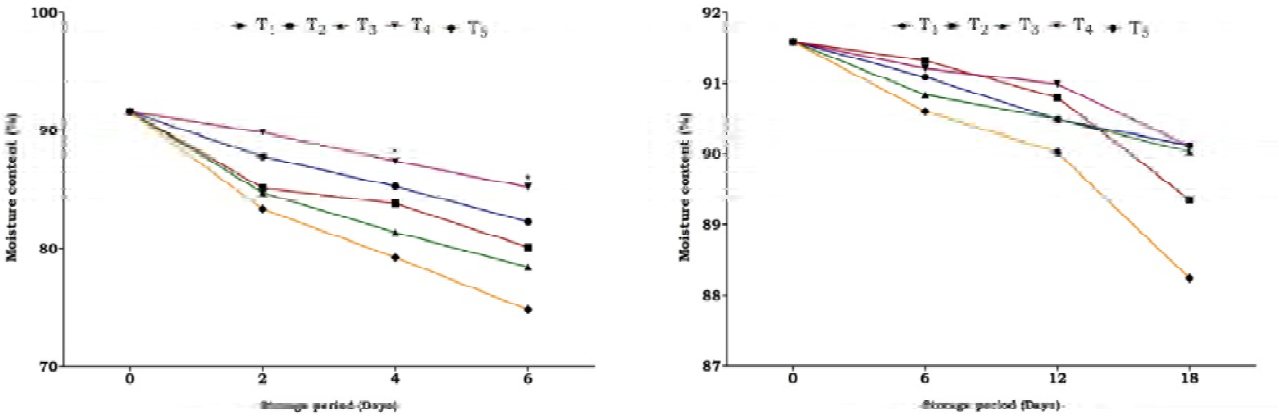


Fig. 43 (a &b): Changes in Moisture Content during storage

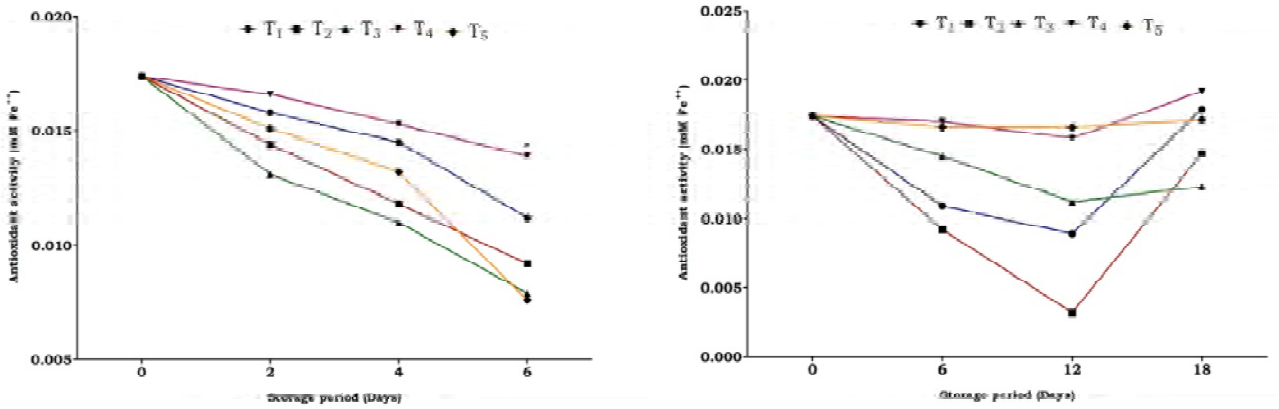


Fig. 44 (a& b): Changes in Total Antioxidant Activity during storage

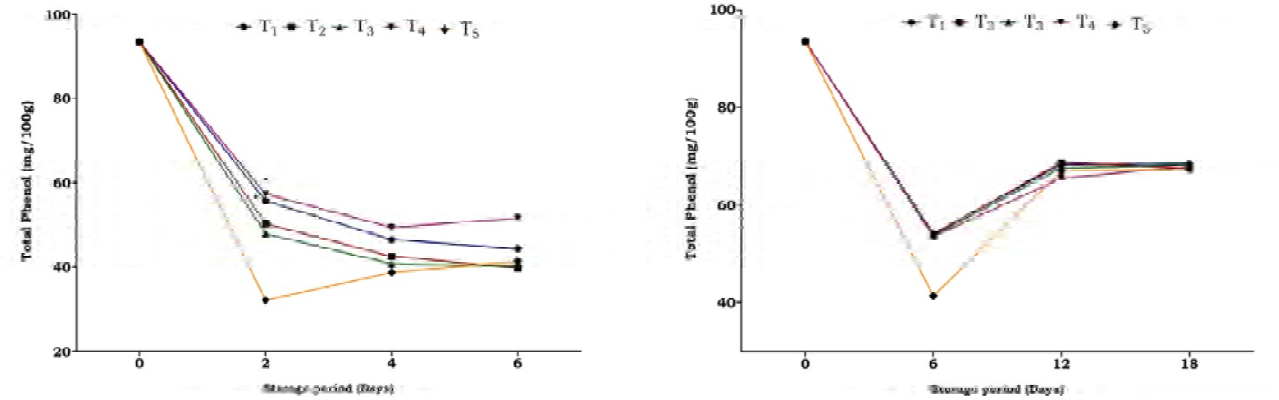


Fig. 45 (a& b): Total Phenolic Content during storage

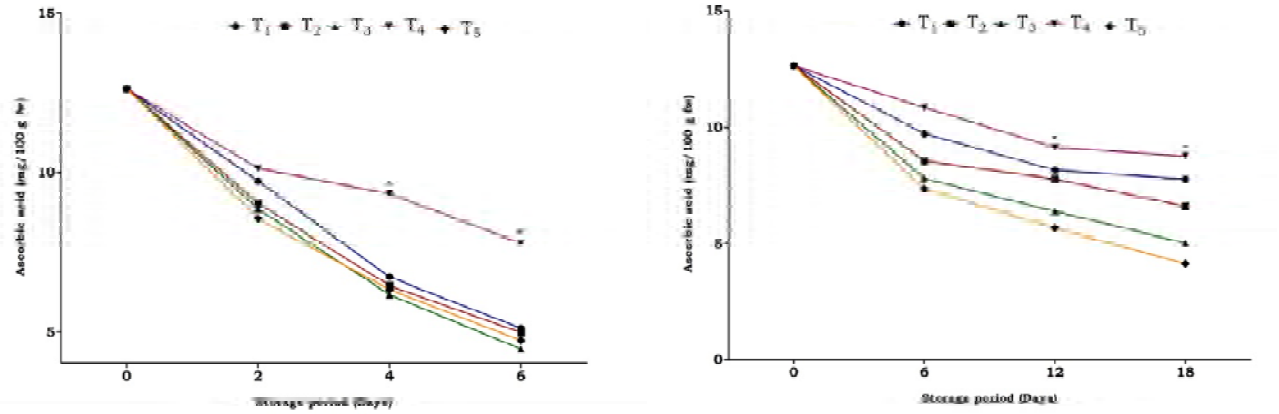


Fig. 46 (a& b): Effect of Ascorbic Acid during storage

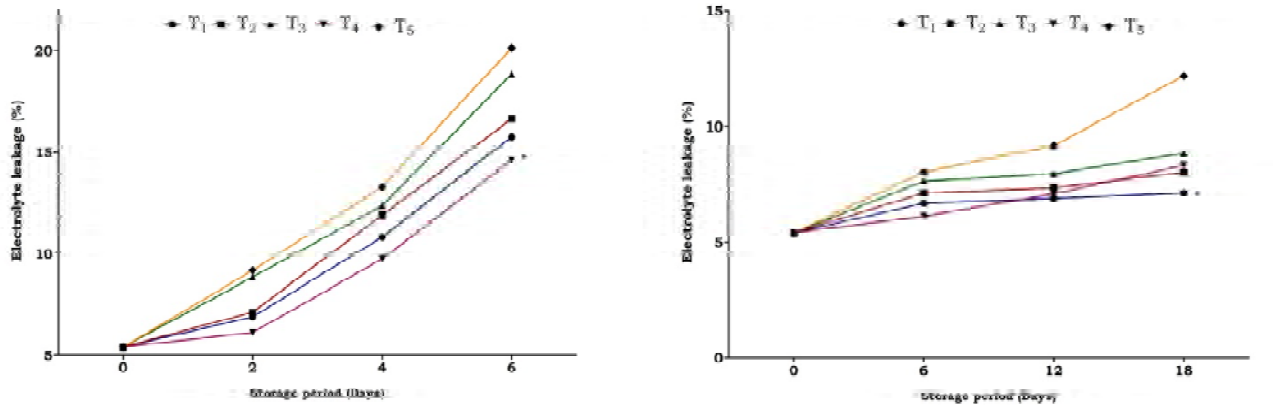


Fig. 47 (a& b): Effect on Electrolyte leakage during storage

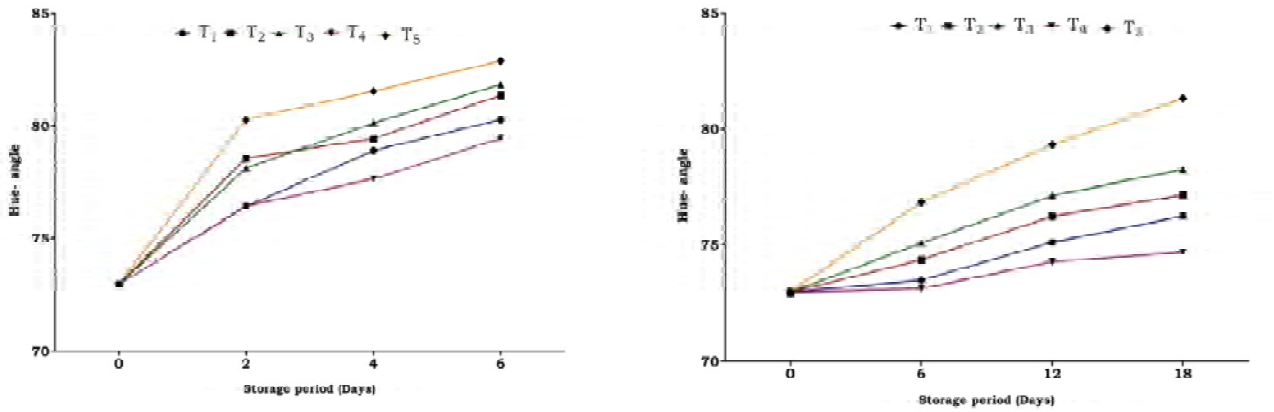


Fig. 48 (a& b): Effect on Hue Angle during storage

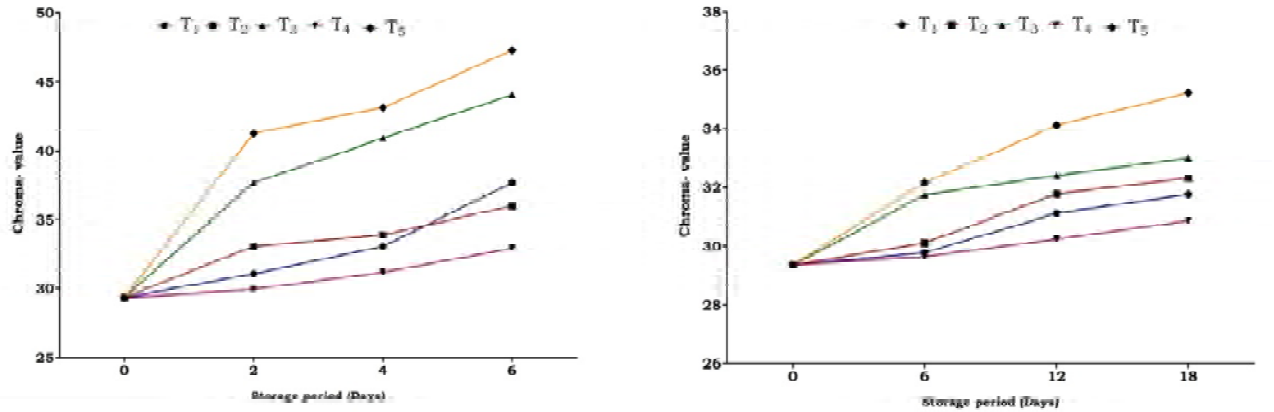


Fig. 49 (a& b): Effect on Chroma Value during storage

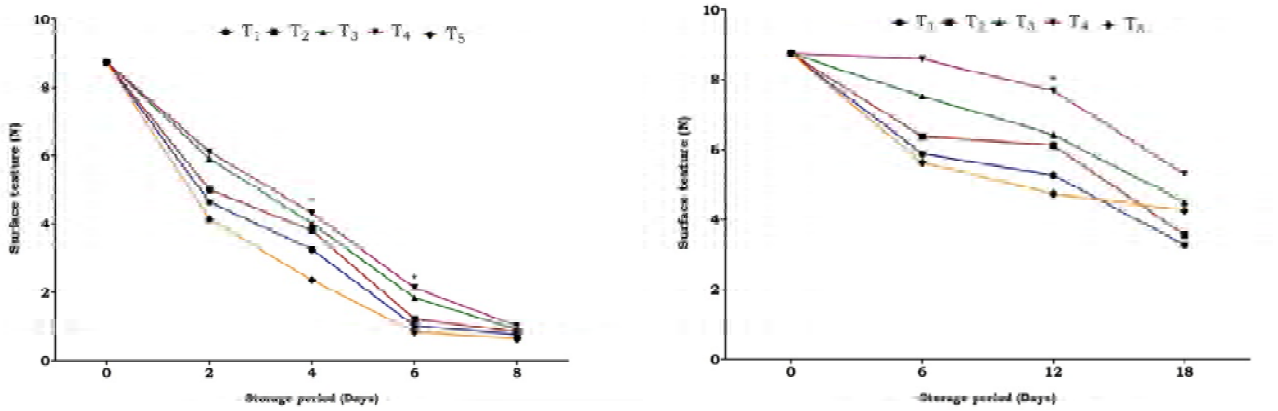


Fig. 50 (a& b): Effect on Surface Texture during storage

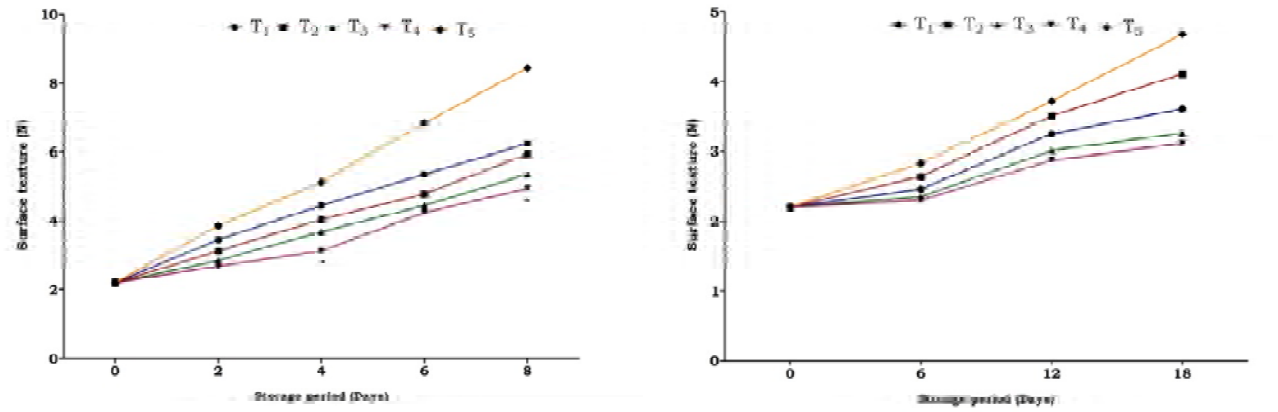


Fig. 51 (a& b): Effect on Seed Texture during storage

SUB PROJECT: 4.2 Exploration of Vegetable Nutraceuticals for the Development of Functional Food

TK Koley, Sudhir Singh and Y Bijen Kumar

Antioxidant diversity in pepper (Capsicum) fruits of diverse genotype including commercial cultivar, hybrid, wild species and inter-specific derivatives: A comprehensive study on antioxidant compounds of twenty five Capsicum genotypes representing three pepper species, *Capsicum annuum, C. frutescens* and *C. baccatum* has been performed. All samples were analyzed at green and red ripe stage. Major antioxidant in fruits of capsicum species, capsaicin, flavonoids, phenols and ascorbic acid were analyzed. Additionally five *in vitro* methods *viz.* FRAP, CUPRAC, DPPH, ABTS, CERAC were used for determination of antioxidant potentiality. The results showed that antioxidant composition and potentiality in fruits varied greatly between accessions. The content of total phenolics and flavonoids ranged from 54.02 to 1099.10 mg GAE/100 g and 4.83 to 257.12 mg CE/100g, respectively. Capsaicin content ranged from 12.95 to 4271.45 mg/100g. The antioxidant activity varied from 4.34 to 75.57 µ mol TE/g measured in FRAP. Significantly higher antioxidant activity was observed in CUPRAC method which varied from 7.94 to 116.20 µ mol TE/g. It has been observed that antioxidant composition and antioxidant activity were higher in red ripe stages than green stages. Some of the potential genotype having higher antioxidant composition are BS 35, IC 383072, CO 0309 *etc.*

Encapsulation of black carrot anthocyanin pigments in carrier matrices: A process of microencapsulation of black carrot anthocyanin was developed (Fig. 52). To encapsulate the pigments various material like maltodextrin, starch and gum arabic were chosen as carrier materials. In 100 mL volumetric flask, 20 grams of matrix carrier materials were dissolved in 80 mL distilled water and adjusted the pH to 2. In this, 1 gram of black carrot extract was added and volume adjusted with distilled water. This gives a ratio of 1:20 between anthocyanin extract and encapsulating agent. The mixture was stirred for 15 min and aliquots of 50 mL of the solution were distributed to series of plastic container. The mixture was freeze-dried subsequently at constant temperature of -95°C and pressure of 0.064-0.21 bar.

Fig. 52: Encapsulated black carrot pigment

Effect of black carrot on metabolic syndromes of experimental animal: Studies were carried out on the effect of black carrot juice (BCJ) on rat in collaboration with IMS, BHU. It was observed that thirty days feeding with BCJ did not change the fasting glucose level in normal rat. However consumption of BCJ decreases concentrations of serum triglycerides level in dose and time dependent manner, whereas the average serum triglyceride concentration in normal rat varied from 58.52 to 68.99 mg/dL which did not change significantly ($p < 0.05$) throughout the experiment. Thirty days feeding of BCJ also reduced the SOD activity significantly in dose and time dependent manner. In addition to this, BCJ significantly decreased the fasting glucose concentration during oral fat tolerance test which may due to its delaying effect on the absorption of glucose into the blood or increasing effect on either insulin sensitivity and/or insulin secretion. In steptozotocin induced diabetic rat black carrot juice significantly decreased the fasting plasma glucose concentration both in acute and chronic condition. It was also observed that fourteen days feeding of black carrot juice increased intestine incretin hormones (GLP1 and GIP) which have multiple health benefits.

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

Programme Leader: Neeraj Singh

SUB PROJECT 1: Research Prioritization for Vegetable Crops

Shubhadeep Roy and Neeraj Singh

During previous years, priority study was undertaken targeting agricultural experts from National Agricultural Research System in public sector i.e. ICAR institutes, State Agricultural Universities and Krishi Vigyan Kendras. During 2014-15, vegetable research priority study was undertaken targeting the vegetable farmers. Use of chemicals in vegetable cultivation have been perceived as one of the priority issue to be considered at grassroot level. A study was undertaken targeting 160 farmers from four districts (Nalanda, Muzaffarpur, Newada and Palamu) of the state Bihar. Among the respondents, 70% were male and 30% female. Regarding their age distribution 15% were upto 30 years, 60% were 31 to 50 years and 25% were 50 years and above. Regarding their educational status 17.5% were below 10th pass, 45% were 10th pass, 10% were 12th pass and 27.5% were graduate. Regarding their land holding 72.5% held upto 5 acre, 20% held 6-10 acre and 7.5% held more than 10 acre of land. 14 crucial statements were formulated regarding pesticide application to respond yes or no and the result is depicted in Table 32.

Table 32: Statement regarding pesticide application

Statements	Yes (%)	No (%)
Seed treatment before sowing	57.5	42.5
Weed problem faced	100	-
Applying pesticides as per the dose prescribed	27.5	72.5
Taking bath after pesticide spray	47.5	52.5
Covering face when spraying pesticides	47.5	52.5
Proper washing of sprayer after spraying	57.5	42.5
Use different nozzle for different pesticides	27.5	72.5
Do you eat the same vegetables cultivated for commercial purpose	57.5	42.5
Do you have kitchen garden	65	35
Awareness about pheromone traps	45	55
Awareness about bio-control agents	60	40
Cases about pesticide infection	37.5	62.5
Knowledge about antitodes	15	85
Spray pesticide after harvesting vegetables	55	45

Regarding spraying time of the pesticides, 10% of the respondents told that they do spraying operation in morning, 40% in mid noon, 45% in afternoon and 5% during night time. When enquired about the meaning of the colour code printed on the container of the pesticide, some of the respondents gave correct answer and some of them did not have idea about the meaning of the colour code. The result is depicted in Table 33.

Farmers do not follow the recommended harvesting gap after applying pesticides. The respondents were asked after how many days they used

Table 33: Distribution of the farmers having knowledge about colour code of pesticides

Colour Code	Correct (%)	Wrong (%)
Red	60	40
Yellow	25	75
Blue	40	60
Green	50	50

to harvest vegetables after spraying pesticides and the result depicted in Table 34.

Table 34: Harvest gap followed by the farmers for vegetables

Harvest interval	Percentage of the farmers used to follow
Same days	32.5
1 day	5.0
2 days	17.5
3 days	25.0
4 days	2.5
5 days	2.5
6 days	2.5
7 days	7.5
8 days	2.5
10 days	2.5

From the above results it is evident that at the grassroot level, farmers have severe lacuna about the pesticide use in comparison to scientific recommendation. So awareness creation is a priority issue regarding safe use of pesticides to avoid serious health hazard in future.

SUB PROJECT 5.2 Impact of Improved Vegetable Technologies Developed by IIVR

Neeraj Singh and Shubhadeep Roy

The advent of vegetable technologies and increasing awareness about nutritional security among the masses have provided impetus to vegetable production. The credit for this vertical expansion in vegetables goes to production and protection technologies developed by various research organizations, extension efforts for dissemination of those developed technologies and farmers for adopting the recommended technologies. As the results during the past one decade, our country has achieved an average annual growth rate (AAGR) of 4.5% and 6.1% in vegetable area and production, respectively which is much more than any other agriculture crops. ICAR-IIVR has developed number of improved vegetable varieties which is popular among the growers in different states. It has been observed that during the last two years 83.25% breeder seeds and 87.75% truthful label (TL) seeds of different vegetable crops have been lifted by various farmers and government agencies in two states *i.e.*, Bihar and Uttar Pradesh (Table 35) which showed its popularity in the states, however seeds marketed by private seed sectors and unorganized producers are also reaching to the growers in other states.

Further, U.P. and Bihar are the major producer of pea and okra where 90.7 thousand ha (21% of national area) and 70.4 thousand ha (13.2% of national area) area are under respective crops. During the last two years 8.6% and 69.8% of total breeder seeds in pea produced by the institute were provided to Bihar and U.P., apart 26.2% and 67.2% respectively truthful label pea seeds. Similarly, 65.9% breeder seeds and 21.7% TL seeds of okra were provided to Bihar while 25.8% breeder and 61.5% TL seeds of okra were provided to U.P. (Table 35).

During 2014-15 study was conducted for okra variety Kashi Pragati and pea varieties Kashi Nandini, Kashi Udai and Kashi Mukti that were widely adopted by growers in Bihar and U.P. The results revealed that Kashi Pragati in okra though cover less area in Bihar & U.P. (21% & 19.27%, respectively) but percent share in production is more *i.e.*, 23.34% in Bihar & 23.68% in U.P. with an average productivity of 15.1 t/ha and 15.6 t/ha respectively in compare to state productivity of merely 13.5 t/ha, in Bihar and 12.2 t/ha in U.P. Similarly, in pea area under institute's varieties were 10.8% in Bihar & 6.46% in U.P. with production share of 19.66 & 7.40%, respectively (Table 36). During the last one decade our country has achieved an average

Table 35: Vegetable seeds supplied to Bihar and Uttar Pradesh

Year	Breeder Seeds Supplied from ICAR-IIVR				TL Seeds Supplied from ICAR-IIVR			
	Total Seeds (kg)	Bihar (%)	U.P. (%)	Other (%)	Total Seeds (kg)	Bihar (%)	U.P. (%)	Other (%)
2012-13	1691.3	16.7	76.9	6.4	9344.3	19.4	67.1	13.5
Pea	1566.3	10.6	72.8	16.6	7551.1	23.3	71.0	5.7
Okra	204	71.1	28.4	0.5	554.8	19.7	63.2	17.1
2013-14	2256.6	14.6	58.3	27.1	5916.3	27.7	61.3	11.0
Pea	1797.5	6.5	66.8	26.7	5327.6	29.1	63.3	7.6
Okra	191.0	60.7	23.1	16.2	260.2	23.6	59.8	16.6

Table 36: Status of okra and pea in Bihar and Uttar Pradesh

Crop (State)	Total Cropped Area ('000 Ha)	% Share in Area under IIVR Varieties	Total Production ('000 MT)	% Production Share of IIVR Varieties	Average State Productivity (MT/Ha)	Average Productivity of IIVR Varieties (MT/Ha)
Okra (Bihar)	58.08	21.0	783.54	23.51	13.5	15.1
Okra (U.P.)	12.19	19.27	148.64	23.65	12.2	15.6
Pea (Bihar)	10.16	10.8	67.15	18.63	6.6	11.4
Pea (U.P.)	171.17	6.46	1782.63	7.57	10.4	12.2

annual growth rate (AAGR) of 4.3% and 4.2% in area under pea and okra, respectively whereas in case of production average annual growth rate (AAGR) is 7.3% and 5.7%, respectively.

State agriculture officials played a mojor role in dissemination of recommended technologies to ultimate users. Keeping this in view a study with sample size of 40 such officials were conducted to observe their perceived condition of work (PCOW). The results revealed that majority (61.1%) of agricultural officials perceived their condition of work (influence, amenities, nature of job & supervisory behavior) as so so (Table 37 & 38) *i.e.*, neither good nor bad which means to improve the working environment in state departments for extracting the effective potential of their official which ultimately help in quicker dissemination of improved agricultural technologies to ultimate users. Further, analyzing the data of PCOW it was observed that majority of agricultural officials perceived average level of their working environment *i.e.*, perceived influence (66.7% respondent), amenities (61.1% respondent), nature of job (50.1% respondent) and supervisory behavior (66.7% respondent).

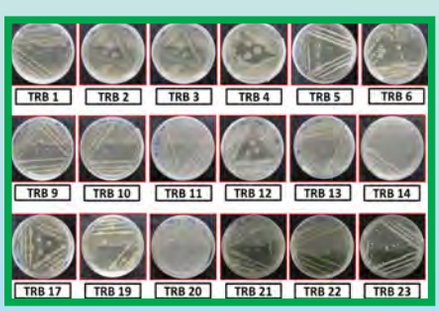
Table 37: Perceived condition of work obtained by State Agricultural Officials (N=40)

Perceived Condition of Work Score	Frequency in %
24-43	0.0
44-63	27.8
64-83	61.1
84-103	11.1
104-120	0.0
Range	45-88
Mean	68.4

Table 38: Dimensions of Perceived condition of work obtained by State Agricultural Officials (N=40)

Score	Perceived Influence	Perceived Amenities	Perceived Nature of Job	Perceived Supervisory Behavior
06-10	5.6	0.0	0.0	5.6
11-15	22.1	**61.1**	22.1	16.7
16-20	**66.7**	38.9	**50.1**	**44.4**
21-25	5.6	0.0	16.7	33.3
26-30	0.0	0.0	11.1	0.0
Range	8-21	11-20	13-27	9-25
Mean	16.4	14.7	18.7	18.6

Division of Vegetable Protection



MEGA PROGRAMME 6: INTEGRATED PLANT HEALTH MANAGEMENT

Programme Leader: Dr AB Rai

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

AB Rai, MH Kodandaram, Jaydeep Halder and Neeraj Singh

Evaluation of IPM modules for the management of pod borer in cowpea: Different pest management modules viz., biointensive, integrated and chemical modules were evaluated against pod borer, *Maruca vitrata* in cowpea (cv Kashi Kanchan) during kharif season. Among these, integrated module comprising spray of rynaxpyre 18.5 SC @0.5 ml/l followed by azadirachtin 0.15% @ 5ml/l, emamectin benzoate 5 SG 0.5 gm/l and *Bt* @1ml/l at 10 days interval during flowering and fruiting recorded 85.71% reduction in fruit damage by *M. vitrata* with higher yield (118.62 q/ha) in cowpea (Table 39).

Table 39: Effect of different pest management modules against pod borer in cow pea

Treatment	Per cent pod borer damage						PPOC*	Yield (q/ha)
	1	2	3	4	5	Avg		
Biointensive (T1)	32.66	30.39	25.49	22.18	20.22	26.19	26.72	102.22
Integreated (T2)	2.32	1.35	11.11	4.93	5.75	5.09	85.75	118.62
Chemical (T3)	20.01	19.84	21.56	20.47	18.50	20.07	43.83	102.06
Control (T4)	40.00	44.54	21.34	35.29	37.50	35.74	-	83.11
SEm (±)	2.28	2.42	0.84	2.29	2.18	-	-	
CD 5 %	6.92	7.35	2.56	6.96	6.63	-	-	

*PPOC- Per cent protection over control

Evaluation of IPM modules for the management of diamond back moth (DBM), *Plutella xylostella* in cabbage: Different pest management modules *viz.*, biointensive, integrated and chemical modules were evaluated against DBM in cabbage (cv Aneesa-27). Among these, integrated module comprising spray of azadhiractin 0.3% @ 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 68.17% reduction in DBM and recorded 91.67% increase in yield as compared to untreated control (Table 40).

Table 40: Effect of different pest management modules against DBM, *Plutella xylostella* in cabbage

Treatments	No. of DBM larvae		Yield (q/ha)	
	Pooled mean	PPOC*	q/ha	PIOC#
Biointensive Module	16.37	34.75	128.37	54.05
Integrated Module	8.11	68.17	159.72	91.67
Chemical Module	9.12	64.20	128.97	54.77
Untreated Control	25.48	-	83.33	-
SEm (±)	0.12	-	1.41	-
CD(5%)	0.38	-	4.90	-

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

SUB PROJECT 6.2: Toxicological Investigations on the Novel Insecticide Molecules and Plant Origin Insecticides Against major Insect Pests of Vegetables

MH Kodandaram, AB Rai, Jaydeep Halder, Sujoy Saha and Y Bijen Kumar

Biotype diversity of whitefly, *Bemisia tabaci* and their bacterial endosymbioants occurring on vegetable host plants: Whitefly, *Bemisia tabaci* samples were collected from eight different vegetables at different locations of IIVR farm both in protected and open fields and six nearby villages during summer and kharif seasons. The total DNA of whitefly samples were extracted, amplified using Mt CoI gene primers, cloned and sequenced. Results revealed the presence of Asia I, Asia II-1 and Asia II 5 genetic groups of *B. tabaci* in Varanasi region. A new invasive genetic group "China 3" was first time recorded in the region. Based on percentage of occurrence of genetic groups, the results indicated Asia I (39.39%) and Asia II 5(33.33%) to be the most predominant genetic groups followed by China 3 (21.21%). The total DNA of whitefly samples was amplified using 16SrDNA primers for diversity of bacterial endosymbioants associated with whitefly. The sequence analysis showed the infection of *Wolbachia* (91.25%), *Rickettsia* (83.83%), *Arsenphonus* (83.16%) and *Cardinium* (71.33%). Among different genetic groups of whitefly, *Wolbachia* infection was highest in Asia I and China 3 with 92.30 and 100%, respectively, whereas *Arsenphonus* infection was maximum in Asia II 5 (90.90%). The new invasive genetic group "China 3" harboured highest percentage of *Wolbachia* (100%) infection followed by *Cardinium* and *Rickettsia* with 85.71% (Fig 53, 54, 55 & 56).

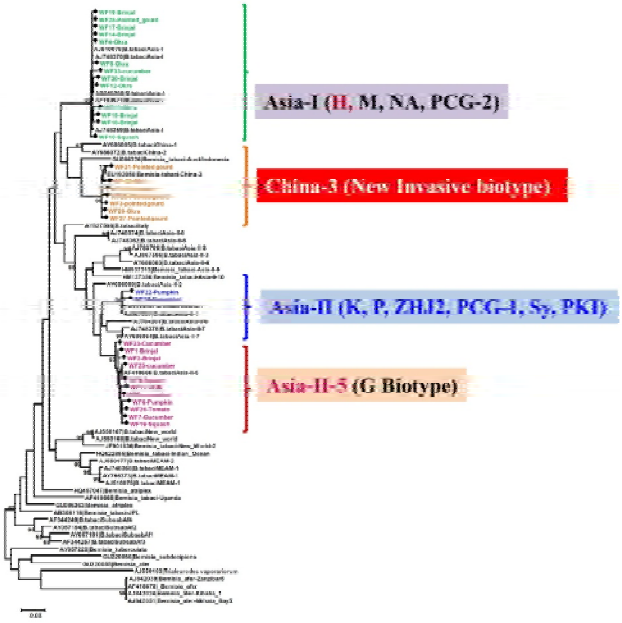


Fig. 53: Phylogenetic tree showing the relationship of the *B. tabaci* mtCO1 sequences of field collected *B. tabaci* population with mtCO1 sequences used by Boykin *et. al.*, 2007

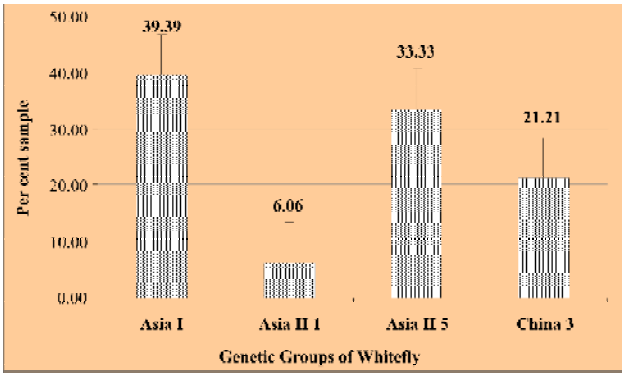


Fig. 54: Per cent diversity of whitefly genetic groups on vegetable hosts

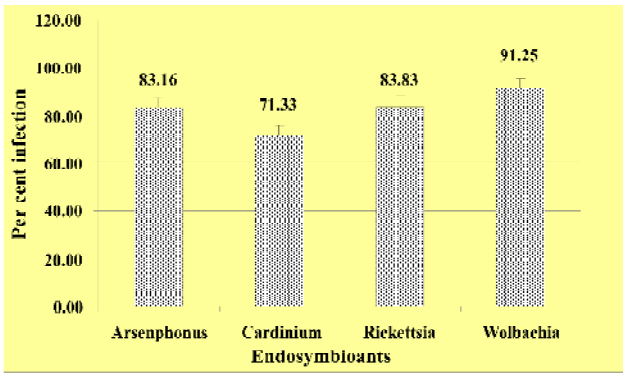


Fig. 55: Per cent infection of bacterial endosymbionats in field collected whiteflies

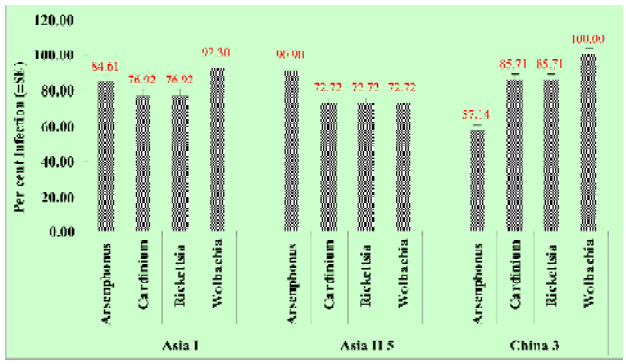


Fig. 56: Per cent infection frequencies of bacterial endosymbionats in different genetic groups of whitefly

Evaluation of different insecticide use strategies as resistance management and control tactics for shoot and fruit borer, *Leucinodes orbonalis* in brinjal: A field experiment was conducted to evaluate different insecticide use strategies as resistance management and control tactics for shoot and fruit borer during kharif season 2014 in brinjal (cv. Punjab Sadhabhar). Among different treatments, rotational strategey modules *viz.*, spray of rynaxpyre (0.4ml/l) followed

Table 41: Effect of IRM strategies on shoot and fruit damage by, *L. orbonalis*

Treatment Details	Per cent shoot damage	Per cent Protection Over		Per cent fruit damage (Number basis)*	Per cent Protection Over	
		Control	Check Treatment		Control	Check Treatment
SEQUENTIAL STRATEGY						
T1 – Rynaxpyr 0.4 ml/l	0.63	97.51	97.55	9.34	75.49	77.77
T2 – Emmamectin Benzoate 0.5 g/l	3.78	85.20	85.43	16.40	56.95	60.97
T3 – Spinosad 1.5 ml/l	2.22	91.29	91.43	13.58	64.36	67.69
T4 – Chlorpyriphos 2 ml/l	15.14	40.66	41.62	25.99	31.78	38.14
T5 – Cypermethrin 0.5 ml/l	25.94	-1.63	-	42.01	-10.28	-
ROTATIONAL STRATEGY						
T6 – IRM Module I (5 MOA)	**1.29**	**94.93**	**95.01**	**10.32**	**72.91**	**75.43**
T7 –IRM module II (2MOA)	**0.73**	**97.14**	**97.18**	**9.36**	**75.44**	**77.73**
MIXTURE STRATEGY						
T8 - Chloropyriphos + Cypermethrin 2 ml/l	29.21	-14.44	-12.61	26.71	29.89	36.42
T9 –Untreated Control	25.52	-	1.61	38.10	-	9.32
SEm(±)	5.76			5.75		
CD	17.27			17.13		
CV	12.60			7.54		

by emamectin benzoate (0.4 g/l), spinosad (1.5 ml/l), chloropyriphos (2 ml/l) and cypermethrin (0.5 ml/l) and rynaxpyre (0.4 ml/l) followed by emamectin benzoate (0.4 g/l) proved to be most effective against *L. orbonalis* with 94.92% and 97.14% protection of shoot damage and 72.90 and 75.43% protection of fruit damage and 91.29 and 54.50% increase in yield, respectively as compared to untreated control (Table 41 & 42).

Table 42: Effect of different IRM strategies on marketable fruit yield

Treatment Details	Yield (q/ha)	Per cent Increase in Over Control	Per cent avoidable yield loss
SEQUENTIAL STRATEGY			
T1 - Rynaxpyr 0.4ml/l	220.00	28.76	**22.34**
T2 - Emmamectin Benzoate 0.5g/l	237.94	39.26	**28.19**
T3 - Spinosad 1.5ml/l	296.67	73.63	**42.41**
T4 - chlorpyrephos 2ml/l	248.25	45.30	**31.18**
T5 - Cypermethrin 0.5ml/l	167.78	-1.80	**-1.84**
ROTATIONAL STRATEGY			
T6 - IRM Module I (5 MOA)	326.83	91.29	**47.72**
T7 -IRM module II (2MOA)	263.97	54.50	**35.27**
MIXTURE STRATEGY			
T8 - Chloropyriphos + Cypermethrin (mixture) 2 ml/l	193.02	12.97	**11.48**
T9 - Control	170.86	-	
SEm (±)	0.833		
CD	2.496		
CV	9.671		

Optimization and standardization of flonicamid 50WG for the management of sucking insect pests of okra: A field experiment was conducted to optimize and standardize the doses of new insecticide molecule flonicamid 50 WG against sucking insect pests of okra (cv. Kashi Pragathi) during kharif season 2014. Flonicamid @ 50-75 g a.i/ha was found to be most effective against leafhopper and whitefly with 98.53 and 81.87% reduction, respectively as compared to untreated control (Table 43).

Evaluation of newer alternatives to neonicotinoid insecticides against major sucking insect pests of vegetables: New insecticide molecules *viz.*, cyantraniliprole 10 OD, sulfoxaflor 24 SC and flupyridifurone 200 SL having novel mode of action were evaluated against sucking insect pests of okra (cv. Kashi Pragathi) during 2014. Sulfoxaflor 24 SC @ 90 g a.i/ha and flupridifurone 200 SL @ 250 g a.i/ha were most effective giving 87.40 and 88.19 % reduction in leafhopper population. Whereas, cyzapyr 10 OD @ 75 g a.i/ha was found to be most effective against whitefly (97.81% reduction) as compared to untreated control (Table 44).

Baseline toxicity of cyantraniliprole 10 OD against five aphid species infesting vegetable crops: Cyantraniliprole 10 OD was highly toxic to *Myzus persicae* followed by *Aphis gossyipi, Aphis craccivora, Liphaphis eryisimi* and *Brevicornye brassicae* with LC_{50} values of 0.0561, 0.0593, 0.0757, 0.0940 and 0.2160 ppm, respectively when tested by direct spray method. In case of lead dip bioassay method, it was more toxic to *Brevicornye brassicae* followed by *Aphis carccivora, Myzus persicae, Aphis gossyipi* and *Liphaphis eryisimi* with LC_{50} values of 0.0322, 0.0455, 0.1831, 0.2060 and 0.4100 ppm, respectively. Based on LC_{50} values, cyantraniliprole 10 OD was 79.14, 64.34 and 30.74 times more toxic to *Myzus persicae, Liphaphis eryisimi* and *Aphis gossyipi* respectively as compared to imidacloprid 17.8 SL, (Table 45 & Fig. 57).

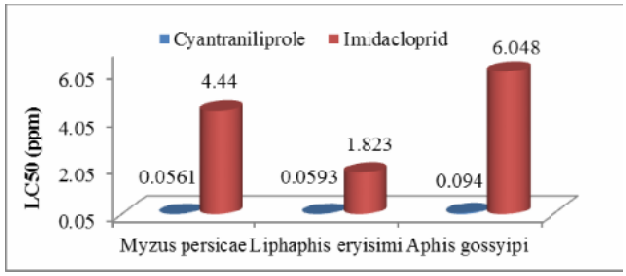


Fig. 57: Comparative toxicity of cyantraniliprole with imidacloprid to aphids species

Table 43: Bio efficacy of flonicamid 50 WG against leafhopper and whitefly of okra

Treatment	Dose (g/l)	Avg. number of leafhoppers* (3 leaves/plant)			Avg. number of whitefly* (3 leaves/plant)		
		Before Spray	Avg.	PPOC	Before Spray	Avg.	PPOC
Flonicamid	0.2	12.33	1.11	97.90	5.00	1.29	81.86
Flonicamid	0.3	10.67	0.78	98.53	5.00	1.42	80.00
Flonicamid	0.4	13.00	1.04	98.03	4.33	1.67	76.54
Imidacloprid	0.35	11.67	12.67	76.11	4.00	2.75	61.27
Thiomethoxam	0.35	12.33	15.38	71.00	5.33	5.78	18.76
Dimethoate	2 ml/l	11.67	18.49	65.13	4.33	5.58	21.55
Control	-	13.00	53.02		5.00	7.11	
SEm (±)			0.18			0.142	
CD			0.556			0.44	
CV			9.714			12.606	

*Pooled data of three sprays

Table 44: Field efficacy of newer molecules against leafhopper and whitefly in okra

Treatment		Avg. No Leafhoppers* (3 leaves/plant)			Avg. No whitefly* (3 leaves/plant)		
	Dose (g a.i/ha	Before Spray	Avg.	PPOC	Before Spray	Avg.	PPOC
Cyantraniliprole 10 OD	75	56.33	62.29	46.00	15.67	0.53	97.81
Cyantraniliprole 10 OD	90	56.67	65.22	43.46	13.33	0.76	96.99
Sulfoxaflor 24 SC	75	53.00	22.00	80.93	19.67	14.73	39.45
Sulfoxaflor 24 SC	90	44.67	14.53	87.40	14.67	16.02	34.15
Flupyrodifuron 200 SL	250	45.67	13.62	88.19	15.67	14.87	38.90
Imidacloprid 17.8 SL	25	48.67	32.76	71.60	12.00	15.33	36.98
Thiamethoxam 25 WG	25	47.00	39.80	65.50	17.00	9.16	62.37
Control		53.00	115.36		16.33	24.33	
SEm		0.34	0.38		0.28	0.12	
CD		1.04	1.10		0.66	0.35	

*Pooled data of three sprays

Table 45: Dose mortality response of different aphid species to cyantraniliprole 10 OD

Aphid species	Direct Spray			Leaf Dip Method		
	$\chi 2$ (df)	Régression Equation (Y = a + bx)	LC_{50} (ppm)	$\chi 2$ (df)	Régression Equation (Y = a + bx)	LC_{50} (ppm)
Brinjal aphid (*Aphis gossyipi*)	4.88 (6)	9.79+0.918x	0.0593	5.54 (4)	10.24+1.119x	0.2060
Radish aphid (*Brevicornye brassicae*)	3.97 (5)	9.16+0.892x	0.2160	5.18 (5)	10.19+0.945x	0.0322
Cabbage aphid (*Myzus persicae*)	2.81 (4)	10.14+0.980x	0.0561	3.66 (4)	9.86+1.027x	0.1831
Cowpea black aphid (*Aphis carccivora*)	1.88 (4)	8.62+0.707x	0.0757	1.14 (5)	9.55+ 0.853x	0.0455
Mustrad Aphid (*Liphaphis eryisimi*)	5.13 (4)	12.37+1.47x	0.0940	2.86 (4)	9.67+1.066x	0.4100

Fig. 62: Comparative toxicity of cyantraniliprole with imidacloprid to aphids species

Effectiveness of new anthranilic diamide insecticide cyantraniliprole (cyazypyr) 10% OD against major insect pests of cruciferous vegetables: Effectiveness of cyantraniliprole 10% OD was evaluated in comparison to commonly used insecticides against DBM, *Plutella xyllostela* and sucking pests of crucifers by leaf dip bioassay method. The three doses of cyantraniliprole @ 60, 70, 90 g a.i./ha were most effective and similar to the effectiveness of other novel insecticide emamectin benzoate with 100% mortality against third instar larvae of *P. xyllostela* at 48 hours after treatment (Fig. 58). Spinosad was next best treatment with 82.67% mortality. In case of different species of aphids, cyantraniliprole @ 60 g a.i./ha

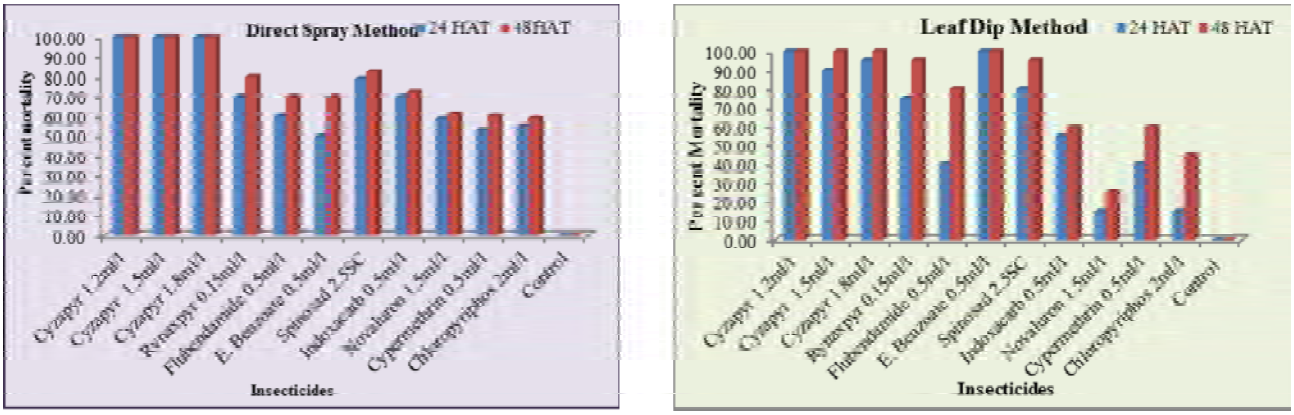
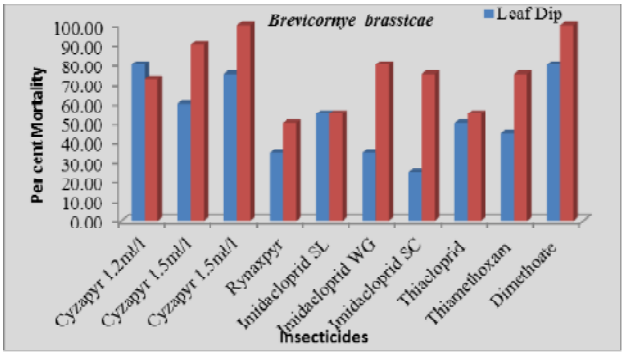
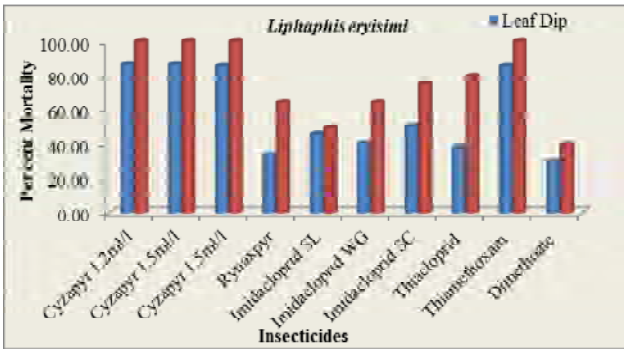


Fig. 58: Efficacy of cyazypyr and other novel molecules against *P. xyllostela*





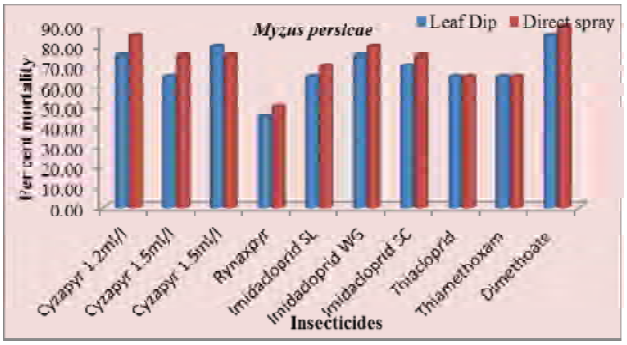
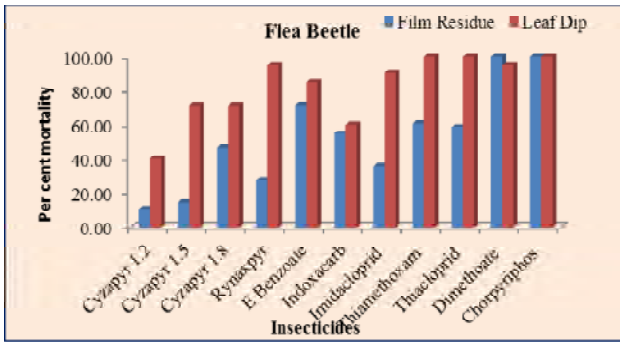


Fig. 59: Efficacy of cyazypyr and novel molecules against different aphids infesting cruciferous vegetables



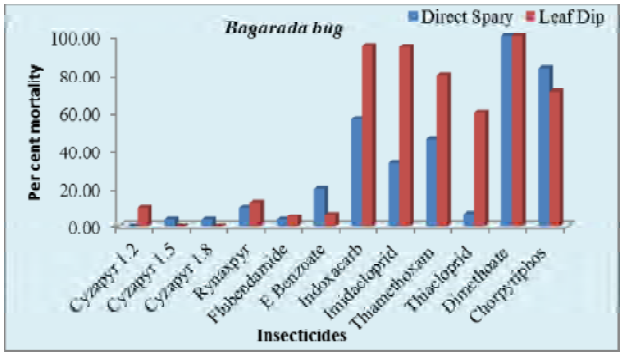


Fig. 60: Efficacy of cyazypyr and novel molecules against flea beetle and bagarda bug

resulted highest per cent mortality of 80, 86 and 75 against *B. brassicae, L. erysimi* and *M. persicae*, respectively (Fig. 59). Flea beetle was less susceptible to cyantraniliprole as compared to other commonly used insecticides, however maximum mortality of 71.25% was in the highest does of cyantraniliprole @ 90 g a.i./ha. Whereas, cyantraniliprole was ineffective against painted bug at all the three doses (Fig. 60). Cyantraniliprole 10 OD @ 60 g a.i./ha proved to be highly effective against *P. xyllostella* and all aphid species infesting crucifers can be taken advantage in strengthening integrated pest management (IPM).

SUB PROJECT 6.3: Biological Control of major Insect Pests of Vegetable Crops

Jaydeep Halder, AB Rai, MH Kodandaram, Sujoy Saha and M Manjunath

Several promising parasitoids *viz.*, *Trathala flavor orbitalis* from *Leucinodes orbonalis* infesting brinjal, *Aenasius arizonensis* from invasive mealy bug, *Phenacoccus solenopsis* infesting brinjal, tomato, okra, pointed gourd, chillies, and *Apanteles paludicole* from *Sphenerches caffer* infesting bottle gourd were recorded during the period.

Adult of *Trathala flavo orbitalis*

As regard to the periodical activities of major insect pests and their natural enemies, *Trathala flavo-orbitalis* (Ichneumonidae: Hymenoptera) was found to be an important larval endoparasitoid of brinjal shoot and fruit borer, *Leucinodes orbonalis*. Its incidence was noted from 33rd SMW (third week of August) onwards and continued till 8th SMW (last week of February). Highest parasitization (17.25%) was recorded during 42nd SMW (third week of October) whereas during second fortnight of December to first week of January its activity reduced (Fig. 61) due to severe winter in North India. Like other endoparasitoids, it also pupates outside the host insect with whitish silken cocoon and

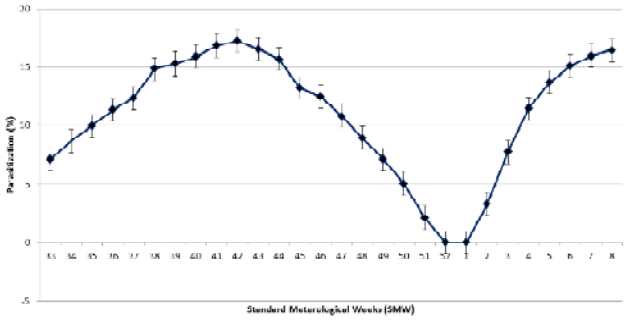


Fig. 61: Seasonal incidence of *Trathala flavor orbitalis*, an endoparasitoid of *Leucinodes orbonalis*

pupal periods lasted for about 4-7 days depending upon the environmental conditions.

Another promising solitary endoparasitoid *Aenasius arizonensis* (Girault) (=*Aenasius bambawalei* Hayat) (Encyrtidae: Hymenoptera) recorded from invasive solenopsis mealy bug, *Phenacoccus solenopsis* (Tinsley) infesting major vegetables like tomato, brinjal, *Capsicum*, cucurbits, okra, etc. Host mediated interaction was observed during the recovery of the parasitoid from different hosts and highest recovery was obtained from tomato (28.23%) followed by okra (26.5%) whereas the lowest recovery (10.89%) was in case of cucurbits.

Efficacy of different biopesticides alone & their combination with neem oil (1:1) against hadda beetle, *Epilachna dodecastigmata*

Hadda beetle (*Epilachna dodecastigmata*) now a days is becoming a serious threat in crops like cow pea, brinjal etc. More over its incidence was also observed in so called non-host crop like bitter gourds in many parts of Uttar Pradesh, Bihar and West Bengal. Recently, its severe incidence was observed on cowpea. To control this polyphagous pest, different microbial insecticides *viz., Beauveria bassiana, Metarhizium anisopliae, Lecanicillium* (=*Verticillium*) *lecanii, Pseudomonas fluorescens, Bacillus thuringiensis, Bacillus subtilits*-2 alone and their 1:1 combination with Neem oil (1%) were evaluated against third instar grubs of *E. dodecastigmata* infesting cowpea under laboratory conditions. Amongst the entomopathogens, *M. anisopliae* IIVR strain @ 5 g/lit, isolated from soils from organic plots of IIVR, had lowest median lethal time (LT_{50}) of 60.86 hour followed by of *L. lecanii* (65.95 hr). However, amongst the biopesticides, neem oil (1%) took only 45.09 hour to kill the 50 per cent test population. Combinations of these microbial with neem oil were also evaluated at 1:1 ratio. Lowest LT_{50} value (33.85 hour) was recorded when *M. anisopliae* IIVR strain + Neem oil (1:1) was sprayed followed by *M. anisopliae* commercial formulation + Neem oil (43.07 hr). Co-toxicity coefficient (CC) values clearly indicated that and all the EPF were compatible and synergistic with neem oil at this ratio (Table 46).

Efficacy of different biopesticides alone & their combination with neem oil (1:1) against *Spodoptera litura:* Studies were conducted to determine the most effective biopesticides against polyphagous *Spodoptera litura* infesting crops like tomato, cabbage, cauliflower, chilies, cowpea, etc. A series of biopesticides like *Beauveria bassiana* (both commercial formulation and native-IIVR strain), *Metarhizium anisopliae* (both commercial formulation and native-IIVR strain), *Lecanicillium* (=*Verticillium*) *lecanii, Bacillus thuringiensis, Bacillus subtilis*-2 (BS-2), Nuclear Polyhedrosis Virus (NPV) alone and their 1:1 combination with Neem oil (1%) were evaluated against third instar larvae of *S. litura.* Amongst the biopesticides, combination of NPV

Table 46: Toxicity of different entomopathogens alone and their combinations (1:1) with neem oil against *E. dodecastigmata*

Biopesticides	Heterogeneity		Regression equation (Y=)	LT_{50} (hr)	Fiducial limit	CTC*
	df	$\chi 2$				
Beauveria bassiana	6	1.811	2.611X – 0.362	113.19	124.75– 02.70	--
Metarhizium anisopliae	6	1.452	2.622X – 0.327	107.52	117.55– 98.35	--
Beauveria bassiana IIVR strain	5	0.574	2.901X – 0.547	81.68	88.17 – 75.67	--
Metarhizium anisopliae IIVR strain	6	1.047	2.733X – 0.123	60.86	69.38 – 53.39	--
Leanicillium lecanii	4	0.228	2.311X + 0.797	65.95	75.68 – 57.47	--
Bacillus subtilis - 2	6	0.456	2.469X – 0.004	109.67	120.93– 99.45	--
Bacillus thuringiensis	6	1.997	1.901X+0.699	183.32	247.65–135.70	--
Neem oil	6	3.527	2.32X + 1.163	45.09	49.50 – 41.06	--
Beauveria bassiana + Neem oil (1:1)	6	6.099	2.507X+0.841	44.96	49.74 – 41.80	1.003
Metarhizium anisopliae + Neem oil (1:1)	6	4.248	2.516X+0.888	43.07	47.07 – 39.41	1.047
Beauveria bassiana IIVR strain + Neem oil (1:1)	6	7.800	2.267X + 1.268	44.31	48.78- 40.26	1.018
Metarhizium anisopliae IIVR strain + Neem oil (1:1)	5	1.004	1.786X + 2.269	33.85	41.04 – 27.92	1.332
Verticilium lecanii + Neem oil (1:1)	5	0.726	2.162X – 1.453	43.71	48.52 – 39.37	1.032
Bacillus subtilis – 2 + Neem oil (1:1)	3	1.181	2.795X – 0.311	79.39	98.12 – 64.23	0.568
Bacillus thuringiensis + Neem oil (1:1)	4	1.987	1.111X – 2.523	169.69	365.82– 78.71	0.266

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

and Neem oil (1%) (1:1 ratio) was found compatible and gave 68.75% mortality followed by *M. anisopliae* IIVR starin and Neem oil (62.5% mortality) after 5 DAT (Fig. 62).

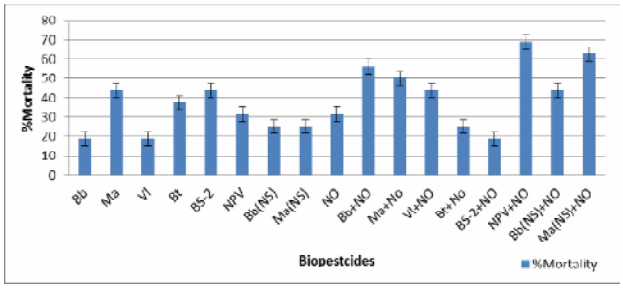


Fig. 62: Bioefficacy of biopesticides alone and their combination with neem oil (1:1) against *S. litura*

Compatibility and synergism of major neonicotinoids with different entomopathogenic fungi (EPF) against *Lipaphis erysimi* Kalt.: *Lipaphis erysimi* is an oligophagous sucking pest feeding on Cruciferous crops like cabbage, cauliflower, mustard, rapeseed etc. To control these pests, farmers are commonly using neonictinoids insecticides *viz.*, Imidacloprid, Thaimethoxam or biopesticides like different entomopathogenic fungi (EPF) like *Beauveria bassiana, Metarhizium anisopliae, Lecanicillium* (=*Verticillium*) *lecanii*. All these entomopathgens and neonicotinods at half of their recommended doses were found compatible and synergistic against *L. erysimi*. Combination of imidacloprid and *V. lecanii* took the lowest median lethal time (21.22 hour) and there by recording highest Co-toxicity coefficient (CTC) value (1.42). Similar observation was also noted in case of Thiamethoxam where *V. lecanii* when mixed with Thiamethoxam 25 WG at half of their recommended doses took the lowest median lethal time (11.39 hour) and with highest Co-toxicity coefficient (CTC) value (1.90) (Table 47 & 48).

Toxicity of different biopestcides against *Trichogramma chilonis* Ishida: Amongst the tested microbial insecticides *viz.*, *Beauveria bassiana* (both commercial formulation and native-IIVR strain), *Metarhizium anisopliae* (both commercial formulation and native-IIVR strain), *Verticillium lecanii, Bacillus thuringiensis*, *Spodoptera litura*, Nuclear Polyhedrosis Virus (SlNPV) at their recommended doses and neem

Table 49: Toxicity of major biopestcides against *T. chilonis*

Biopesticides	Emergence (%)
Beauveria bassiana	77.86
Metarhizium anisopliae	76.25
Beauveria bassiana IIVR strain	79.56
Metarhizium anisopliae IIVR strain	80.26
Verticillium lecanii	78.67
NPV *Sl*	79.24
Bacillus thuringiensis	79.64
Neem oil	71.08
Control	81.75

Table 47: Effect of different entomopathogens alone and their combination with Imidacloprid 17.8 SL (1:1)

Biopesticides	Heterogenity		Regression equation (Y=)	LT_{50} (hr)	Fiducial limit	CTC*
	df	$\chi 2$				
Beauveria bassiana (NS)	4	2.902	3.236X – 0.32	44.07	50.35 – 38.58	--
Metarhizium anisopliae (NS)	4	8.102	3.152X – 0.267	46.86	53.99 – 40.67	--
Verticillium lecanii	4	3.175	2.605X + 0.759	41.46	50.82 – 37.18	--
Imidacloprid 17.8 SL	4	3.673	4.059X – 1.004	30.15	33.90 – 26.82	--
Beauveria bassiana (NS) + Imidacloprid (1:1)	4	0.939	4.383X – 1.181	25.72	29.05 – 22.77	1.17
Metarhizium anisopliae (NS) + Imidacloprid (1:1)	3	5.012	4.147X – 0.899	26.45	29.96 – 23.36	1.14
Verticillium lecanii + Imidacloprid (1:1)	4	6.599	5.7X – 2.562	21.22	23.62 – 19.07	1.42

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

Table 48: Effect of different entomopathogens alone and their combination with Thiamethoxam 25% WG (1:1)

Biopesticides	Heterogenity		Regression equation (Y=)	LT_{50} (hr)	Fiducial limit	CTC*
	df	$\chi 2$				
Beauveria bassiana (NS)	4	2.902	3.236X – 0.32	44.07	50.35 – 38.58	--
Metarhizium anisopliae (NS)	4	8.102	3.152X – 0.267	46.86	53.99 – 40.67	--
Verticillium lecanii	4	3.175	2.605X + 0.759	41.46	50.82 – 37.18	--
Thiamethoxam 25% WG	4	2.306	3.884X – 0.185	21.63	25.27 – 18.52	--
Beauveria bassiana (NS) + Thiamethoxam (1:1)	4	3.084	3.241X + 1.109	15.86	20.58 – 12.22	1.36
Metarhizium anisopliae (NS) + Thiamethoxam (1:1)	3	1.435	3.345X+1.059	15.07	19.96 – 11.37	1.44
Verticillium lecanii + Thiamethoxam (1:1)	4	0.575	2.795X + 2.047	11.39	17.96 – 7.22	1.90

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

oil (1%) were tested against egg parasitoid, *Trichogramma chilonis*. All these microbial insecticides were found relatively safe to this parasitoid. However, neem oil was found comparatively toxic to *T. chilonis* (Table 49).

SUB PROJECT 6.4: Management of Important Fungal Diseases of Vegetable Crops

M Loganathan, S Saha, M Manjunath and C Sellaperumal

Effect of biocontrol agents and chemicals against soil borne pathogens (*Pythium aphanidermatum*, damping off and *Sclerotium rolfsii*, collar rot) of tomato under field condition: *Trichoderma* formulation (BATF 43-1) and PGPR endophytic bacteria (H86NV) and Sel 7 were evaluated against damping off (*Pythium aphanidermatum*) and collar rot (*Sclerotium rolfsii*) in tomato. Tomato seeds (cv. Kashi Amrit) were treated with the bioformulation @ 10 g/kg of seeds or Carbendazim @ 2g/kg. Root dipping with bioformulation (@ 10%) and soil drenching with chemical (Fosetyl Al /Copper hydroxide/ tebuconazole) @ 0.1% were also applied. Among the biformulations, BATF43-1 showed maximum damping off control (>60%) and in chemicals, carbendazim seed treatment followed by drenching with Fosetyl Al recorded (>80%) control of the disease (Fig. 63).

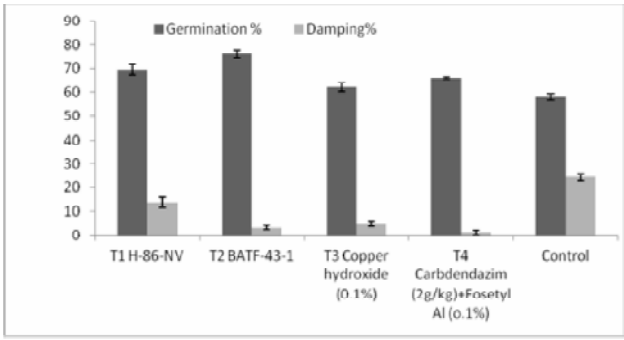


Fig. 63: Bioefficacy of biocontrol agents and chemicals against soil borne pathogens

However, in case germination, BATF 43-1 recorded as the best among all treatments. Incidence on collar rot was negligible but invariably in all the treatments a high incidence (30-50%) of late blight (*Phytophthora infestans*) was noticed (Table 50).

Effect of *In vitro* efficacy of Tebuconazole and Copper hydroxide at different concentrations on mycelial inhibition of *Sclerotium rolfsii* and *Pythium aphanidermatum*: The fungicides at various concentrations (0.025-0.1%) were tested against mycelial inhibition of *Sclerotium rolfsii* and *Pythium aphanidermatum*. Among them tebuconazole showed 100% inhibition of mycelial growth of *Sclerotium rolfsii* and *Pythium aphanidermatum* (Table 51). However it should be further confirmed by evaluation the chemicals under field conditions.

Table 51: *In vitro* efficacy of Tebuconazole and Copper hydroxide at different concentrations on mycelial inhibition of *Sclerotium rolfsii* and *Pythium aphanidermatum*

S. No	Treatment	Mycelial inhibition (%)	
		P. aphanidermatum	*S. rolfsii*
1.	Tebuconazole (0.1%)	100	100
2.	Tebuconazole (0.05%)	100	100
3	Tebuconazole (0.025%)	100	100
4	Copper hydroxide (0.1%)	100	100
5	Copper hydroxide (0.05%)	17.4	0
6	Copper hydroxide (0.025%)	0	0
7	Control	0	0

Differentials for identification of races in *Phytophthora infestans* : *S. lycopersicum* no R *S. lycopersicum*: Differential lines viz., *S. lycopersicum* TS 19 (no R gene); *S. lycopersicum* TS 33 (Ph-1); *S. lycopersicum* var. *cerasiforme* W. Va. 700 (Ph-2); *S. lycopersicum* CLN2037B (Ph-3); *S. pimpinellifolium* L03708 (Ph-3,4) and *S. habrochaites* LA1033 S3 (Ph-5) were imported form AVRDC Taiwan and seed multiplication of the same is in progress.

Table 50: Effect of endophytic PGPR on damping off and growth attributes of tomato under portray nursery conditions

S. No	Treatments	*Collar rot (%)	*Late blight (*Phytopthora infestans*) PDI (%)*
T1	H86NV seed treatment +sel 7 (root dip)	3.18 (2.09)	38.33 (38.23)
T2	BATF-43-1 (Seed treatment)+seedling dip	1.67 (1.15)	34.5825 (36.01)
T3	Copper hydroxide (0.1%) drenching in nursery + Tebuconazole (0.1%) seedling dip	0.00 (0.87)	30.415 (33.46)
T4	Carbendazim seed treatment + drenching with fosetyl AL(0.1%) after germination	1.67 (1.20)	34.63 (36.03)
T5	Control	3.33 (2.90)	51.94 (46.12)
	CD(0.05)	NS	2.809377
	CV	-	12.51424

SUB PROJECT 6.5: Bioprospecting of Microorganisms Associated with Vegetable against Plant Pathogens

Manjunath, M, M Loganathan and B Mahesha

Molecular based identification of the pathogen suppressing microbes selected from cucumber, bitter gourd and bottle gourd: The genomic DNA of selected pathogen suppressing microbes was isolated. The 16srRNA region was amplified using universal primers. The amplified product was purified and sequenced. The sequence data was analysed. On the basis of maximum similarity, the isolates were identified as *Stenotrophomonas maltophila*, *Serratia marsecens* and *Alcaligenes* sp. The phylogenetic trees of the microbes were generated (Fig. 64,65 & 66).

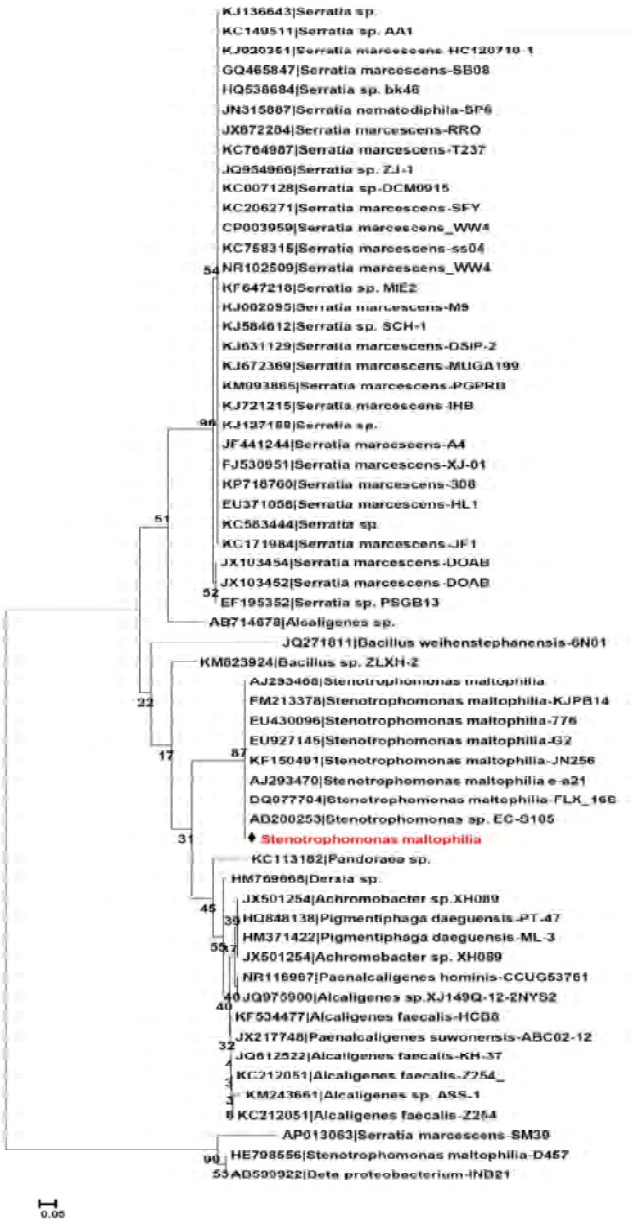


Fig. 64: Phylogenetic tree of *Stenotrophomonas maltophila*

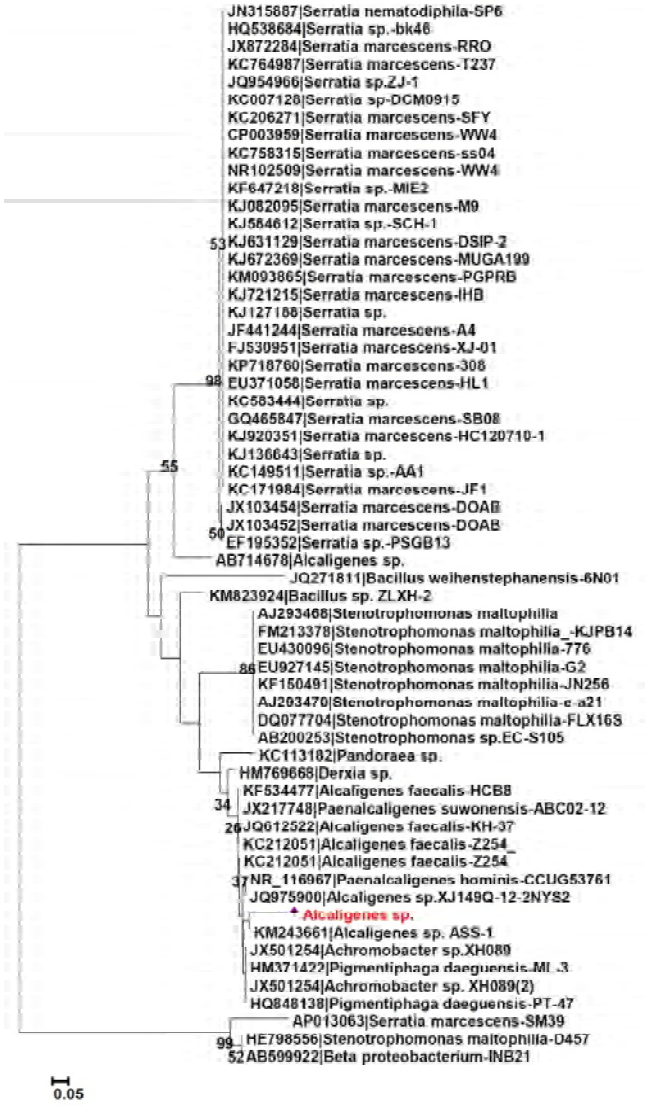


Fig. 65: Phylogenetic tree of *Serratia marsecens*

Development of suitable bioformulations: The talc based formulations of pathogen suppressing microbes were developed and further studied are in progress.

Study of Compatibity of *Isaria farinosa* with different pesticides: Compatibility of *Isaria farinosa* was anlysed with 10 different pesticides at the recommended dosage. The mycelia growh was observed in all the treatments. The data was recorded after 7 and 15 d after inoculation (Fig. 67 and Table 52). After 15 d maximum colony growth was observed in T5 (Spiromesifen), however there was no significant difference among the treatments except T10 (Dimethoate). Similar trend was observed in fresh and dry weight of mycelium, indicating *Isaria farinosa*'s compatibility with the tested pesticides.

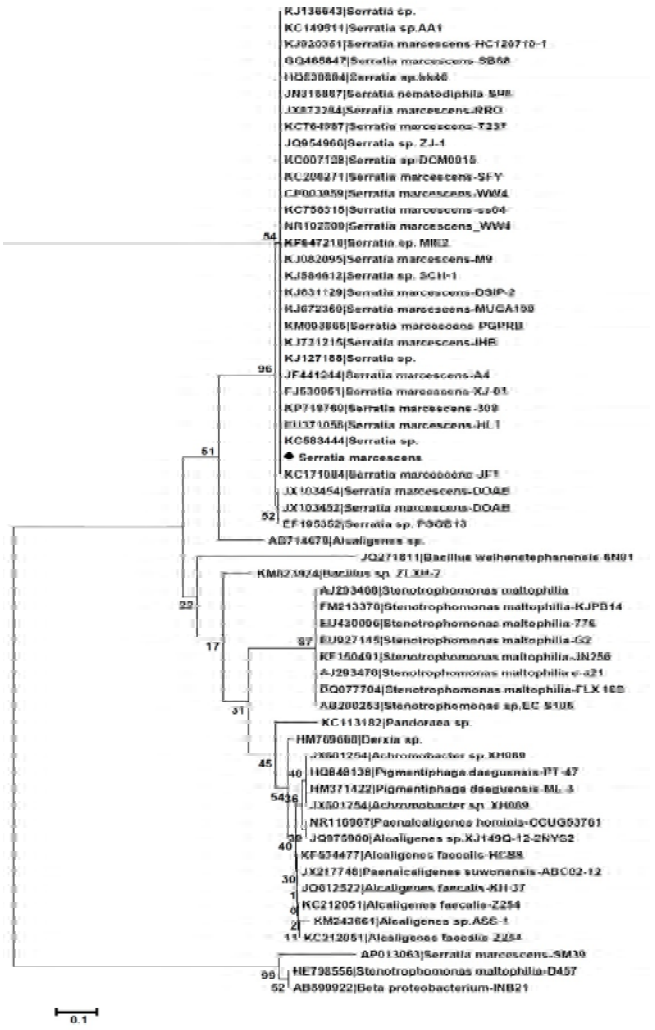


Fig. 66: Phylogenetic tree of *Alcaligenes* sp.

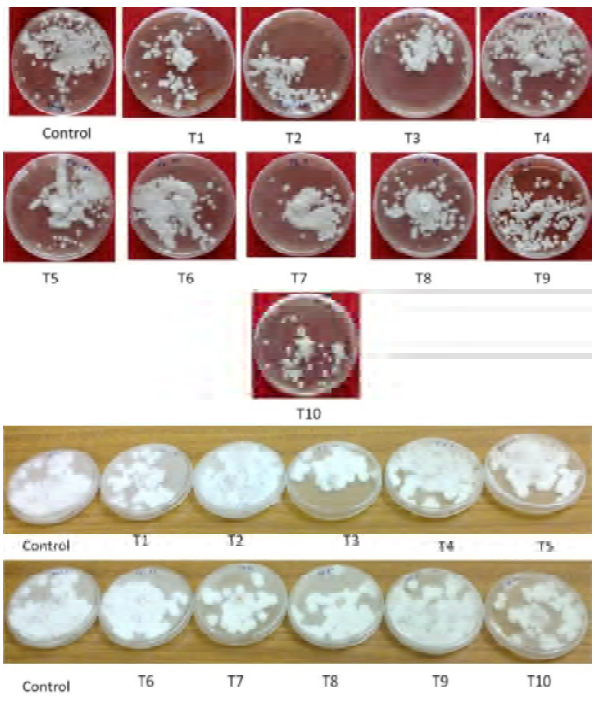


Fig. 67: Effect of different insecticides on the colony growth of *Isaria farinosa* after 15 days

Table 52: Effect of different insecticides on the colony growth, Fresh and dry weight of *Isaria farinosa*

	Treatments	Colony growth (Cm) after 7 days	Colony growth (Cm) after 15 days	Fresh weight (g)	Dry weight (g)
1	Cyzpyre 1.8ml/L	3.93	4.00	7.83	1.80
2	Flopyridifuron 2.5ml/L	4.00	4.10	8.10	1.61
3	Sulfoxaflour 0.75 ml/ L	3.90	4.10	6.72	1.42
4	Flonicamid 0 .33 g/L	3.96	4.03	8.08	1.51
5	Spiromesifen 1ml/L	4.00	4.16	8.60	2.12
6	Difenthiron 1.2ml/L	4.03	4.06	6.89	1.52
7	Imidacloprid 0.35ml/L	3.83	4.13	8.02	1.70
8	Thiomethoxam 0.35g/L	4.06	4.06	8.15	1.59
9	Acetamprid 0.2g/L	4.06	4.06	8.04	1.45
10	Dimethoate 2 g/L	3.53	3.50	4.75	1.24
11	Control	4.03	4.10	7.8	1.62
SEM		0.121	0.083	0.71	0.18
CD @ 5 %		0.381	0.261	2.26	0.58

Invitro screening of *Isaria farinosa* against fungal pathogens: Effectiveness of *Isaria farinosa* on inhibition of mycelial growth of 2 fungal pathogens viz. *Sclerotium rolfsii* isolate *Sr1* and *Sclerotinia* isolate *Sq3* was tested under invitro conditions (Table 53 and Fig. 68a and 68b).

Table 53: Effect of *Isaria farinosa* on fungal pathogens

Treatments	Mycelial inhibition (%) days after incubation		
	2 d	3 d	4 d
Sclerotium rolfsii isolate *Sr1*	27.76	28.29	38.79
Sclerotinia isolate *Sq3*	38.87	53.75	55.26
Control	0	0	0

Fig. 68a: Effect of *Isaria farinosa* on *Sclerotium rolfsii* isolate *Sr1*

Fig. 68b: Effect of *Isaria farinosa* on *Sclerotinia* isolate *Sq3*

***Invitro* screening of cultures received from NBAIM:** The microorganisms procured from NBAIM were screened for their antagonistic activity. The microorganisms viz. *Pseudomonas fluorescens*, *Bacillus subtilis*, *B. licheniformis* and *B. pumilus* were found to be inhibitory to the mycelia growth of *Sclerotium rolfsii*-1 to the extent of 78.33, 76.11, 45.55 and 18.88 % respectively after 5 days (Fig. 69).

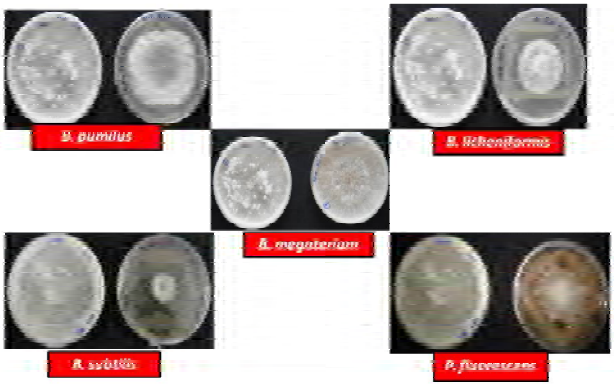


Fig. 69: *Invitro* screening of NBAIM cultures

Isolation and purification of fungi: The fungi were isolated and purified on PDA. On the basis of morphological appearance on petriplate, they were grouped as 10 different isolates (Fig. 70 and 71).

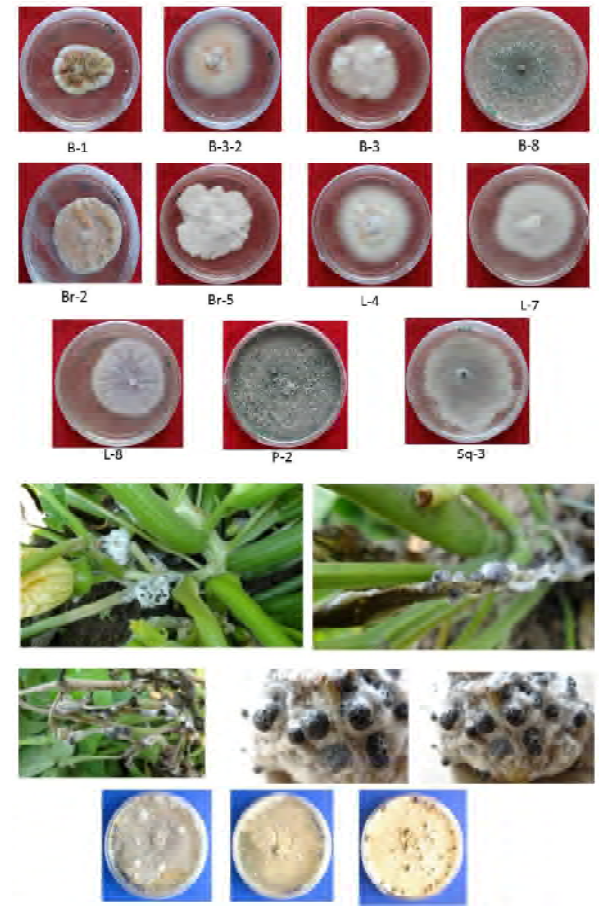


Fig. 70 and 71: Fungal isolates; Infection of Sclerotinia on squash and beans and its isolation

SUB PROJECT 6.6: Management of Important Bacterial Diseases of Vegetable Crops

S Saha, M Loganathan, M Manjunath and Y Bijen Kumar

Leaf spot of tomato (*Xanthomonas axonopodis* pv *vesicatoria*)

***Effect of different bactericides on the biochemical components of tomato infected with bacterial spot*:** Bacterial spot infected tomato plants when sprayed with different bactericides had a varied response regarding the biochemical component of plants as compared to control. Out of six treatments (Table 54) streptocycline @100 ppm gave the highest content of chlorophyll a, chlorophyll b, carotenoids, superoxide dismutase (SOD), proline, nitrate reductase and total protein component as compared to control (Table 55 & 56), 15 days after second application (DASA). This treatment was followed by Copper hydroxide @ 2 g/ litre of water. Increased biochemical components may be one of the reasons for the plants to endure the biotic stress and hence provide better control against the bacterial pathogen.

Black rot of cabbage (*Xanthomonas campestris* pv *campestris*)

***Role of adjuvants with bactericide in the control of black rot and soft rot of cabbage*:** Seven different adjuvants (Table 57) with differential chemical background were tank mixed with Streptocycline to see their effects in controlling black and soft rot of cabbage. There was no significant difference between the treatments although each of the treatment was better than untreated control. The best result in case of black rot was manifested by Streptocycline 100 ppm + APSA-80 @ 1mL/litre followed by Streptocycline 100ppm + Sandaril @ 1mL/ litre with a PDI of 10.21 and 10.37 respectively (Table 58). In case of soft rot the best control was given by Streptocycline @ 100 ppm

Integration of biological control agents (BCA) and SAR inducers against black rot of cabbage: Two sprays at 10 days interval after the initiation of the disease was given using bio control agents *Pseudomonas fluorescens* and *Bacillus subtilis* individually and in combination with chemicals which induce systemic acquired resistance *i.e.*, salicylic acid and acibenzolar-s-methyl (Table 59) Combining BCA and SAR inducers the best result was obtained when *Pseudomonas fluorescens* and *Bacillus subtilis* were applied along with ASM. Out of these two, the combination with BS was superior than *Pf.* (Table 60).

Table 54: Effect of different bactericides on the biochemical components of tomato infected with bacterial spot

T1	Azoxystrobin @ 1 ml/litre
T2	Copper oxychloride @ 2.5 g/litre
T3	Copper hydroxide @ 2.0 g/litre of water
T4	Streptocycline @ 100 ppm
T5	Mancozeb 75 WP @ 2.5 g/litre
T6	Mancozeb 35 SC @ 1.5 ml/litre
T7	Untreated control

Spray conditions: 1) DAFA- Days after first spraying, 2) DASA- Days after second spraying

Table 55: Content of chlorophyll a, b and carotenoids in tomato leaves after different days of spraying bactericides

Treatment	Chlorophyll a (mg/g fresh weight)		Chlorophyll b (mg/g fresh weight)		Carotenoid (mg/g fresh weight)	
	15 DAFA	15 DASA	15 DAFA	15 DASA	15 DAFA	15 DASA
T1	0.78	0.65	0.88	1.03	0.81	0.96
T2	1.36	1.69	1.80	1.58	1.50	1.51
T3	1.46	1.73	1.95	1.82	1.65	1.63
T4	1.51	1.85	2.17	2.84	1.79	1.85
T5	1.38	1.72	1.22	1.66	1.43	1.48
T6	1.25	1.54	1.17	1.49	1.34	1.42
T7	0.87	1.37	1.02	1.17	0.95	1.09
CD at 5%	0.10	0.16	0.10	0.08	0.18	0.04
SEd	0.046	0.078	0.0481	0.039	0.0841	0.0221
CV	21.37	24.73	33.47	18.53	25.14	18.14

Table 56: Activity of tomato leaves at different days after spraying

Treatment	SOD(IU)		Proline (mg/gm dry weight)		NR activity (nanomole NO_2 /gm dry wt. of leaf)		Protein (mg/g dry weight)	
	15 DAFA	15 DASA	15 DAFA	15 DASA	15 DAFA	15 DASA	15 DAFA	15 DASA
T1	1.071	1.278	0.24	0.17	1620.93	1333.50	170.94	510.03
T2	1.655	1.858	0.33	0.31	3473.50	2929.76	275.34	806.21
T3	1.725	1.875	0.34	0.36	3582.77	3618.62	304.72	818.04
T4	1.734	1.970	0.41	0.58	3917.23	3922.87	332.91	831.39
T5	1.545	1.662	0.24	0.19	3136.67	2287.50	249.14	791.03
T6	1.428	1.849	0.22	0.29	2361.98	2368.91	235.52	774.95
T7	1.124	1.525	0.20	0.18	2224.34	1977.67	213.97	649.51
CD at 5%	0.045	0.094	0.0009	0.007	9.170	12.116	8.417	10.247
SEd	0.021	0.0441	0.0004	0.003	4.27	5.64	3.924	4.777
CV	16.9	12.9	26.08	33.05	27.27	26.96	19.744	14.116

Table 57: Role of adjuvants with bactericides in the control of black rot and soft rot of cabbage

Treatment Details

T1	Streptocycline 100 ppm + Dhanuvit @ 1 ml/litre (Alkoxy fatty acid)
T2	Streptocycline 100 ppm + Wetcit @ 1 ml/litre (Non ionic)
T3	Streptocycline 100 ppm + Sandaril @ 1 ml/litre (Alkyl aryl polyglyco ether)
T4	Streptocycline 100 ppm + Indtron @ 1 ml/litre (Alkyl phenoxy poly ethoxy ethanol)
T5	Streptocycline 100 ppm + Filwet @ 1 ml/litre (Silicon based)
T6	Streptocycline 100 ppm + APSA-80 @ 1 ml/litre (Nonyl phenoxy ethoxyl ethanol)
T7	Streptocycline 100 ppm + Adsee AB 650 @ 1 ml/litre (Fatty amine polymer + sugar)
T8	Streptocycline 100 ppm
T9	Untreated control

Table 58: PDI for Black rot and soft rot of cabbage

Treatment	PDI (%)	
	Black rot	Soft rot
T1	10.39	12.9
T2	10.46	12.6
T3	10.37	12.5
T4	11.5	12.6
T5	10.88	12.7
T6	10.21	12.5
T7	10.92	12.1
T8	11.6	11.4
T9	21.64	38.3

Table 59: Integration of biological control agents and SAR inducers against black rot of cabbage

Treatment Details

T1	*Pseudomonas fluorescens* @ 5 g/litre of water
T2	*Bacillus subtilis* @ 10 g/litre of water
T3	T1 + SA @ 1 g/ litre of water
T4	T2 + SA @ 1 g/ litre of water
T5	T1 + ASM @ 0.5 g/litre of water
T6	T2 + ASM @ 0.5 g/litre of water
T7	SA @ 1 g/litre of water
T8	ASM (Acibenzolar S-methyl) @ 0.5 g/litre of water
T9	Streptocycline @ 100 ppm
T10	Untreated control

Table 60: PDI for Black rot of Cabbage

Treatment	PDI (%)
T1	9.68
T2	9.32
T3	6.71
T4	7.41
T5	5.61
T6	5.28
T7	11.92
T8	12.15
T9	4.21
T10	12.83
CD (0.05)	0.56
CV(0.05)	19.05

SUB PROJECT 6.7: Development of Diagnostic Kits for Major Viral Diseases of Vegetable Crops

V Venkataravanppa and B Mahesha

Squash leaf curl China virus requires the DNA B component of Tomato leaf curl New Delhi virus to cause yellow mosaic disease in Squash: Severe incidence of yellow mosaic disease was observed in squash planted in experimental farm of IIVR. The infected plant shows severe mosaic, puckering of the leaves, stunting of the plants, fruits become small, blistered and mottled with darker green areas (Fig. 72). The disease incidence was ranged from 95 to 100% and yield loss are greatest in during February to May, when the vector population at peak.

Fig. 72: Squash leaf curl China virus infected with Summer squash (Pepo)

Virus –vector relationship: The virus vector relationship of Squash leaf curl China virus was carried out with different number of whiteflies, AAP, IAP and Age of okra seedlings. The maximum transmission efficiency (100%) was achieved using 6 insects per plant, applying 24 hr of AAP and IAP in Squash leaf curl virus. Study on AAP and IAP indicates, the maximum transmission (100%) was achieved in 24 hr of AAP and IAP respectively. Further study on the age of squash seedling susceptibility, the young seedlings up to the age of two week seedling were found to be highly vulnerable to the virus. This indicated that as the age of the seedlings increased, their susceptibility to virus infection decreased accordingly.

Genome organization of Begomoviruses infecting pumpkin: The complete genome (DNA-A) of virus isolate infecting Squash was determined to be 2738nts with a typical genome organization of other old world monopartite begomoviruses comprising two open reading frames (ORFs) [AV1 (CP), AV2] in virion-sense strand and four ORFs [AC1 (Rep), AC2, AC3, AC4] in complementary-sense strand, separated by an intergenic region (IR) (Fig 73).

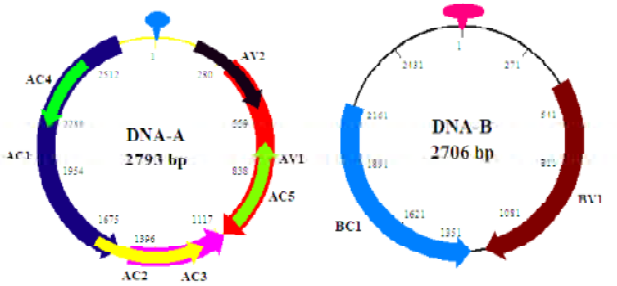


Fig. 73: Genome organization of DNA-A and DNA-B component of PYVMV. Arrow represents ORFs in both orientations. ORFS in sense strand are AV1 and AV2 and ORFs in complementary sense strand are AC1, AC2, AC3 AC4 and AC5 in DNA-A. the intergenic region (IR) harboring the stem loop structure is also shown , ORF sense strand BV1 and ORF and BC1 in complementary sense strand in DNA-B the intergenic region (IR) harboring the stem loop structure is also shown

Comparison DNA A like sequence of virus infecting Squash with other begomoviruses sequences revealed that, the isolate share highest nucleotide identity of 91.7% with *Squash leaf curl China virus* (SLCCNV) infecting Pumpkin in India and shares less than 87% with other sequences used in the analyses (Fig. 74).

Phylogenetic analysis: The phylogenetic tree derived from the complete nucleotide sequences of the DNA-A component of the SLCCNV infecting Squash and other selected begomoviruses indicates, the squash isolate are closely cluster with SLCCNV (AM286794), SLCCNV (EU573715) infecting pumpkin Indian subcontinent (Fig. 75).

Genomic organization and affinities of the DNAB components: The complete nucleotide sequence of DNA B like sequences of the virus isolate of squash was determined to be 2695 nts in length. The begomovirus showed typical genome organization similar to other bipartite begomoviruses having two ORFs, one on the virion strand and the other on the complementary strand with the capacity to encode proteins of predicted molecular mass of 30 kDa or more (Fig). Alignment of complete nucleotide sequences of DNAB like sequences with other begomovirus sequences revealed that the isolates share highest nucleotide sequence identity of 99.1% with DNB B of ToLCNDV-cucumber reported from Thailand (Fig. 76).

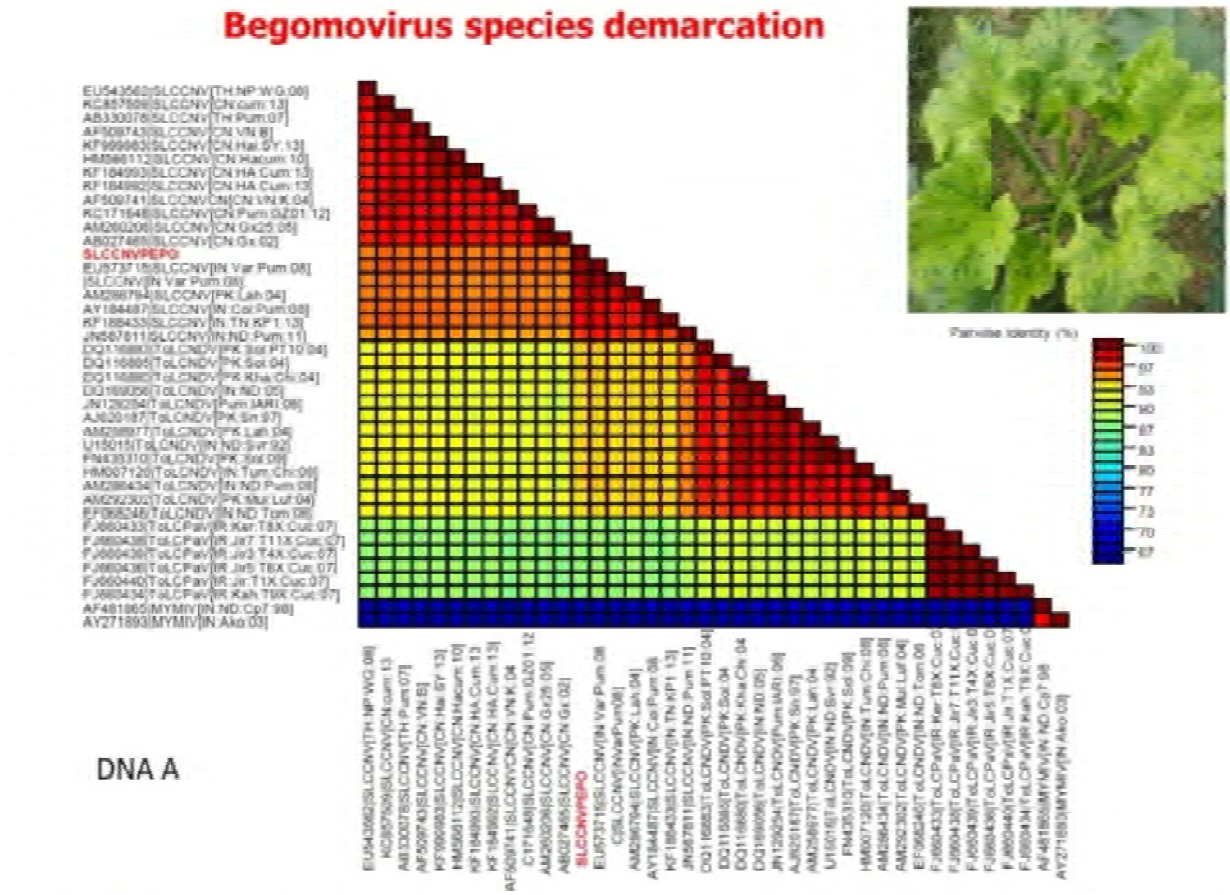


Fig. 74: Graphical representation of percentage pairwise genome scores and nucleotide identity plot of full genomes of SLCCNV and other begomoviruses

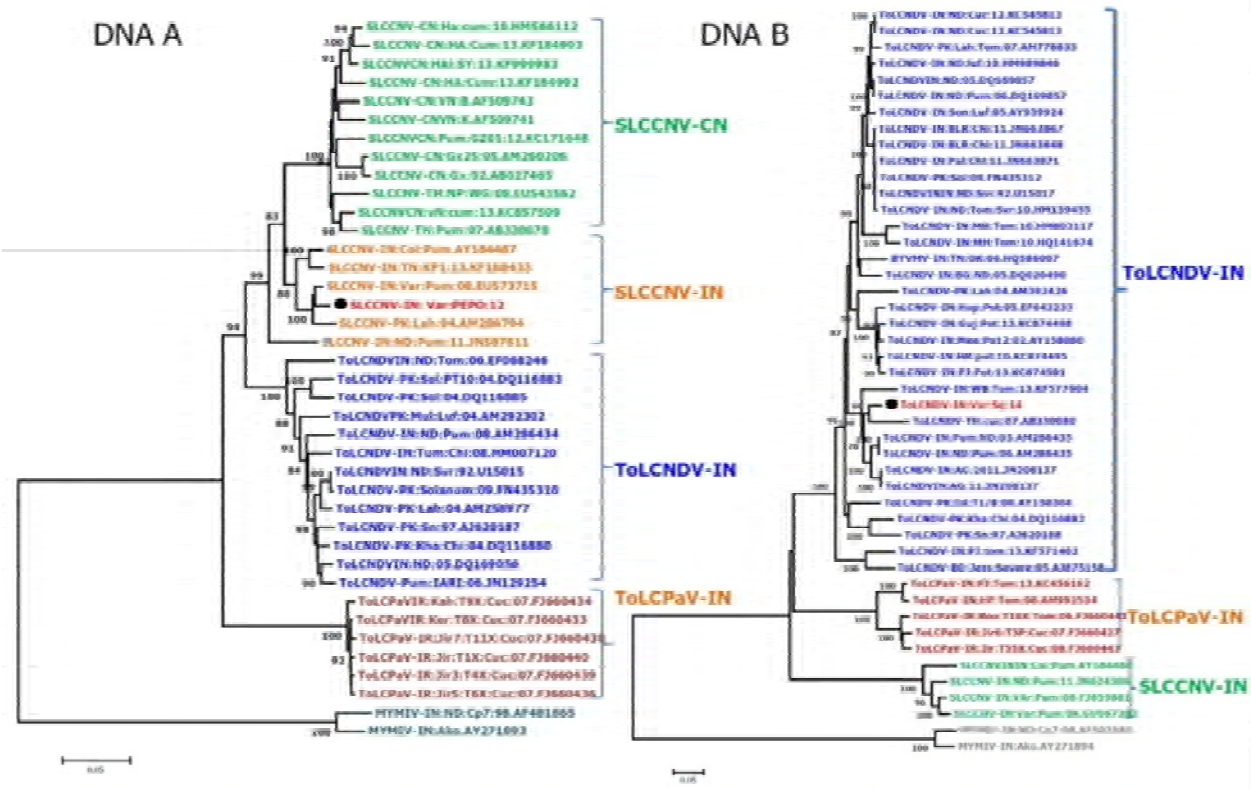


Fig. 75: Phylogenetic tree of complete nucleotide sequences of DNA-A and DNA-B of SLCCNV

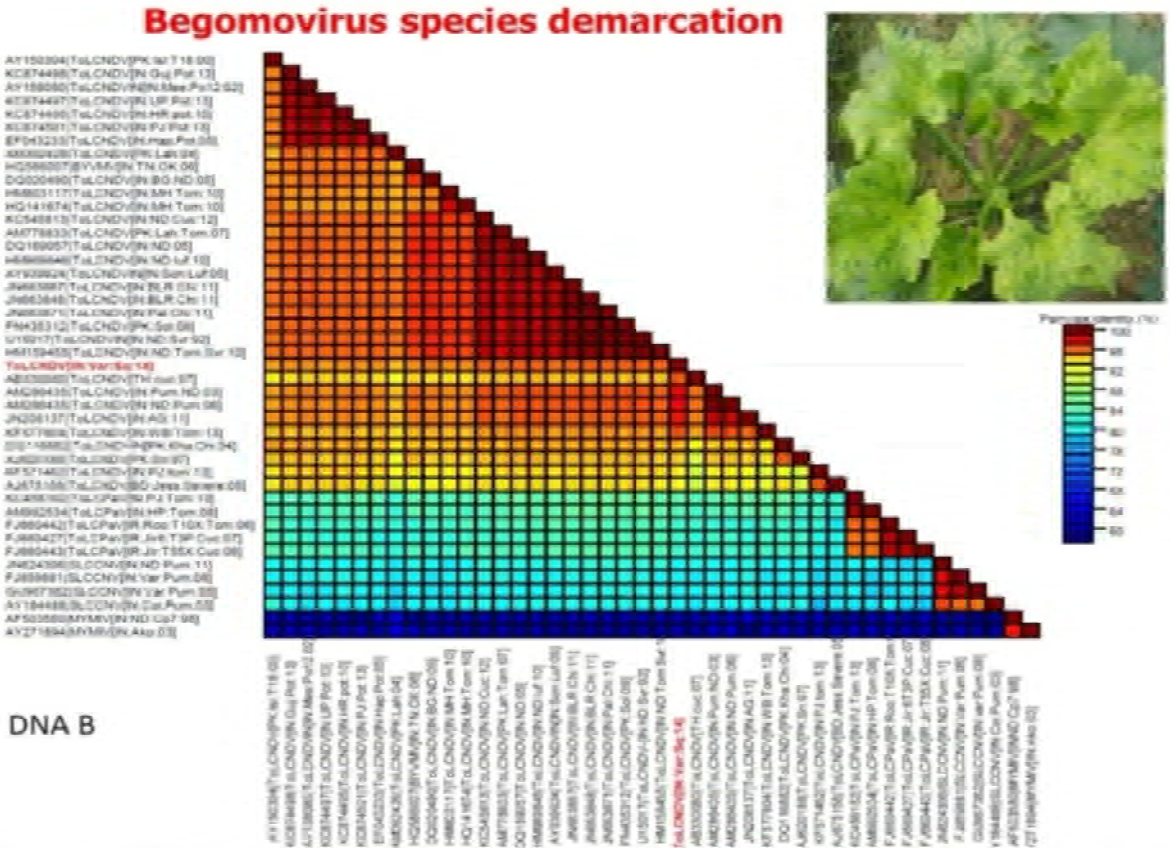


Fig. 76: Graphical representation of percentage pairwise genome scores and nucleotide identity plot of full genomes of SLCCNV and other begomoviruses

Phylogenetic analysis: The phylogenetic tree derived from the complete nucleotide sequences of the DNA-B component SLCCNV infecting Squash and other selected begomoviruses indicates, the squash isolate are closely cluster with ToLCNDV infecting cucumber in Thailand.

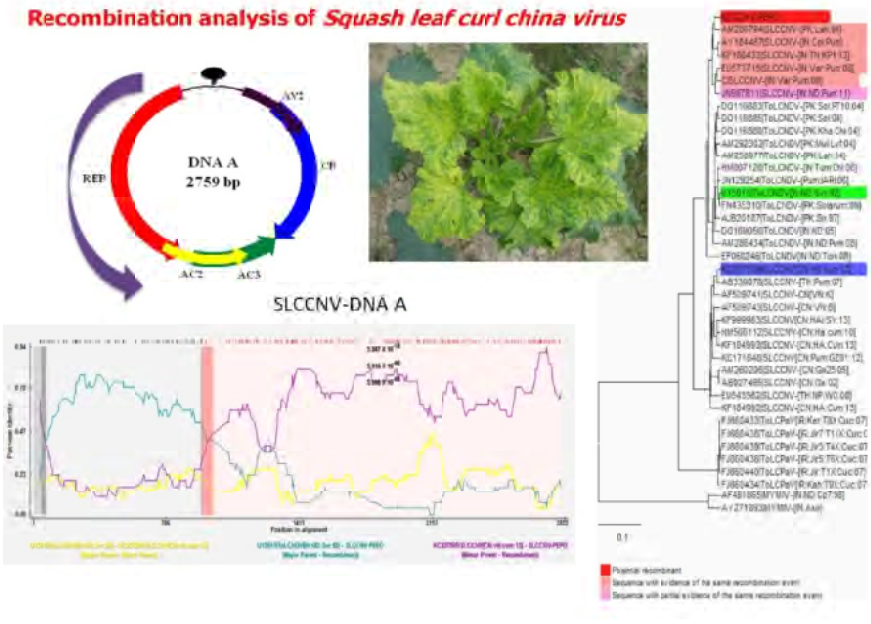


Fig. 77: Recombination analysis of DNA-A component of the begomovirus associated with yellow mosaic disease of Squash.

Recombination analysis of *Squash leaf curl China virus infecting Squash:* A comprehensive break point analysis for recombination using RDP3 based on the alignment of DNA A like sequence of SLCCNV-Squash isolate and other selected begomviruses from database was carried out. The analysis indicates the evidence of recombination in SLCCNV infecting Squash with most of the DNA fragments derived from TOLCNDV (U15015) and SLCCNV (KC857509) to emerge as a new strain of SLCCNV infecting Squash (Fig. 77). Further, RDP analysis of DNA B like sequence isolated from squash indicated the evidence of recombination in DNA B like sequence suggestive of the most part of DNA B descended from BYVMV (HQ586007) and ToLCNDV (JN663848) infecting okra and chilli in India (Fig. 78).

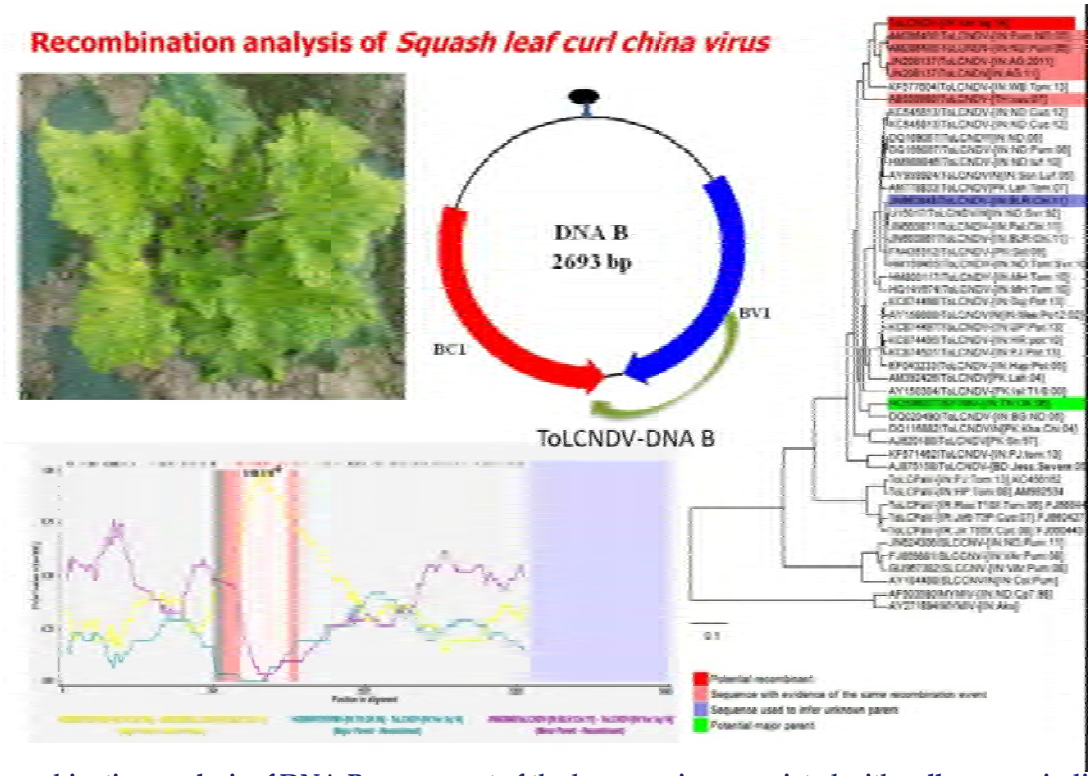


Fig. 78: Recombination analysis of DNA-B component of the begomovirus associated with yellow mosaic disease of Squash.

Recombination analysis of *Tomato leaf curl Joydebpur virus infecting brinjal:* A comprehensive break point analysis for recombination using RDP3 based on the alignment of sequence of ToLCJoV-eggplant isolate and other selected begomviruses from database was carried out. The analysis indicates the evidence of recombination in ToLCJoV infecting eggplant with most of the DNA fragments derived from ToLCJoV, ChiLCuV and AEV, to emerge as a new strain of ToLCJoV infecting eggplant. Further, RDP analysis of betasatellite indicated the evidence of recombination in betastallite suggestive of the most part of satellite DNA descended from PaLCuB (EU126825) infecting papaya in India (Fig. 79).

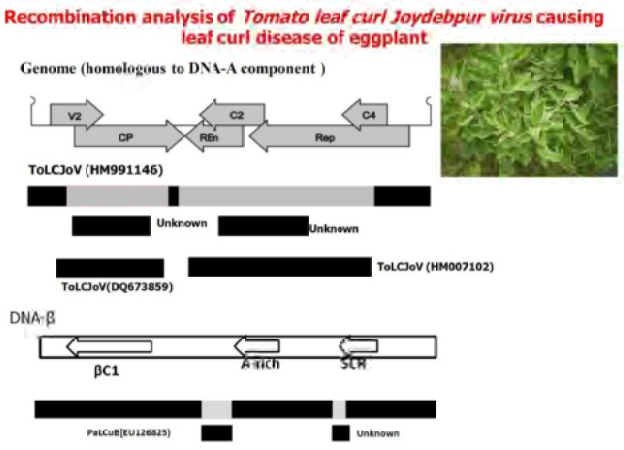


Fig. 79: Recombination analysis of DNA-A and DNAâ component

DNA based screening of bitter gourd genotypes against mosaic and leaf curl disease: Bitter gourd genotypes (28 genotypes) showing mosaic, leaf curl and plant showing the symptomless characteristic under natural condition were used for in-vitro DNA based screening using PCR. The total DNA of twenty eight were isolated and amplified by PCR using coat protein gene specific primer of begomovirus. None of the genotype was free from the begomovirus. All genotypes showed strong positive for begomovirus infection.

DNA based screening of Dolichos genotypes against yellow mosaic disease: Dolichos bean (100 genotypes) showing yellow mosaics symptoms were used for in-vitro DNA based screening using PCR. The total DNA was extracted from 100 mg of leaf tissue using the CTAB method. The pellet was suspended in TE buffer. The quality of the genomic DNA was checked on 1% agarose gel and stored at -20^{0}C till further use. The total DNA of 100 genotypes was amplified by PCR using coat protein gene specific primer of begomovirus. None of the genotype was free from the begomovirus. All genotypes showed strong positive for begomovirus infection.

Screening of Chilli genotypes/lines against different viruses by DAS-ELISA: Total 113 lines were tested by DAS-ELISA using CaCV, GBNV and CMV polyclonal antibodies. Result found that twenty six samples were

positive for GBNV, sixty samples were positive for CMV and 105 samples are positive for CaCV respectively. Further the twenty one samples are showing the positive for both GBNV and CMV, fifty seven samples are positive with both CMV and CaCV, twenty one samples are positive for both GBNV and CaCV and twenty one samples are showing the positive for both GBNV, CMV and CaCV respectively.

SUB PROJECT 6.8: Management of major Viral Diseases of Vegetables

Mahesha, B, Venkataravanappa, V and MH Kodandaram

Different vegetable crops were surveyed for incidence of viral diseases in and around IIVR farm (Table 61). Incidence of thrips in relation to GBNV infection in tomato were recorded in different villages (Fig. 80). Further these samples were also analysed through bio-chemical techniques to know the shift in total protein and host defence enzyme levels in infected and healthy plants (Table 62). Poly phenol- oxidase activity in diseased plants compared to healthy plants were also estimated (Table 63).

Table: 61. Incidence of viral diseases in different vegetable crops at IIVR

Sl. No.	Crop	Viral dissease	Incidence (%)
1.	Bottle gourd	PVY	23
2.	Bitter gourd	ToLNDV	96
3.	Pumpkin	ToLCNDV	84
		Pumpkin yellow vein mosaic virus	79
4.	Cucumber	CGMMV	13
		Groundnut bud necrosis virus	12
		Watermelon bud necrosis virus	08
5.	Watermelon	WBNV and GBNV (Mixed infections)	89
6.	Tomato	ToLCV	93
		GBNV	11
7.	Brinjal	Mosaic	14
8.	Chilli	CaCV	93
		GBNV	62
9.	Okra	BYVMV	93

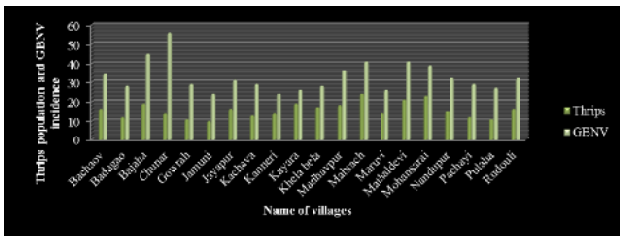


Fig. 80: Incidence of thrips population and GBNV on tomato plants at Varanasi and nearby villages.

Table 62: Change in total protein levels observed in virus infected and healthy host plants

Sl. No.	Sample	Pathogen	Protein values @ 660 nm absorbance (mg/gram of leaf)
1.	Chilli	Healthy	3.66
2.	Chilli	CaCV	4.52
3.	Chilli	CaCV	5.66
4.	Chilli	CaCV	6.59
5.	Chilli	GBNV	4.39
6.	Chilli	GBNV	3.50
7.	Okra	Healthy	2.05
8.	Okra	BYVMV	4.91
9.	Parval	Healthy	6.23
10.	Parval	Mosaic	7.61
11.	Field bean	Healthy	6.67
12.	Field bean	DYMV	5.29
13.	Bottle gourd	Healthy	4.71
14.	Bottle gourd	PVY	6.12
15.	Watermelon	Healthy	3.69
16.	Watermelon	GBNV	5.72
17.	Brinjal	Healthy	2.53
18.	Brinjal	Mosaic	4.57

Table 63: Poly phenol- oxidase activity in diseased plants compared to healthy plants

Sl. No.	Samples	Pathogen	PPO activity (Unit/gram)
1.	Okra	Healthy	0.0272
2.	Okra	BYVMV	0.51136
3.	Chilli	Healthy	0.0272
4.	Chilli	Begomovirus	0.23936
5.	Chilli	CaCV	0.36448
6.	Chilli	Leaf curl and bud necrosis virus	0.28832
7.	Chilli	CaCV Sap inoculated	1.43616
8.	Pumpkin	Healthy	0.82688
9.	Pumpkin	Begomovirus	0.22304

Identification of viral disease resistant sources in different vegetable crops: In cucumber (*Cucumis sativus* L.) 19 genotypes were screened under polyhouse against *Cucumber green mottle mosaic virus* (CGMMV), *Groundnut bud necrosis virus* (GBNV), *Cucumber mosaic virus* (CMV), infections. The results confirmed that the genotypes DC-54, DC-75, VR-101 and K-90 found resistant for CMV, CGMMV and GBNV; PCVC-9, PCVC-10, seven star and KTS-07-01 found resistant for CGMMV and GBNV; JLG and Cucumber long green were found resistant for CMV.

In brinjal, 100 genotypes were screened against begomovirus both under natural field conditions and molecular methods (PCR technique). The results confirmed that none of the genotypes were free from Begomovirus infections. This was confirmed both by symptomatic expressions and PCR technique with Begomovirus and phytoplasma specific primers.

In chilli 450 entries were screened under natural field conditions at IIVR against begomovirus and tospoviruses. The results confirmed that VR-339 and Gaurav were symptomatically free from viral diseases (Table 64) compared to other genotypes. Similarly in bitter gourd the genotype BRVTG-47 were tolerant to ToLCNDV.

Table 64: Resistant hosts identified for major vegetable diseases in other vegetables

Sl. No.	Crop	Genotypes	*Resistant/Tolerant
1.	**Cucurbits**		
	Bittergourd	BRVTG-47	Tolerant to ToLCNDV
	Watermelon	Nil	Tospo viruses (GBNV and WBNV)
	Muskmelon	Nil	Begomovirus (Mosaic virus)
2.	**Solanaceous**		
	Chilli	Gaurav and VR-339	Tolerant to GBNV, CaCV, PeLCV
3.	**Malvaceous**		
	Okra	*Abelmoschus esculentus var. manihot*	BYVMV
4.	**Legume**		
	French bean	FB-2	Moderately resistant to mosaic

**Need to be validated through molecular techniques and sequence information*

a) Bitter gourd leaf curl

b) Severity of CGMMV on cucumber

Fig. 81: Viral symptoms on bitter gourd and cucumber

Investigations on bitter gourd (*Momordica charantia* L.) viruses at Varanasi: There were 80-100% infection of whitefly (*Bemisia tabaci*,) mediated leaf curl virus infecting bitter gourd. Typical symptoms of infections were yellowing, leaf curling, vein banding, thickening of midrib, puckering, deformation of leaves, reduced leaf size, twisted fruits and reduced fruit size. Further, infected samples were analysed at serological, molecular and biological levels. The results revealed the *Tomato leaf curl New Delhi virus* to be the causal organism (Fig. 81).

SUB PROJECT 6.9: Management of Nematodes Infesting major Vegetable Crops

Satyandra Singh, C Sellaperumal, M Loganathan, Jaydeep Halder and Subhadeep Roy

Population dynamics: Extensive survey for nematode infestation was carried at IIVR, Varanasi and Kushinagar and Deoria research farms. At IIVR farm tomato, brinjal, okra, chilli, bitter gourd, pointed gourd, cowpea etc. were studied for root-knot nematode, *Meloidogyne incognita* infestation. The population *M. incognita* recorded in the range of 240 to 960 J_2/g soil with a root gall index (1-4). Maximum infestation of root-knot nematode was recorded from pointed gourd (960 J_2/g soil). All the surveyed crops showed nematode inoculums level above economic threshold level (Table 65 and Fig. 83a & 83b). The results of population fluctuation at IIVR farm showed that *M. incognita* multiplied well in the month of October-November and April (Fig. 82).

Table 65: Infestation level of root-knot nematode at IIVR, Varanasi and SPC, Sargatia farm.

Crop	Nematode population and Gall index					
	Nematode population (J_2/200 g soil)			Gall index (0-4)		
	IIVR	RS, Kushinagar	Deoria	IIVR	RS, Kushinagar	Deoria
Tomato	500	600	-	02	03	-
Brinjal	520	480	-	03	03	-
Chilli	240	210	-	01	01	-
Okra	560	500	400	03	04	03
Cowpea	220	-	180	01	02	01
Pointed gourd	960	600	-	04	04	-
Bitter gourd	560	700	500	03	04	03
Papaya	-	-	350	-	-	03
Bottle gourd	-	-	110	-	-	01
Cauliflower	-	-	160	-	-	01
Zinger	-	-	510	-	-	03

*Gall index: 0=0 galls; 1=1-25% galls; 2=26-50% galls; 3=51-75% galls and 4=76-100% galls **Average of 3 counts; ***EITL-Economic injury threshold level i.e. 1-2 nematode (J_2)/g (cc) soil under field condition.

Population fluctuation of root-knot nematode, *M. incognita* was recorded throughout the year at IIVR research farm. Data showed that nematode multiplication and reproduction was maximum during Rabi crop and highest population of *M. incognita* was recorded in the month of October, 2014 followed by November and April, 2014.

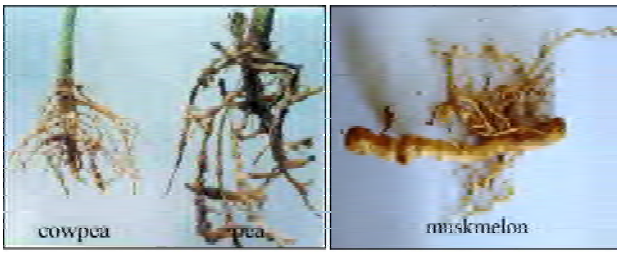


Fig. 82: Population fluctuation of *M. incognita* at IIVR farm during 2014-15

Fig. 83a: Root-knot infestations on cowpea, muskmelon, bitter gourd, eggplant and pea at Varanasi and Kushinagar areas.

Fig. 83b: Root-knot nematode infestation from Deoria areas on bitter gourd, okra, papaya, bottle gourd and zinger.

Grafting of tomato scion on resistance rootstocks: Grafting of root-knot nematode resistant tomato root stock was tried with high yielding cultivars of tomato as Scion. Among H-88-78-1, Hissar lalit and LA 2823, H-88-78-1 was recorded with highest compatibility with DVRT-1and DVRT-2 (Fig. 84 and Fig. 85).

Fig. 84: Grafting of tomato scion on resistance rootstock of *solanum tarvum* against *M. incognita*

Fig. 85: Transplanting of grafted tomato plants on pot for management of root knot nematode, *M. incognita*.

Botanicals extracts: Organic solvents extract of botanicals like Aak, *Calotropis procera* was tested for nematicidal effect against *M. incognita* under multi-well plate which was kept in BOD, exposed the nematode up to 24h at 28±2°C. The results found that hexane extract recorded highest mortality (62.7%) at 1% concentration followed by chloroform (51.3%), methanol (25.0%) and acetone (17.7%) over control. Methanol extract of Datura, *Datura* metal showed 36.3% mortality in *M. incognita* and 11.3% in *Rotylenchulus reniformis* were recorded under *in-vitro* condition (Table 66).

Table 66: Organic solvents extract of botanicals against root knot nematode, *M. incognita in-vitro*

Botanicals	Dilutions	Organic Solvents extracts % Mortality (after 24h) of M. incognita			
		M	A	C	H
Calotropis	2000 ppm	3.0	0.4	4.3	24.0
	5000 ppm	5.3	2.0	18.3	39.0
	10000 ppm	25.0	17.7	51.3	62.7
	EmH2O	0.0	0.0	0.0	0.0

M-Methanol, A-Acetone, C-Chloroform, H- Hexane

Botanicals	Dilutions	Organic solvents (Methanol) % mortality after 24h	
		M. incognita	Reniform nematode
Datura	2000 ppm	9.3	1.3
	5000 ppm	33.7	10.3
	10000 ppm	36.3	11.3
	EmH2O	0.0	

***In-vivo* testing of various bacterial isolates against root-knot nematode, *M. incognita* in tomato:** Various isolates of bacteria (local and formulation from IIHR)

were tested under glass house condition and recorded that BG-11 (root-knot gall reduction up to 65.7%). Local isolate did not differ significantly when compared with Formulation of *B. subtilis* (IIHR) up to 65.7% as compared to Furadon which reduced no of galls up to 78.1% over control (Table 67).

10 g/kg seed each and soil application at 10 kg/ha increased vine length of bitter gourd by up to 66% and enhanced marketable yield by up to 57%. This treatment reduced nematode reproduction by up to 84% with a reproductor factor 0.2 and gall index 01 when compared to control. This treatment did not show any

Table 67: In-vivo testing various bacterial isolates against root-knot nematode, *M. incognita* in tomato under glass house condition

Treatment	Plant height (cm)	% increase or decrease over control	Number of galls / root system	%decrease over control	Soil population/ 200 g soil	%increase or decrease over control	RF
T1-Control	59.0 (7.7) b	0.0	350 (18.7) g	0.0	2873 (53.6) i	0.0	1.4
T2-Furadon at 1.5 kg a.i./ha	80.2 (9.0) cd	(+) 35.9	76.7 (8.8) b	(-)78.1	211.7 (14.6) a	(-) 92.6	0.1
T3-BG-11	76.8 (8.8) d	(+) 30.2	120.7 (11.0) c	(-) 65.7	483.7 (22.0) de	(-) 83.2	0.2
T4-BG-2	47.2 (6.9) a	(-) 20.0	44.3 (6.7) a	(-) 88.0	284.7 (16.9) b	(-) 90.1	0.1
T5- BG-18	67.3 (8.2) bcd	(+) 13.9	176.0 (13.3) e	(-) 49.4	781 (28.0) g	(-) 72.8	0.4
T6-S-66	66.3 (8.2) bc	(+) 12.4	293.3 (17.2) f	(-) 16.3	1195.0 (34.6) h	(-) 58.4	0.6
T7-H-88V	44.9 (6.7) a	(-) 23.9	38 (6.2) h	(-) 89.1	387.3 (19.7) c	(-) 86.5	0.2
T8-H-88NV	68.4 (8.3) cd	(+) 15.9	162.3 (12.8) e	(-) 53.7	653.0 (25.6) f	(-) 77.3	0.3
T9-Sel-7V	76.3 (8.8) d	(+) 29.3	136.7 (11.7) d	(-) 60.3	507.3 (22.5) e	(-) 82.3	0.3
T10-*Bacillus subtillis*	68.9 (8.3) cd	(+) 16.8	122.7 (11.1) c	(-) 65.7	413.0 (20.3) cd	(-) 85.6	0.2
CD at 0.05	0.57		0.55		1.93		
CV	4.16		2.49		4.38		
SE(d)	0.27		0.26		0.92		

Integrated management of root-knot disease of bitter gourd at farmer's field: An integrated trial to manage root-knot nematode, *Meloidogyne* sps. was carried out at naturally nematode infested field. The field was heavily infested with *M. incognita*. Biological control agents, PGPR, *Pseudomonas flourescens* and fungal bioagent, *Trichoderma harzianum* was applied enriched with farm yard manure. Integrated application of both the bioagents enriched with FYM as seed treatment at significant difference with treatment where carbofuran 3G was applied and was kept as one of the control (Table 68 and 69).

Screening of bio-control agents against, *M. incognita*: The screening of biocontrol agents were screened against root knot nematode *M. incognita* in *in-vitro* in multiwell plate for nematicidal property was observed after 24 h of exposure period. The following isolates

Table 68: Evaluation of plant growth parameters of bitter gourd under integrated management of root-knot disease at farmer's field

Treatment	Vine (plant) length* (cm)	Average Number of fruit/plant	Yield/plot (kg) up to 130 days	Yield/ha (q)
T1-Control	110.9 [0.0] (10.59±0.27)^{a}	8 [0.0] (2.97±0.29)a	4.2 [0.0] (2.25±0.26)a	407.2 [0.0] (20.19±0.32)a
T2-Carbofuran 3G at 1.5 kg a.i. per ha	135.8 [22.5] (11.69±0.25)^{b}	11 [27.3] (3.45±0.25)bc	6.8 [38.24] (2.78±0.21)b	496.0 [21.8] (22.28±0.09)b
T3-FYM at 1.5 t/ha	137.1[23.6] (11.74±0.25)^{c}	10[20.0] (3.28±0.36)b	6.7[37.31] (2.78±0.14)b	493.1[21.1] (22.23±0.09)b
T4-*Pseudomonas flourescens* alone (ST+SA) at (10g/kg seed + 10kg /ha) + FYM	167.3[50.9] (12.97±0.22)^{d}	12[33.3] (3.69±0.16)c	8.9[52.81] (3.14±0.09)bc	548.4[34.7] (23.42±0.48)b
T5-*Trichoderma harzianum* alone (ST + SA) at (10g/kg seed + 10kg /ha) + FYM	170.2 [53.5] (13.07±0.21)^{d}	13 [38.5] (3.74±0.16)c	9.5 [55.79] (3.23±0.08)c	589.2 [44.7] (24.28±0.98)c
T6-T4+T5 (combined application) + FYM	184.8 [66.6] (13.61±0.21)^{e}	13 [38.5] (3.72±0.23)c	11.2 [62.50] (3.34±0.17)c	639.3 [57.0] (25.29±0.41)c
CD at 0.05	0.52	0.26	0.39	1.85
SE (m)	0.16	0.08	0.12	0.52

Note- Data presented in parentheses ( ) are square root transformed value ± standard error & parentheses [ ] are percentage increase (+) or decrease (-) over control; Spacing: 2 X 1.5 m; No. of plants- 06; DOS: 20.02.2014; Variety: Pusa Do Moshami.

Table 69: Evaluation of integrated management on nematode reproductive parameters of *M. incognita* infecting bitter gourd at farmer's field

Treatment	G.I (0-4)*	RKN/200 cc soil	R.F
T1-Control	4	1118.0 [0.0] (33.43±0.83)d	1.3
T2-Carbofuran 3G at 1.5 kg a.i. per ha	1	162.3 [-85.5] (12.36±2.29)a	0.2
T3-FYM at 1.5 t/ha	3	661.5 [-40.8] (25.69±1.08)c	0.8
T4-PF alone (ST+SA) at (10g/kg seed + 10kg /ha) + FYM	2	373.9 [-66.6] (19.25±1.44)b	0.4
T5-TH alone (ST + SA) at (10g/kg seed + 10kg /ha) + FYM	2	307.1 [-72.5] (17.41±1.60)b	0.4
T6-T4+T5 (combined application) + FYM	1	168.6 [-84.9] (12.63±2.24)a	0.2
CD at 0.05	-	1.91	
SE (m)	-	0.59	

Note- Data presented in parentheses ( ) are square root transformed value ± standard error & parentheses [ ] are percentage increase (+) or decrease (-) over control; Spacing: 2 X 1.5 m; No. of plants- 06; DOS: 20.02.2014; Pusa Do Moshami.

were tested *viz.*, D-27(Iso-1), Iso-2, Iso-3, Iso-4, Iso-5, Iso-6, Iso-7, Iso-8, *Bacillupumilis*, T3, *B. licheniformis*, Pb-3 and *B. subtilis* after 24 hr exposure period which was showed that 8.2, 0.0, 0.5, 0.8, 1.2, 5.3, 8.7, 5.7, 15.7, 32.5, 18.4, 11.6 and 12.8 per cent mortality, respectively.

SUB PROJECT 6.10: Dynamics of Pest and Diseases and Development of Forecasting Models

AB Rai, MH Kodandaram, Jaydeep Halder, M Loganathan, Sujoy Saha, V Venkataravanappa, Satyendra Singh and TD Lama

The dynamics of fruit fly incidence *Bactrocera cucurbitae* in cucurbits and brinjal fruit and shoot borer, *Leucinodes orbonalis* in brinjal was studied by installing the cue lure and sex pheromone traps, respectively. Highest cucurbit fruit fly, *B. cucurbitae* was recorded during first week of November, 2014 (287.67 nos/trap) followed by last week of March, 2014 (266.33) (Fig. 86). Incidence of BSFB was recorded for 52nd SMW (10-09) during year 2014-15. Large fluctuation in the incidence of BSFB in brinjal was observed with two peaks of trap catches first during 16th SMW (27.67 moths/trap) and second in 09th SMW (33 moths/trap) (Fig. 87). Incidence late blight in tomato (*Phytophthora infestans*) initiated when minimum temperature starts <18-20 ÚC (44-45 Std wks) and progresses rapidly when >80% RH and <10-15 ÚC (52 to 3 std wks (Fig. 88). Periodical incidence of black rot in cabbage (*Xanthomonas campestris* pv. *campestris*) observed for 14 meteorological weeks with maximum during 3rd week of February (48.3%) (Fig. 89).

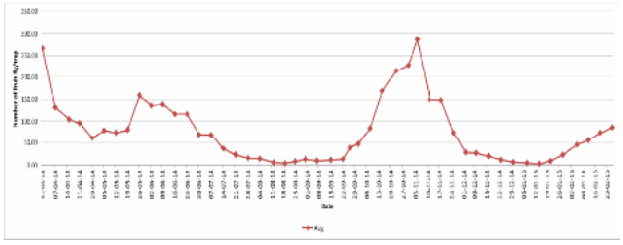


Fig. 86: Population dynamics of cucurbit fruit fly, *Bactrocera cucurbitae*

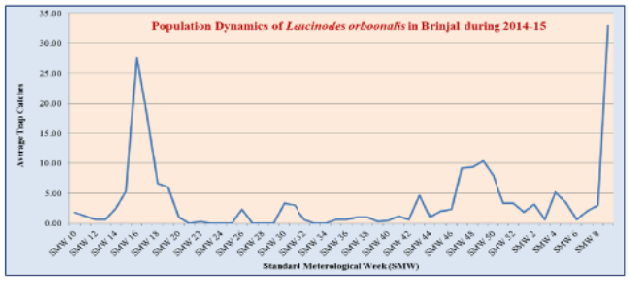
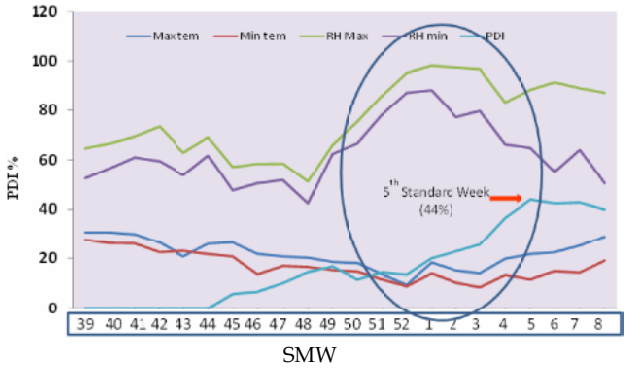


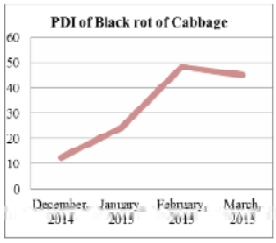
Fig. 87: Population dynamics of BSFB, *Leucinodes orbonalis*



Tomato variety: DVRT1
Date of transplanting: 26.09.14

39th SMW: 24 Sep - 30 Sep
5th SMW: 29 Jan - 4 Feb

Fig. 88: Incidence of late blight of tomato (*Phytophthora infestans*)

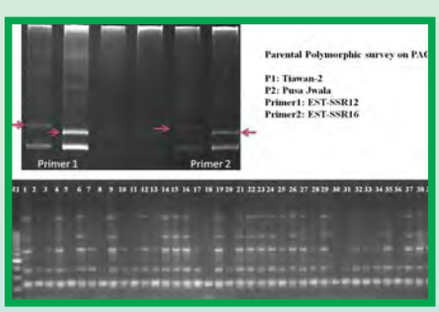


Month/ week	Dec 2014	Jan 2015	Feb 2015	Mar 2015
1 Week	10.3	18.6	39.7	45.4
2 Week	12.5	24.5	48.3	45.2
3 Week	12.8	28.3	48.2	-
4 Week	12.8	31.2	48	-

Sungro hybrid; DOT: 25-11-2014; Weekly observation starting from 1st week of Dec 2014

Fig. 89: Periodical incidence of black rot of cabbage (*Xanthomonas campestris pv. campestris*)

Externally Funded Projects



PROJECT 1: National Initiative for Climate Resilient Agriculture (NICRA)

Major Singh, N Rai, Rajesh Kumar, Anant Bahadur, SK Tiwari and AB Rai

Effect of high temperature stress on morphological attributes in tomato: Forty-two promising lines were evaluated for biochemical and physiological parameters. The temperature during the cropping season ranged between 29 ^{0}C to 45 ^{0}C. Two lines were found to be highly tolerant, 6 tolerant, 13 moderately tolerant, 11 sensitive and 10 highly sensitive. CLN-1621, 15 SB and CLN-2026 performed better under high temperature stress.

Effect of heat stress on pollen viability: Pollen viability of the 42 genotypes was evaluated at two intervals under high temperature (temp. <43 ^{0}C and >43 ^{0}C) in open field conditions. Pollen viability ranged from 23.3 (EC-521078) to 78.3% (CLN-2026) in first sampling (<43 ^{0}C) while 0.0% (EC-501580) to 100% (NDTVR-73) in second sampling (temp. > 43 ^{0}C). Genotypes CLN-2026, CLN-1621 and EC-538441 showed higher tolerance to high temperature with respect to pollen viability.

Effect of high temperature stress on physiological and biochemical parameters: The chlorophyll fluorescence (an indicator of photosynthetic efficiency, PSII), revealed higher PSII activity in EC-538441 (0.72) followed by EC-538380 (0.69) and VRT-101A (0.68) whereas minimum PSII activity were recorded in EC-526139 (0.32) indicating susceptibility to high temperature stress. While the PSII activity under optimum temperature for tomato is 0.83, the genotypes EC-538441, EC-538380 and VRT-101A showed comparatively better performance with respect to photosynthetic efficiency.

In biochemical evaluation, proline content showed non-significant variation ranging between 0.78 µg/FW (EC-538380) to 9.57 µg/FW (VRT-103-6-1). Hydrogen peroxide (H_2O_2) was recorded minimum in Superbug (37.0 mM/FW) and highest in Pusa Ruby (79.67 mM/FW). Similarly, superoxide dismutase (SOD) ranged from 0.65 IU/mL (VRT 101A) to 1.21 IU/mL and peroxidase (POX) varied from 0.61 IU/mL (CLN 2026) to 6.17 IU/mL (Punjab Chhuhara).

Heat stress markedly decreased the fruit weight and the percentage of fruit set significantly in all genotypes however, genotype CLN-2026 performed better fruit setting percentage (53.7%) followed by EC-538441 (50%) at highest temperature. Maximum flower drop was noticed in Punjab Chuhhara, EC-520075, EC-520078, EC-605696 and Money Maker *i.e.*; 100%.

High temperature tolerant genotypes showed drastic drop in physiological parameters measured, compared to better performing genotypes. Total soluble solid (TSS) ranged between 3.1% (VRY-103) to 8.0% (EC-520078). In response to the high temperature stress, CLN-1621, CLN-2026, EC-538441, EC-620419, Sun Cherry, EC 538380 and VRT-101A performed better for morphological, physiological and fruit quality traits.

Assessment of selected genotypes in temperature gradient tunnel (TGT): Eleven genotypes (nine tolerant - CLN-1621, CLN-2026, EC-620438, EC-620421, 15 SB, EC-620386, EC-538441, TLH-27 and C-26-1 and two susceptible CO-3 and Hisar Arun) were selected for further validation in temperature gradient tunnel (TGT), where temperature rises up to +9 ^{0}C from the ambient temperature and develops a gradient in the tunnel measurable at 6 points (T_1 lowest to T_6 highest).

In response to high temperature, bud initiation/flowering accelerated in all 11 genotypes- the earliest 50% flowering (52 DAS) was observed in EC-620386 at T6 (highest temp. 38.4 ^{0}C) compare to ambient (61 DAS; temp. 30.8 ^{0}C). The tolerant genotype CLN-1621 took 61 days after sowing (DAS; temp. 39.1 ^{0}C) at ambient temperature (AT; temp. 34.9 ^{0}C) and 63 DAS at T6 for 50% flowering. At full bloom stage in gradient T6, maximum *Fv/Fm* was recorded in CLN-1621 (0.809), whereas PS II efficiency was found lower in Hisar Arun (0.483) and CO-3 (0.562) indicating CLN-1621 to tolerate heat stress to some extent maintaining the PS II activity. The highest LAR was noted 92.87 cm^2/g at T2, whereas at gradient T6, 72.35 cm^2/g in case of CLN-1621. Pollen viability in genotypes ranged from 71% (Hisar Arun in gradient T6) to 95% (EC-620438 in Control). CLN-1621 and EC-538441 showed higher pollen viability at all 6 temperature gradient with the viability of 87% at T6 (highest temp.).

Genotype CLN-1621 recorded maximum cluster (37) followed by EC-538441 (35), CLN-2026 (34) and C-26-1 (30) at gradient T6. However, a maximum cluster (43) was recorded in CLN-1621 at ambient temperature. Fruit setting duration (from anthesis to fruit set) varied from 5 to 13 days in all the genotypes at different temperatures. Fruit setting duration decreased with increase in the temperature, which was recorded minimum 6 days in TLH-27 and EC-620386 at highest temperature (ambient +9 ^{0}C), whereas in ambient conditions it took 10 days from anthesis. Fruit setting percentage varied significantly in all eleven genotypes. CLN-1621 exhibited higher setting percentage *i.e.* 72.36% followed by CLN-2026 (68.34%) at highest

temperature regimes (Fig. 89 and 90) compared to the control in both the genotypes. In CLN-1621 and EC-620421 the percentage reduction in fruit diameter was 7.85% and 11.87%, respectively compared to the control, whereas in sensitive genotypes *i.e.* CO-3 and Hisar Arun it was 33.07% and 34.09%, respectively compared to the ambient. Total fruit weight was high in CLN-1621 (685 g/plant) under highest temperature regimes (T6), whereas at ambient temperature it was 1234 g/plant. The maximum total fruit weight found in Hisar Arun (1261 g/plant) at ambient temperature, whereas in CO-3 it was minimum (230 g/plant) at the highest temperature. Temperature in gradient T6 was higher as compared to ambient condition which affected the fruit size and weight adversely (Fig. 91).

Heat stress also altered the chlorophyll and carotenoid contents in tomato genotypes. An increase in chlorophyll a/b was observed in CLN-1621 and EC-538441 under high temperature stressed plants. The carotenoids content increased during the stress in CLN-1621, EC-538441, TLH-27 and CLN-2026. Chlorophyll/carotenoids ratio decreased significantly in CLN-1621, EC-538441 and TLH-27 plants with respect to the control treatment.

Fig. 90: Stigma excretion and flower drop is common feature in susceptible genotypes at T6 (highest temperature)

Maximum SOD was recorded in CLN-1621 (1.98 1U mL-1 in T4 followed by T5, *i.e.* 1.861U mL^{-1}) and it was minimum in CO-3 (0.97 1U mL^{-1} in T5). The highest APX activity under heat stress was noticed in genotype CLN-2026 (0.180 1U mL^{-1} at T3 and T4) and in CLN-1621 (0.150 1U mL^{-1} in T1 and T2). Genotype CLN-1621, EC-538441, CLN-2026 and TLH-27 perform better, whereas CO-3 and Hisar Arun could not perform well under high temperature stress.

Fig. 91: Relative performance of genotypes (Susceptible and tolerant) at high temperature in T6: Stigma excretion and flower drop

Effect of drought stress on morphological parameters: A total of 30 diverse genotypes of tomato were transplanted and exposed to several cycles of three levels of drought stress *i.e.* withholding irrigation for light stress (12.1-16.0% moisture), mild stress (8.1-12.0% moisture) and severe stress (5.0-8.0% moisture) for drought tolerance in pots under net-house along with well watered control (Fig. 92).

On the basis of RWC and fruit setting %, WIR-4361 yielded better under severe and mild stress condition and WIR-3959 was high yielder in light stress and control condition in both year experiments.

Screening of tomato cultivars/genotypes for water logging tolerance: A total of 130 diverse cultivars/genotypes of tomato were evaluated in pot, both at active

Fig. 92: Performance of tomato genotypes at different drought levels with control

growth (40 DAT) and reproductive stages (70 DAT). Three levels of water stress were imposed, *i.e.* 48h, 72h and 96h of water-logging along with control (no stress) at vegetative stage and 48h, 72h and 112h at reproductive stage.

Three genotypes, *viz;* EC-620512, EC-620522 and EC-528422 showed tolerance to water-logging for 48h, 72h and 96h at vegetative stage, and 48h, 72h and 112h at reproductive stage except EC-620512 at 112h. Genotype EC-501574 and EC-620648 were found as most susceptible as they could not survive even in 48 or 72 h of water-logging condition (Fig. 93).

Further, water-logging experiments with 97 other tomato genotypes were initiated in pot during December 2014 to March 2015. Preliminary evaluation of 97 tomato genotypes revealed that WIR-6360, WIR-13706, EC-1161-4-2-1-1, EC-520049 and EC-520078 have more tolerance against water-logging and survive in 48h, 72h and 96h of water-logging at vegetative stage. At reproductive stage, WIR-4360 showed tolerance to water-logging for 48h, 72h and 112h whereas EC-520049 could not survive 112h of water-logging (Fig. 94). Genotypes WIR-3950, WIR-4361, WIR-13706, EC-1161-4-2-1-1 and EC-520078 survive only in 48h of water-logging. These genotypes were found healthy and had less yellowing symptom even after 112 hr (5 days) of water-logging condition. Genotype 620597 and EC-620539 were observed as most susceptible and they could not survive even after 48 hr of water-logging (Fig. 94).

Water-logging tolerant genotypes

EC-620512 EC-620522 EC-528422

Water logging susceptible genotypes of tomato

EC-501574

Fig. 93: Tolerance and susceptibility of tomato genotypes under water-logged conditions

Evaluation of flood tolerance through grafting in tomato: Grafting of high yielding tomato cultivars (Kashi Vishesh, TLH-27, CLN-1621, Arka Rakshak, Arka Samrat and Kashi Aman) over water-logging tolerant brinjal rootstock was initiated. Data on evaluation of suitable rootstocks for water-logging stress, and effect of water-logging on physio-biochemical and other traits of tomato are in progress (Fig. 95).

WIR-4360- Water-logging tolerant line EC-520049- Water-logging tolerant line

Fig. 94: Tolerance of tomato genotypes under water-logged condition

Fig. 95: Performance of grafted tomato plant at active growth stage- Arka Samrat grafted over brinjal rootstock (IC 111056), Grafting of high yielding tomato cultivar (Kashi Aman) over water-logging tolerant brinjal rootstock was initiated in open field during August, 2014

Identification of SNPs in tomato for drought tolerance: Two tomato genotypes (H-88-78-1 and Punjab Chhuhara) and twenty selected RILs selected for SNP detection through reduce or capital representation library technology (Table 70).

Table 70: Summary of SNPs identified

S. No	Steps in the workflow	No. of SNPs
1	Key SNPs in both P1 and P2	7707
2	Homozygous SNPs in both P1 and P2	P1: 919; P2: 924
3	Polymorphic SNPs between P1 and P2 – Polymorphic markers	504
4	Co-segregating markers	14

PROJECT 2: Network Project on Transgenic Crops (NPTC)

Major Singh, AB Rai, Rajesh Kumar, HC Prasanna and SG Karkute

Water use efficiency of *AtDREB1A and BcZAT12* transgenic tomato lines: Water is a major limiting factor for sustainable agriculture production. Increased water-use efficiency is an important challenge for sustainable agricultural production in an ever-decreasing area of arable land and will have a major impact on conservation and availability of water globally and for food security. Drought tolerance have a major impact on more sustainable cropping systems worldwide, mainly in developing countries like India, where drought will likely be more prevailing and severe. Drought transgenic tomato lines containing *AtDREB1A* or *BcZAT12* gene were developed. To compare water use efficiency (WUE) of these transgenic lines with drought tolerant tomato genotypes, we germinated seeds of *AtDREB1A* events (D41, D53, D76, D86, and D90), *BcZAT12* events (ZAT1, ZT2, ZT5, and ZT6), non-transgenic line (WT; cv. Kashi Vishesh), drought tolerant genotypes (H88-78-1 and VRT32-1), and drought susceptible genotypes (EC520046 and EC620598) (Fig. 96). The trial was conducted in a insect proof screen house. Both the transgenic lines have significantly higher fruit yield (40% FC = 36-58% higher) and more number of fruit under the drought conditions. The fruit characters of transgenic lines have higher TSS, sugar, ascorbic acid, citric acid, flavanoids, and carotenoids. The pH of the transgenic fruits were lower than non-transgenic plants. Transgenic fruits were more firm than other genotypes. DREB, DT1 and DT2 fruits of stressed plants became harder.

The pollen viability of transgenic lines showed higher viability under 40% field capacity moisture stress. The transgenic *AtDREB1A* events = 89.5%, *BcZAT12* events = 88.4%, D86 x ZT1 F_1 = 90.3% , DT genotypes = 72.3% , WT line = 70.7% (Fig. 97 & 98).

Fig. 96: Water use efficiency experiment trial in screen house

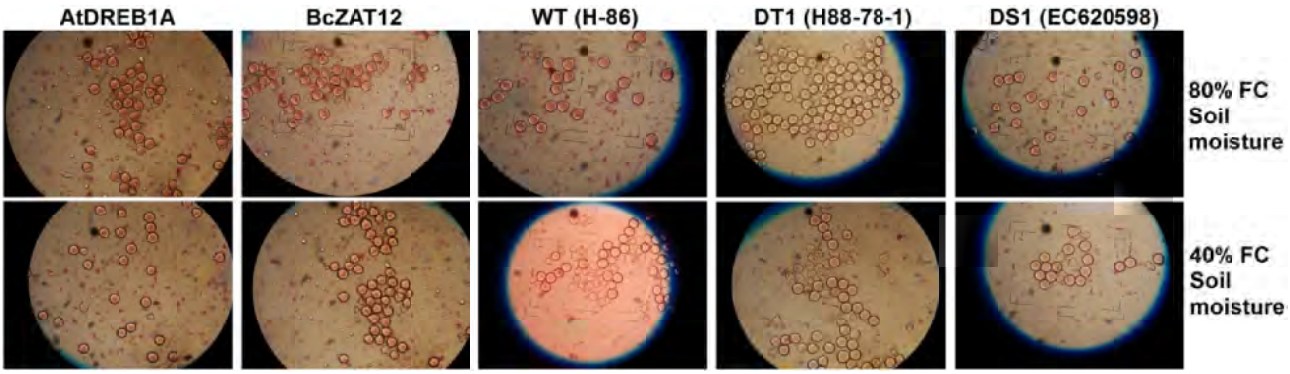


Fig. 97: Pollen viability test of transgenic and non transgenic line under moisture stress

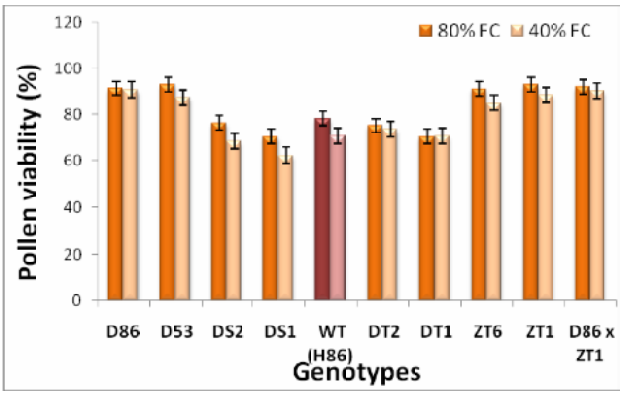


Fig. 98: Comparison of pollen viability transgenic line with non-transgenic lines

Salt stress tolerant transgenic tomato seedlings – *BcZAT12* gene: Abiotic stress like salinity affects tomato plant's growth and productivity in coastal and salt prone areas. Our results showed that *BcZAT12* transformed tomato lines can withstand drought stress and heat-shock stress making these *BcZAT12* transgenics of tomato useful for improving quality of tomato in heat or drought stressed regions. *BcZAT12* gene under the regulatory control of the stress inducible *Bclea1* promoter was working in multiple stress condition. Another experiment with salt stress was applied to *BcZAT12* transformed as well as control tomato seedlings by adding 50, 100 and 200 mM NaCl. Morphological, physiological and biochemical characters of transgenic and non-transgenic tomato seedlings were estimated after stress applied. 50, 100 and 200 mM salt stressed ZT (*BcZAT12*-transformed) lines (ZT1, ZT4, ZT5 and ZT6) and NT (H-86 Control) tomato seedlings were evaluated for leaf area, root and shoot length. Physiological character of electrolyte leakage, relative water content and chlorophyll colour index were estimated for stressed ZT and NT tomato seedlings. Biochemical analysis of H_2O_2, Proline and catalase were observed from leaves of stressed ZT and NT tomato seedlings. Results gave reduced leaf area and shoot length with increase in root length both in NT and ZT seedlings on increasing salt stress condition whereas line ZT1 and ZT5 showed less reduction of leaf size at 200mM stress compared with their respective NT plants whereas root length were significantly higher at all the stress condition in line ZT1 and ZT5 (Fig. 99). Physiological parameter *viz.* CCI and electrolyte leakage were increased with increase in salt stress condition and it was higher in lines ZT1 and ZT5 both in 100 and 200 mM condition. RWC were decreased with increasing the salt stress condition and it was lowered at 200 mM condition (Fig. 100). ZT lines were showed much more water retention capacity compared with NT plants. H_2O_2 free radical was higher in NT plant during the stress condition and it was significantly lowered in lines ZT1 and ZT5 during all the stress condition. CAT activity indicated significantly higher in ZT1 and ZT5 compared with their NT counterpart (Fig. 101). Proline accumulation were indicated significantly higher in

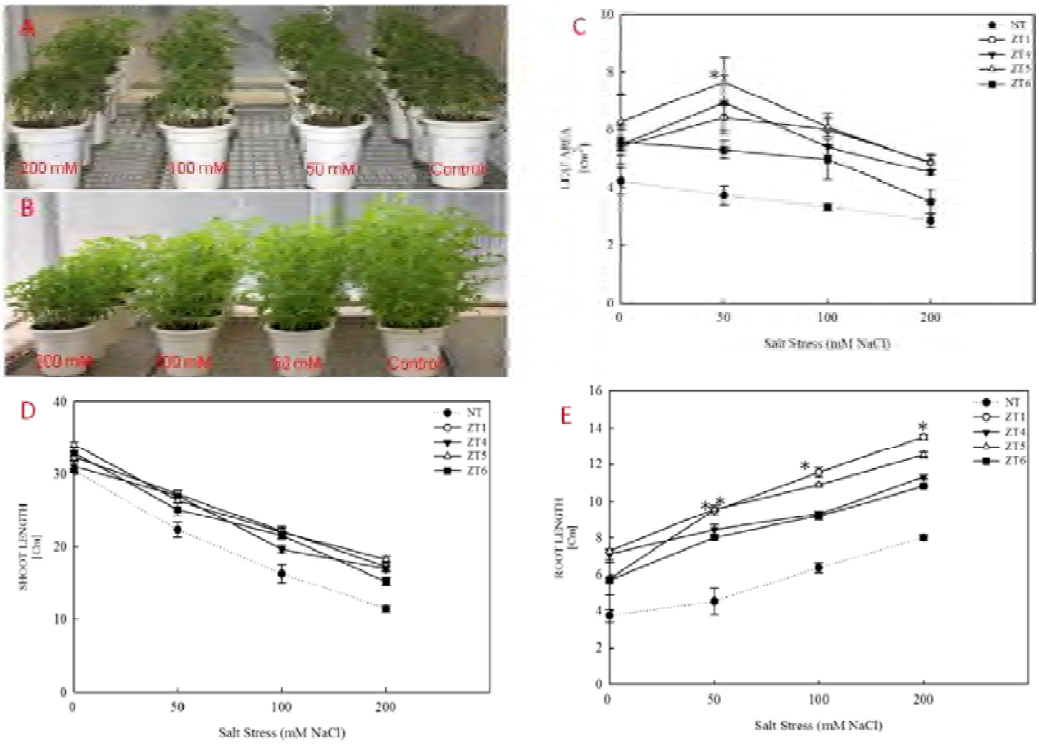


Fig. 99: Seedling on A, Before Salt stress B, After 15 Days of Salt Stress; Morphological Characters C, Leaf area; D, Shoot length; E, Root length; (*) indicate statistically significantly change at P 0.05.

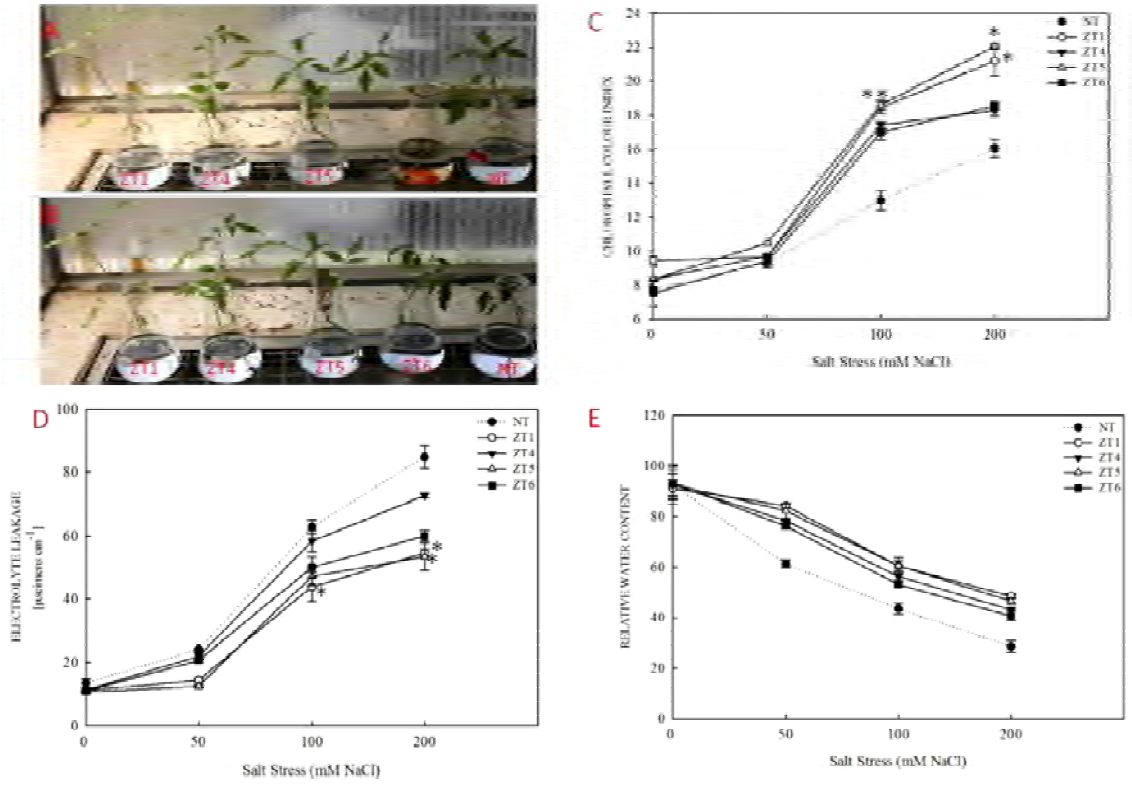


Fig. 100: Old Seedlings on A, after 24 hour in MS Liquid B, After 24 hour in MS liquid with 200 mM NaCl; C, Chlorophyll colour index; D, Electrolyte leakage; E, Relative Water content. (*) indicate statistically significantly change at $P_{0.05}$

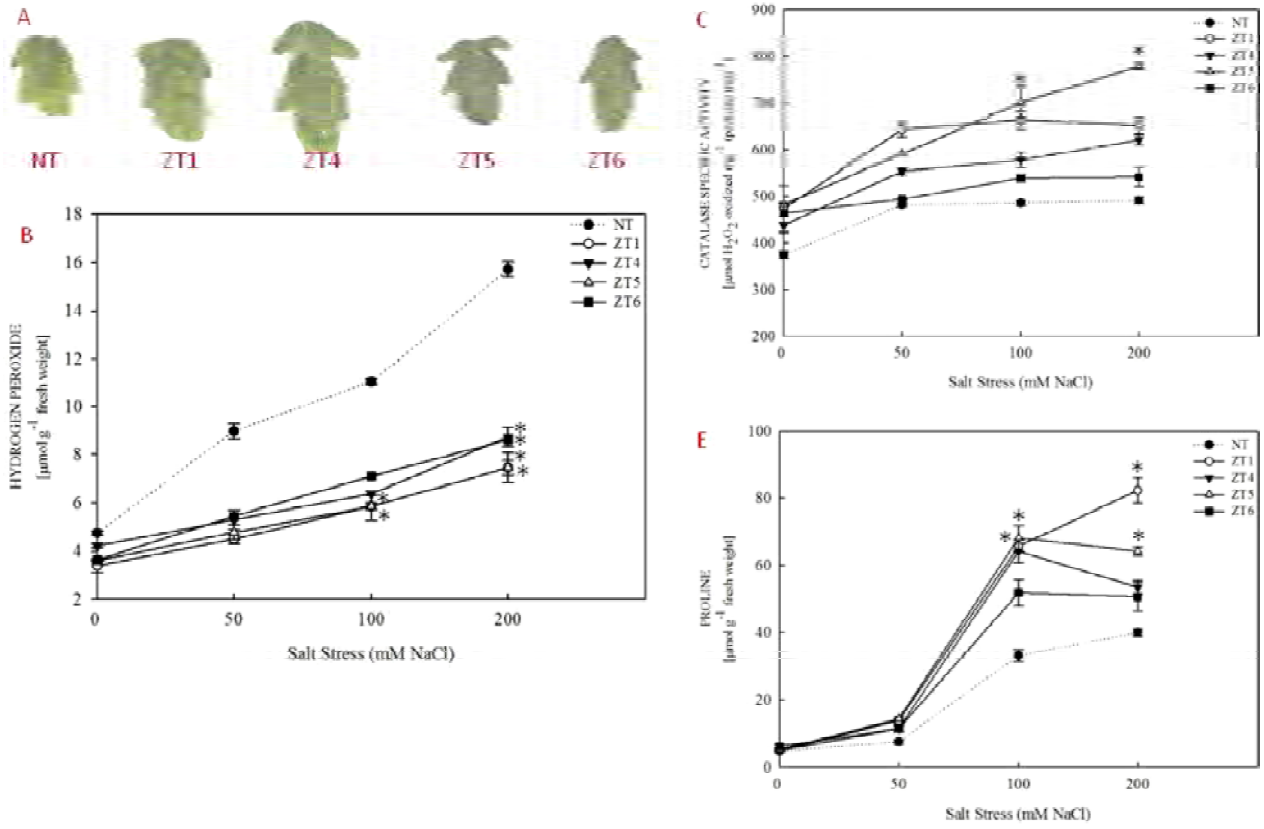


Fig. 101: NT an ZT Leaves on A, after 24 hour on 200 mM H_2O_2 solution; B, H_2O_2 formation in NT and ZT lines; C, Catalase activity on NT and ZT lines; D, Proline accumulation on NT and ZT lines. (*) indicate statistically significantly change at $P_{0.05}$

line ZT1, ZT4 and ZT5 compared with NT plant at 100 mM salt stress condition whereas at 200 mM, only line ZT1 had significant proline accumulation.

Fruit and shoot borer resistant transgenic brinjal – *Cry1Aa3* gene: Homozygous T_4 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_5 generation seeds were harvested from the developed fruits.

Fruit and shoot borer resistant transgenic brinjal – *Cry1Ac* gene: Generation advancement of Bt-brinjal lines (viz. Pant Rituraj, Uttara, Punjab Barsati, VR-14, IVBL-9, VR-5) with high protein expression and similar to recurrent parent were chosen and further selfing was repeated in this season. Plants were again raised for seed multiplication. 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 were survived and the non transgenic plants died. Further the positive plants of each lines were transplanted in nethouse. Selfing was performed with fully grown plants for multiplication. Seeds of mature selfed fruits from all the six lines were harvested and stored.

Fruit borer resistant transgenic tomato – *Cry1Ac* gene: Eight events of transgenic tomato plants cv. Kashi Vishesh carrying *Cry1Ac* gene were advanced to T_6 generation and the best event was selected in year 2012-2013. 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^{-1}) 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.

PROJECT 3: Gene Expression Studies and Development of Functional Markers for Anthracnose Disease in *Capsicum* Species

Rajesh Kumar, M Loganathan and Major Singh

Phenotyping of mapping population: Phenotypic data of 333 F_2 individual plants were recorded for traits, *viz.*, disease severity on fruits under natural condition, artificial screening of mature green and red fruits against *Colletotrichum capsici*, number of fruits per plant fruit length, width, and other morphological traits for mapping anthracnose related QTLs. Individual plants were screened for their fruits for reaction of anthracnose disease under artificial condition (Fig. 102 and Table 71).

Table 71: Screening under artificial condition for anthracnose reaction in F_2 population of chilli

SN	Reaction	No. of individuals
1.	Symptomless	05
2.	Highly resistant	164
3.	Resistant	0
4.	Moderately resistant	123
5.	Moderately susceptible	41
6.	Susceptible	0

Fig. 102: Artificial screening of F_2 population of P Jwala x Taiwan2 for anthracnose disease reaction *C. capsici*

Polymorphism among parental lines and genotyping of F_2 population: Out of 541 SSR primers available in public domain, 86 SSRs and out of 93 EST-SSRs, 16 primers were found polymorphic between the parental lines (Pusa Jwala and IIVRC-452). DNA of 333 F_2 plants along with their parents (Pusa Jwala and IIVRC-452) and F_1 was isolated following the CTAB extraction method for genotyping and molecular analysis. The polymorphic primers are being used for genotyping the F_2 mapping population. So far 17 primers have been genotyped among the 333 individuals of mapping population (Fig. 103).

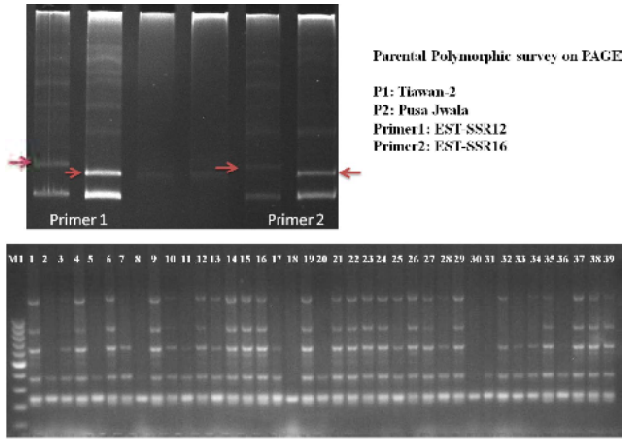


Fig. 103: Genotyping of F_2 population of Pusa Jwala x IIVRC-452 by SSR CAMS-81

Transcriptome analysis/annotation in chillies: Annotations and functional classifications of a comprehensive transcriptome of *Capsicum annuum* [resistance (IIVRC-452) and susceptible (Pusa Jwala)] was done based on mapping to Plant NRDB database: To perform this experiment total RNA was isolated and sequencing of transcript was done on the Illumina Hiseq2000 platform. BLASTX (E value <= 0.001 and Query Coverage Cut off 50% and % identity 20%) tool was used for transcript annotation with the help of plant NRDB database. Annotation and gene ontology summary of IIVRC-452 and Pusa Jwala are given below (Table 72,73 & 74):

Table 72: Annotation Summary

	Resistance (IIVRC-452)	Susceptible (Pusa Jwala)
Total number of transcripts predicted	86,029	85,420
Total number of transcripts annotated	39,925	40,160
Percentage of transcripts annotated	46.40%	47%
Total Number of unique genes mapped	24,954	25,086

Table 73: Gene ontology summary

	Predicted Transcripts with gene ontology annotation
Resistance (IIVRC-452)	28,420 out of 39,925 annotated transcripts
Susceptible (Pusa Jwala)	5,632 out of 40,160 annotated transcripts

Table 74: Gene ontology category

Gene ontology Category	Transcript Detected Resistance (IIVRC-452)	Transcript Detected Susceptible (Pusa Jwala)
Cellular Components	560	550
Biological Process	2269	2294
Molecular Functions	1642	1626

Identification of heterozygous/single nucleotide variations in the *Capsicum annuum* [Resistance (IIVRC-452) and Susceptible (Pusa Jwala)]: For this experiment total RNA was isolated and sequencing of transcripts was done on the Illumina Hiseq2000 platform. High quality paired end reads from *Capsicum annuum* [Resistance and Susceptible] were mapped against the De-novo assembled *Capsicum annuum* [Susceptible and Resistance respectively] transcriptome using the bowtie2 tool and VarScan package tool was used for calling the variations (Table 75).

Table 75: Summary of single nucleotide variation

SNVs	Resistance (IIVRC-452)	Susceptible (Pusa Jwala)
Homozygous SNVs	231	219
Heterozygous SNVs	2341	2231
Total SNVs	2572	2450

Identification of microsatellite SSRs in *Capsicum annuum* [Resistance (IIVRC-452) and Susceptible (Pusa Jwala)] transcriptome sample: To perform this experiment total RNA was isolated and sequencing of transcript was done on the Illumina Hiseq2000 platform. MISA v1.0 tool was used for SSR prediction in *Capsicum annuum* (Table 76).

Table 76: SSRs identification in *Capsicum annuum*

SSR Class	Resistance (IIVRC-452)		Susceptible (Pusa Jwala)	
	Number of SSR Detected	% of SSR Detected	Number of SSR Detected	% of SSR Detected
Mononucleotides	5883	51.63	5621	50.68
Dinucleotides	1697	14.89	1660	14.97
Trinucleotides	2574	22.59	2578	23.24
Tetranucleotides	390	3.42	376	3.39
Pentanucleotides	90	0.79	82	0.74
Hexanucleotides	157	1.38	146	1.32
Complex	604	5.30	628	5.66

Microarray analysis of chilli samples (Pusa Jwala & IIVRC-452): To perform this experiment isolation and purification of total RNA was done using RNeasy mini kit and RNA quality was checked using Bioanalyzer. Chilli_gxp_transcriptome_2X400K AMADID: 70905 slides and Agilent's Quick-Amp labeling Kit was used to perform experiments by T7 promoter based linear amplification labeling method to generate labeled complementary RNA. Agilent's in situ Hybridization kit was used for hybridization (Table 77).

Table 77: Summary of Up and down regulated genes in treated sample

Samples hybridized	Up regulated	Down regulated
Pusa Jwala (red fruit)	56681	56266
IIVRC-452 (red fruit)	29048	37188

PROJECT 4: Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance

Sudhakar Pandey and Anant Bahadur

Relative gene expression through Quantitative Real Time PCR (qRT-PCR) of drought tolerant and susceptible muskmelon under water deficit condition: One genotype that was in the top statistical

group for drought tolerance (DT-1) and one genotype that was in the lowest statistical group for drought suscepitable (DS-1), were selected for gene expression analysis. Seeds were sown in 10 kg capacity pots in 4 set of pots. Leaves collected for RNA isolation and synthesis of complementary DNA (cDNA) from RNA. Six primers for all the target genes and actin gene were used. The relative value obtained for quantitation was expressed as $2^{--''CT}$ where "CT represents the difference between the CT value of the sample and that of actin (endogenous control) and —dCT is difference between the "CT value of a sample and that of its respective control (Table 78). Based on gene specific primers fold change of relative gene expression, was observed higher in drought tolerant accession compared to susceptible (Fig. 104, 105 & 106).

Table 78: Fold change in gene expression compared to control

Primer No.	Drought tolerant line (fold change)			Drought susceptible line (fold change)			Status
	Days of water stress treatment			Days of water stress treatment			
	7 days	14 days	21 days	7 days	14 days	21 days	
1	2.042	8.225	12.381	1.765	3.095	5.169	Upregulated
2	1.035	2.621	6.063	1.014	1.275	1.932	Upregulated
3	1.866	10.483	17.030	1.790	5.657	7.464	Upregulated
4	1.223	6.148	10.267	1.157	3.317	5.134	Upregulated
5	1.558	5.315	8.574	1.057	2.462	2.621	Upregulated
6	3.117	1.117	1.395	1.057	1.404	2.297	Up/Down

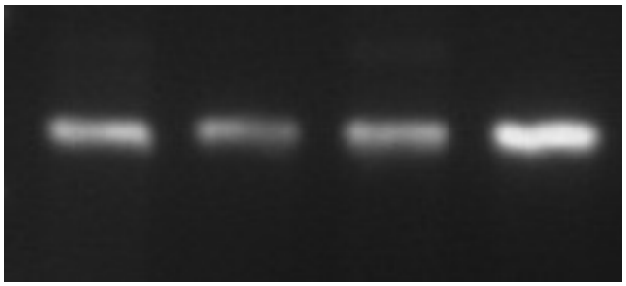


Fig. 104: Expression pattern of drought susceptible line DS-1 with primer 3

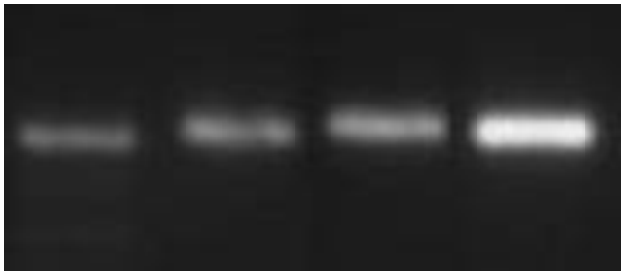


Fig. 105: Expression pattern of drought tolerant line DT-1 with primer 3

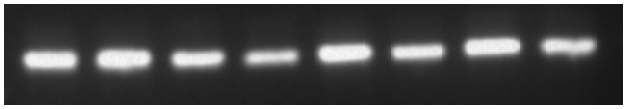


Fig. 106: Expression pattern of actin gene under control, 7 days, 14 days and 21 days of drought stress treatment. Band 1-4, DT-1 while 5-8 DS-1

PROJECT 5: Validation ofDUS Testing Guidelines of Cucurbits *i.e.*, Muskmelon and Watermelon

Sudhakar Pandey

The DUS testing characteristics of muskmelon and watermelon were validated for the various descriptor states according to the DUS minimal descriptor. The muskmelon DUS guidelines was finalized with 34 characters consisting 6 essential characters, while watermelon DUS guidelines was finalized with 27 characters consisting 8 essential characters. The final guidelines have been presented before Task force and submitted to PPV & FR Authority for notification. The Government of India notified (No. 141, SO 205 E dated 21st January, 2015) the muskmelon and watermelon guidelines for registration of *Cucumis melo* and *Citrullus lanatus* varieties.

PROJECT 6: Business Planning and Development Unit of IIVR, Varanasi

PM Singh, Neeraj Singh, SK Tiwari, S Roy, Vanitha SM and Sudhir Singh

Under component-I of NAIP, a Business Planning and Development (BPD) unit was established at IIVR, Varanasi last year for commercialization of horticultural technologies through licensing and development of technology led entrepreneurship through incubation and hand holding. The BPD unit was funded by NAIP only up to 30 June 2014. Towards the commercialization of IIVR technologies, the BPD unit has been able to execute four licences with private companies during the year 2014-15. Out of these four licences, three are for commercial multiplication and sale of seeds of varieties developed by IIVR, whereas one licence has been executed for preparation of dried green chilli powder.

PROJECT 7: New Initiatives in Protected Horticulture

SNS Chaurasia, RN Prasad, RB Yadava, Sudhir Singh, DK Singh, Anant Bahadur, MH Kodandaram, S Saha, TK Koley

Quality assessment of cherry tomato grown under nethouse and polyhouse condition: Three cultivars of

tomato 'Pusa Cherry Tomato-1 (red round), Sheeja F1 (Yellow oblong) and Rosa F1 (Red oblong) grown under both net house and polyhouse condition are evaluated for their processing qualities. Irrespective of varieties TSS was higher under polyhouse condition. Acidity varies from 0.17% to 0.29% with minimum acidity was observed in red round variety. Beta carotene (6.51 ± 0.09 mg/100g) and lycopene content (5.88 + 0.1 mg/100g) was highest in Pusa Cherry Tomato-1 cultivar under net house condition. Antioxidant activity measured through FRAP assay ranged from 4.67 to 7.41 µmol/g (Fig. 107 and 108).

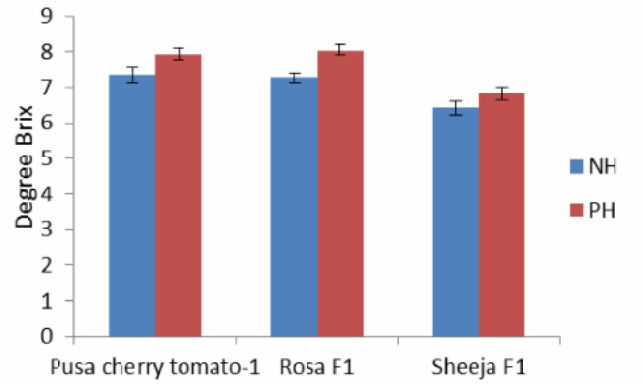


Fig. 107: TSS content of cherry tomato cultivar grown under protected condition.

Fig. 108: Different cultivar of cherry tomato harvested from protected cultivation

PROJECT 8: Network Project on Organic Farming in Horticultural Crops

RB Yadava, SNS Chaurasia, TD Lama, Sudhir Singh, Jaydeep Halder, Manjunath, M and M Loganathan

During *Rabi*, spinach (All Green) and fenugreek (Pusa Early Bunching) were grown under eight different organic treatments (**T1**- 100% FYM-N, **T2**-100% Verrmicompost-N, **T3**-75% FYM-N+biofertilizers, **T4**- 75% Vermicompost-N+ Biofertilizers, **T5**- 50% FYM-N+ Jeevamrit+ Biofertilizers, **T6**-50% Vermicompost-N+ Jeevamrit+ Biofertilizers, **T7**-50% FYM-N+ Panchgavya+ Biofertilizers, **T8**-50% Vermicompost-N+ Panchgavya+ Biofertilizers) alongwith one inorganic control receiving NPK through fertilizers. The results presented in Fig. 8 & 9 reveal that the yield of both the crops was relatively higher under organic treatments as compared to the inorganic system. In case of spinach, the total yield ranged from 204.6 to 237.7 q/ha under different organic management systems, whereas under inorganic treatment, it was found to be 197.8. Similarly, the yield of fenugreek varied from 151.9 q/ha to 185.8 q/ha under organic treatments while it was lowest (110.6 q/ha) under inorganic system (Fig. 109 & 110).

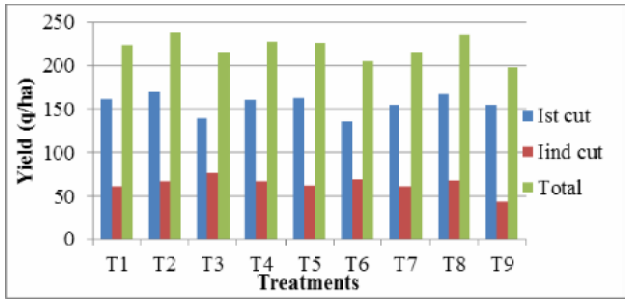


Fig. 109: Response of spinach to different organic treatments

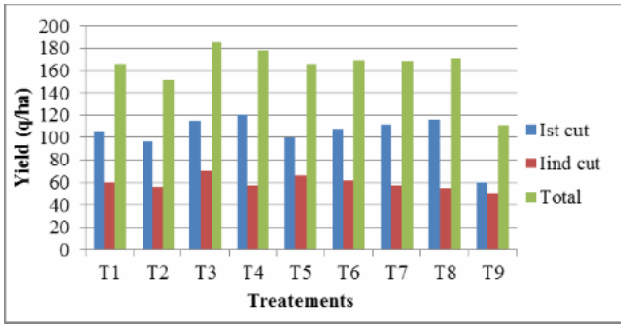


Fig. 110: Response of fenugreek to different organic treatments

PROJECT 9: Network Project on Micronutrients Management in Horticultural Crops for Enhancing Yield and Quality

RB Yadava, SNS Chaurasia, TD Lama and Manjunath M

Delineation of crop boundaries for crop specific micronutrient deficiencies: In order to identify micronutrient deficient areas for different vegetable crops, crop specific boundary maps for tomato, brinjal, okra, pea, chilli, cabbage and cauliflower were prepared using the district map (Administrative Atlas of India, Census of India 2011) and growing area information (Indian Horticulture Database, NHB 2013). These maps will be superimposed on micronutrient deficiency maps.

PROJECT 10: A Total Value Chain on Commercialization of Value Added Convenience Processed Vegetable Products

Sudhir Singh and TK Koley

Osmo-air freeze drying of pea, carrot and cauliflower: The process of instant protein rich vegetable soup mix involved osmo-air drying of green pea, carrot and cauliflower. Green pea and carrot shreds was blanched in 20% sugar syrup at 100°C for 2-3 min followed by immediate cooling in chilled water for 10-15 min while cauliflower shreds were blanched in boiling water for 15-30 sec followed by immediate cooling. Blanched peas, carrot and cauliflower shreds were cabinet dried at 50-55°C for 6-8 hrs and freeze dried at 0.042-0.062 mbar and at temperature of -92 to -98°C. Cabinet dried pea, carrot and cauliflower shreds were stored at ambient temperature of 20-25°C while freeze dried pea, carrot and cauliflower shreds were stored at low temperature of 10-15°C till further use. Initial sugar content in green pea contained 10.37-11.45% which decreased to 8.68-8.86% and 9.25-9.75% in cabinet and freeze dried samples, respectively. Carrot shreds had initial sugar content of 16.5-18.75% which decreased to 9.68-10.45% and 10.45-11.56%, respectively in cabinet and freeze dried samples, respectively. Similarly the intensity of green colour in green pea and red colour in carrot shreds was decreased during cabinet and freeze dried samples. The intensity of green colour in green pea was decreased from -12.94 to -7.6 and -11.34, and red colour in carrot shreds was changed from 4.49 to 6.56 and 3.34 in cabinet and freeze drying, respectively (Fig. 111a, b and c).

Fig. 111: (a) Freeze dried carrot; (b) Freeze dried green pea; and (c) Freeze dried cauliflower

Formulation and physico-chemical properties of instant protein rich vegetable soup mix: Instant protein rich vegetable soup mix was developed with formulation of various ingredients such as whey protein concentrate (17-30%), corn flour (7.5-12.0%), modified starch (17.5-22%), dried cauliflower shreds (2-6%), dried pea (10-12%), dried carrot shreds (3.0-6%), dextrin powder (1.5-3%), black pepper powder (0.5-5%), cumin powder (0.5-0.75%), mono-sodium glutamate (1.5-6.0%), citric acid (2.5-4%), onion and garlic powder (2.5-4% and 0.25-1.75%, respectively). Instant protein rich soup powder showed good reconstitution of 100 g powder in 1.85 litre of water. Reconstituted soup had shown good overall acceptability of 7.75-8.0 to judges on 9-point Hedonic scale. Instant soup powder mix contained moisture (4.54-4.78%), protein (13.81-15.25), insolubility index of 18-19 ml and loose and packed bulk density of 0.294-0.312 gm/cc and 0.4-0.43 gm/cc, respectively.

PROJECT 11: Network Project on Phytochemicals/High Value Compounds

TK Koley and Sudhir Singh

Metabolite profiling of black carrot: Balck carrots were evaluated for hydrophilic compounds through high resolution mass spectrometry (HRMS) in collaboration with ICAR-NRC for Grape, Pune. The major anthocyanins detected are cyanidin-based containing different sugar moieties non-acylated or acylated with acids like sinapic acid, ferulic acid or coumaric acid. Identification of each anthocyanin was made based on MS and MS/MS (fragmentation pattern) in comparison with earlier reported in the literature. 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. Similarly for other three anhocyanins (peonidin derivatives) were detected in very small amounts with the confirmatory ions m/z 301.07001 for peonidin aglycones.

***In silico* studies of potentiality of bioactive compounds of black carrot on enzymes linked with life style diseases:** Autodockvina is one of the best methods for *in silico* interaction studies and is used by many researchers to screen chemical libraries in drug

designing. In present study, we have utilised this tool for studying interactions of bioactive compounds present in black carrot with alpha amylase and alpha glucosidase which are important in glucose regulation in human body. Alpha glucosidase is strongly inhibited by acarbose therefore, we targeted acarbose binding site for docking of these bioactive compounds. In case of alpha amylase, blind docking was performed. Bioactive compounds *viz*. rutin hydrate, cyanin chloride, kuromanin chloride and quercetin 3-glucoside were found to be probable interacting partners with alpha amylase. Out of theses rutin hydrate showed strong interaction with maximum negative binding energy. Similarly in case of alpha glucosidase rutin hydrate, quercetin 3-glucoside exhibited strong interaction at binding site of acarbose and therefore could be potent inhibitor of this enzyme (Fig. 112).

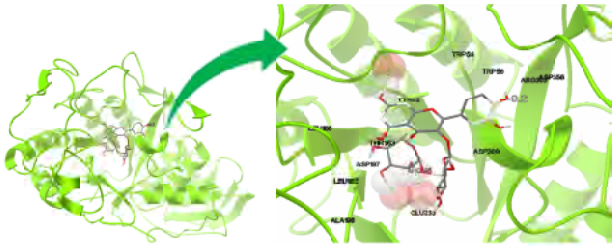


Fig. 112: Interaction of Rutin Hydrate with Alpha Amylase

PROJECT 12: Tribal Sub-Plan (TSP) For Schedule Tribes of Sonbhadra District in Uttar Pradesh

B Singh, Neeraj Singh, Shubhadeep Roy, SNS Chaurasia, TD Lama, Sudhakar Pandey, Sujoy Saha, AK Chaturvedi and Rakesh Pandey

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. ICAR-IIVR with a view to develop agriculture and allied activities in the tribal populated areas of Sonbhadra district of Uttar Pradesh initiated this project during April 2013 to ensure strengthening of agriculture and Social Status of tribes. During 2014-15 major extension activities done by the institute and the significant outcomes are as follows:

- FLDs of drought tolerant paddy cv. HUR 3022 (100 q) were conducted at 1000 tribal's field in an area of 250 ha during Kharif 2014-15 which yielded an average yield of 30.7 q per hectare in compare to conventional cultivar of only 16 q per hectare.
- The FLDs of pigeon pea cv. UPAS-120 (500 kg) were conducted at 1000 tribal's field in an area of 50 ha during Kharif 2014-15 which showed a 27.3% higher yield in comparison to the conventional cultivar (Fig. 113).
- 3200 kitchen garden vegetable seed packets (tomato, brinjal, chilli, cowpea, radish, okra & cucurbits) were provided to 1000 tribal households during 2014-15 for an area of 0.5 acre which resulted in availability of sufficient vegetables to the family along with average additional income of Rs. 600-650 per month.
- 6500 planting materials (Mango, Guava, Custard Apple, Bael, Jack Fruit & Bamboo) provided to 1000 tribal households during July 2014 (Fig. 114).
- FLDs of wheat cv HUW 234 (100 q) were conducted at 1000 tribal's field in area of 250 ha during November 2014 which fetched an average yield of 39.1 q/ha in compare to 27.23 q/ha in conventional cultivars.
- FLD of pea varieties – Kashi Uday, Azad Pea-1 and Kashi Mukti were conducted in an area of 4.0 ha in Sonbhadra districts of Uttar Pradesh under TSP showed an average increase in yield by 17.36% over local check.

Fig. 113: FLDs of drought tolerant paddy cv. HUR 3022

Fig. 114: Development of kitchen garden under TSP programme

- FLDs of Chickpea cv Pusa 362 (10 q) were conducted in 25 ha during November, 2014 which fetched an average yield of 12.7 q/ha (Fig. 115).
- 10,000 day old chicks of improved bred from CARI, Baraily along with 15 days starter feed and nutrients were provided to 600 households for backyard poultry in 14 tribal villages of Dhakudandi and Padrach Gram Shabha in Sonbhadra under TSP during Octobe-December 2014 (Fig. 116).

PROJECT 13: Development and Validation of Effective Formulation(s) of Plant Growth Promoting Rhizobacteria (PGPR) Having Multicide Mechanisms for Pest Management in Vegetables

AB Rai, Sujoy Saha, Jaydeep Halder, Manjunath M, C Sella Perumal, Neeraj Singh

Rhizospheric bacteria were isolated from tomato (*cv*. DVRT1) and chilli (*cv*. Pusa Jwala) plants by serial dilution method using nutrient agar medium. Morphologically distinct colonies, 26 from tomato (Fig. 117) and 25 from chilli were selected and purified by quadrant streak plate method. The purified bacteria were grown on nutrient agar slants and kept at 4^0C for further use. The bacterial isolates were screened for their plant pathogen suppressing ability, insecticidal, nematicidal and phosphorus solubilization activity. Three pathogens *viz. Sclerotium rolfsii* Sr1, *Sclerotium rolfsii* Sr3 and *Alternaria alternata* were used as target pathogens. After preliminary screening of 26 isolates from tomato, two isolates TRB-

Fig. 115: FLDs of wheat cv HUW 234

Fig. 116: Developing backyard poultry under TSP programme

4 and BS-2 proved to be the most effective ones. TRB-4, was found inhibitory to the mycelial growth of *Sclerotium rolfsii* isolate Sr-1, *Sclerotium rolfsii* isolate Sr-3 and *Alternaria alternata* to the extent of 48.88 %, 80% (after 3 days) and 57.14% (after 4 days) respectively over the control. BS-2 registered similar values of 91.32%, 90.62% and 60.32% respectively (Table 79, 80 and Fig 118). Isolates were screened for their insecticidal activity by Leaf residue method (dipping for 20 sec followed by air-drying). Four isolates i.e. BS-2, TRB 1, 6 and 7 were effective against *Lipaphis erysimi* (Table 81). Nematicdal activity was tested using culture filtrate of 48h old cultures of the bacterial isolates with

Table 79: Screening of bacteria from tomato rhizosphere against *Sclerotium rolfsii Sr-1*

S. No.	Bacterial isolates	Mycelial inhibition (%)		S. No.	Bacterial Isolates	Mycelial inhibition (%)	
		After 1 day	After 3 days			After 1 day	After 3 days
1	TRB-1	5.71	0	14	TRB-14	5.71	0
2	TRB-2	14.28	0	15	TRB-15	8.57	0
3	TRB-3	20	0	16	TRB-16	11.42	0
4	TRB-4	22.85	48.88	17	TRB-17	42.85	6.66
5	TRB-5	5.71	0	18	TRB-18	1.85	4.5
6	TRB-6	25.71	0	19	TRB-19	0	0
7	TRB-7	22.85	0	20	TRB-20	0	0
8	TRB-8	11.42	0	21	TRB-21	0	0
9	TRB-9	14.28	0	22	TRB-22	0	0
10	TRB-10	14.28	0	23	TRB-23	16.66	0
11	TRB-11	17.14	0	24	TRB-24	13.88	0
12	TRB-12	28.57	0	25	TRB-25	44.44	22.22
13	TRB-13	0	0		BS2	45.61	91.32
				26	Control	0	0

Table 80: Screening of bacteria from tomato rhizosphere against *Sclerotium rolfsii* Sr3

Sl No.	Bacterial isolates	Mycelial inhibition (%)		S. No.	Bacterial Isolates	Mycelial inhibition (%)	
		After 1 day	After 3 days			After 1 day	After 3 days
1	TRB-1	25.92	0	14	TRB-14	0	0
2	TRB-2	21.42	16.66	15	**TRB-15**	**55.71**	**47.77**
3	TRB-3	45.71	37.77	16	TRB-16	7.4	0
4	**TRB-4**	**80.00**	**80.00**	17	TRB-17	11.11	0
5	TRB-5	29.62	28.88	18	TRB-18	0	0
6	TRB-6	0	2.22	19	TRB-19	14.81	0
7	TRB-7	45.71	16.66	20	TRB-20	14.28	6.66
8	TRB-8	45.71	18.88	21	TRB-21	0	0
9	**TRB-9**	**71.42**	**66.66**	22	TRB-22	0	0
10	**TRB-10**	**44.44**	**44.44**	23	TRB-23	0	0
11	TRB-11	18.51	0	24	TRB-24	3.7	0
12	TRB-12	22.22	0	25	**TRB-25**	**14.81**	**54.44**
13	TRB-13	0	0		**BS2**	**43.44**	**90.62**
				26	Control	0	0

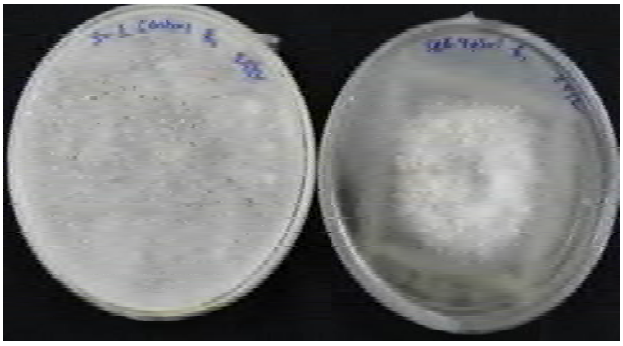


Fig. 118: Inhibition of mycelial growth of Sclerotium rolfsii (sr1) by TRB-4

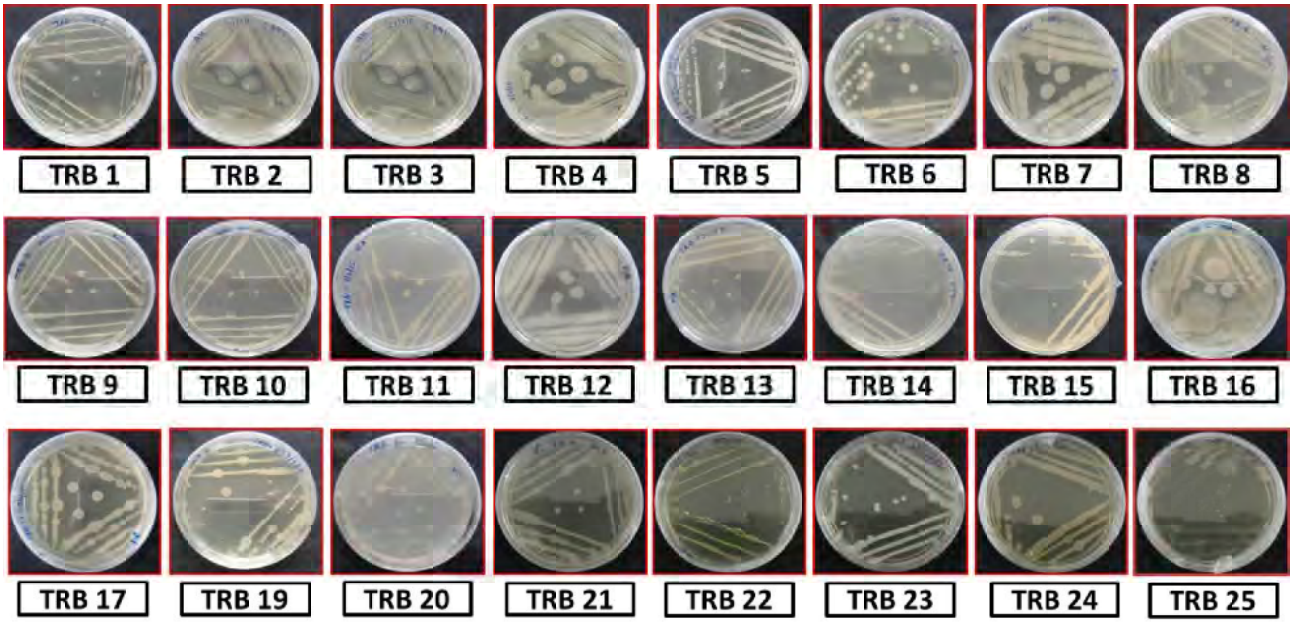


Fig. 117: Rhizosheric bacteria from tomato

Table 81: Bioefficacy of different bacteria isolates against *Lipaphis erysimi* Kalt.

Bacteria	Mortality over control (%)		
	48 hr	72 hr	96 hr
TRB-2	22.22	30.56	36.11
TRB-5	33.33	36.11	41.67
TRB-8	33.33	38.89	44.44
TRB-9	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
BS-2	40	46.67	73.33
SEM ±	2.32	0.87	1.5
CD (P=0.05)	5.91	2.22	3.84

Table 82: *In vitro* screening of bacterial isolates against *M. incognita*

Different Isolates	% mortality after 24 hr of exposure
TRB 1	8.2
TRB 2	0.0
TRB 3	0.5
TRB 4	**32.5**
TRB 5	1.2
TRB 6	5.3
TRB 7	8.7
TRB 8	5.7
TRB 9	0.5
TRB 10	11.6
B. pumilis	15.7
B. licheniformis	**18.4**
BS-2	12.6
Media (Control1)	0.5
Dist H2O (Control 2)	0.0

Table 83: Screening of bacterial isolates from tomato rizhosphere for phosphorus solubilization

S. No.	Bacterial isolates	Phosphorus solubilization		S. No.	Bacterial Isolates	Phosphorus solubilization	
		+/_	Clear zone (cm)			+/_	Clear zone (cm)
1	TRB-1	-		14	TRB-14	-	
2	TRB-2	-		15	TRB-15	+	0.85
3	TRB-3	+	0.9	16	TRB-16	-	
4	TRB-4	+	0.45	17	TRB-17	-	
5	TRB-5	+		18	TRB-18	+	0.6
6	TRB-6	+	1	19	TRB-19	-	
7	TRB-7	-		20	TRB-20	+	0.45
8	**TRB-8**	**+**	**1.3**	21	TRB-21	-	
9	TRB-9	+	0.7	22	TRB-22	-	
10	TRB-10	+	1	23	TRB-23	-	
11	TRB-11	-		24	TRB-24	-	
12	TRB-12	-		25	TRB-25	+	1
13	**TRB-13**	**+**	**1.1**	26	Bs2	+	0.4
					Control	-	O

Juveniles (J_2) of *Meloidogyne incognita* on multi well plates, the isolates TRB 4 and *Bacillus licheniformis* were found effective (Table 82). Two isolates *viz.* TRB-8 and TRB 13 were found to be positive for phosphorus solubilization and made clear zone of 1.3 and 1.1 cm respectively on Pikovskaya's agar medium (Table 83 and Fig 119). Further, screening of tomato isolates against *Fusarium oxysporum* f. sp. *lycopersici* and chilli isolates against *Sclerotium rolfsii* Sr1, *Sclerotium rolfsii* Sr3, *Alternaria* sp. and other insects and nematodes is in progress.

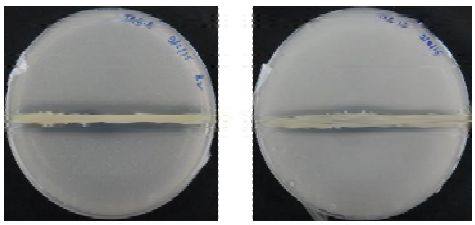


Fig. 119: Solubilisation of phosphorus by tomato rhizospheric bacteria

PROJECT 14: Establishment of Association of Begomovirus Species with Yellow Vein Mosaic Disease (Yvmd) in Wild and Cultivated Species of Okra and Identification of Source of Resistance to the Most Predominant Virus

V Venkataravanappa and SK Sanwal

Survey for collection of wild germplasms of okra: Roving survey was conducted during 2013-14 for collection of wild and cultivated germplasms of okra in Maharashtra (Mumbai), Madhya Pradesh (Rewa and Satna), Uttar Pradesh (Sonebhadra) and Bihar (Samastipur and Patna) states of India. Total 140 samples collected, out of these 20 belongs to wild germplasms of okra, which belong to *A. tetraphyllus*, *A. knaf* and other unidentified okra wild species. The remaining 120 samples are cultivated okra plants are showing the symptoms of yellow vein mosaic and enation leaf curl disease from Madhya Pradesh (Rewa and Satna), Uttar Pradesh (Sonebhadra) and Bihar (Samastipur and Patna), Gujarat (Surat) respectively.

Molecular characterization of begomoviruses associated with yellow vein mosaic (YVMD) and enation leaf curl disease (OELCuD) of okra

a. PCR detection of begomoviruses associated with YVMD and OELCuD

Total of 346 samples collected from Haryana, Odisha, Punjab, Rajasthan, Bihar, Madhya Pradesh,

Gujarat and Uttar Pradesh were analysed for the presence of begomoviruses using PCR with primers specific to the DNA-A/DNA-A-like components of begomovirus genomes that are known to infect malvaceous plants. Out of these, 62 samples comprised of non-symptomatic and leaves showing diverse symptoms of wild (15 samples) and cultivated (47 samples) were selected for further characterization primarily based on the geography and distribution of okra fields. The full length genomes of the begomvirus was amplified by PCR using specific primers for DNA-A (2.7kpb), betasatellites (1.3kb) and alphasatellites(1.34kp) respectively. The amplified products were cloned and sequenced. The sequences were analyzed using bioinformatics tools such as Clustal-X program, Bioedit Sequence Alignment Editor (version 5.0.9) and MEGA 6.01 software.

Genome organization

1. Begomoviruses infecting cultivated and wild species of okra

a. DNA –A-like sequence

The complete nucleotide sequences of 47 isolates (DNA-A -like sequence) ranged from 2709 to 2754nt). The majority of clones that had predicted genes typical of old world begomoviruses with respect to size and position are concern. The details of genome organization all begomoviruses consist of seven open reading frames (ORFs), The two ORFs Precoat protein (AV2) and Coat protein (AV1) in viral sense strand, five ORFs Replicase (AC1), Transcriptional Activator protein (AC2), Replication enhancer protein (AC3), AC4 and AC5) in all the yellow vein mosaic isolates. The intergenic noncoding region lies between starts codon of ORF AC1 and ORF AV2 in all isolates characterized in study.

The phylogenetic tree generated using 47 sequences characterized from cultivated okra species and 35 monopartite and bipartite begomoviruses infecting different crops available in the GenBank database. As expected from the pairwise similarity analyses, newly characterized sequences grouped with previously identified species namely BYVMV, OELCuV, MeYVMV and OYVMV. A total of 28 sequences are showed more genetic similarity to the OELCuV strain from Gandhinagar clustered together. Five formed a phylogroup with OELCuV isolates from Haryana, India (GU111996) and ten isolates formed a phylogroup with MeYVMV (FN645922, KJ462074) isolates from Haryana, India. One new isolate is clustered with okra-infecting monopartite begomoviruses (OELCuV) (Fig. 120).

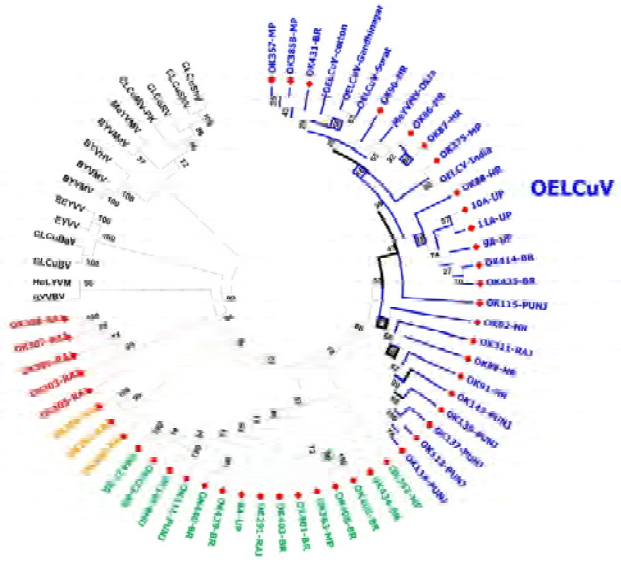


Fig. 120: Phylogenetic tree generated using 47 sequences characterized from cultivated okra species

b. Betasatellites

Total 61 cultivated okra samples showing yellow vein mosaic and enation leaf samples were used for characterization of sub genomic component (Betasatellites). The complete nucleotide sequence of betasatellites of the different isolates ranged from 1331 to 1357nt. The sequences contain all the features typical of DNA betasatellites, a region of sequence rich in adenine, a single predicted gene in the complimentary sense (âC 1) with the capacity to encode a 118 amino acids with a predicted molecular weight of 12.98 kda and a region of sequence conserved across all betasatellites (known as the satellite conserved region). The satellite conserved region is approximately 142 bp and contains at its 3' end a predicted hairpin structure having a loop with the sequence TAATATTAC similar to the origin of replication of geminiviruses.

The phylogenetic tree generated using 61 betasatellites sequences characterized in the present study and 61 different betasatellites sequences isolated from different crops are available in the GenBank database is presented in fig. 121. As expected from the pairwise similarity analyses, newly characterised sequences grouped with previously identified species namely BYVB, OELCuB, LuLDB and RaLCuB. A total of 17 sequences are showed genetic similarity to the BYVB strain from Barrackpore clustered together. Twenty one isolates formed a phylogroup with OELCuB isolates from Gandhinagar, Haryana, India (KJ437509, GU111981) and ten isolates formed a phylogroup with LuLDB (FJ159272) isolate from Vizianagaram in South India.

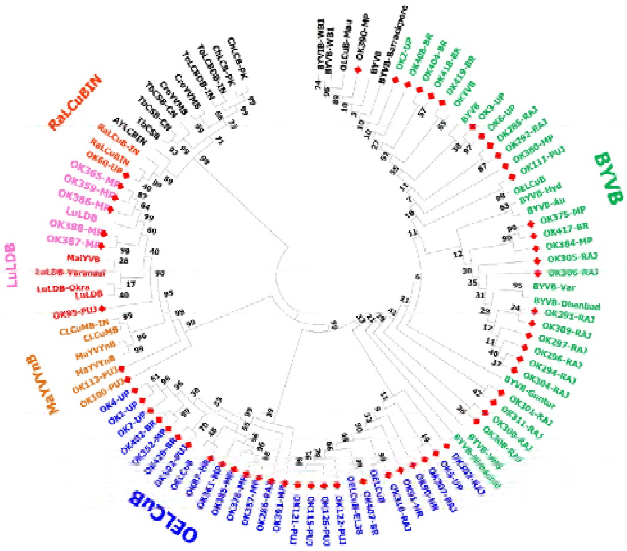


Fig. 121: Phylogenetic tree generated using 61 betasatellites sequences

Natural Screening of wild and cultivated species of okra against YVMD and OELCuD: Total 729 okra genotypes (wild and cultivated) were screened under natural epiphytotic conditions against yellow vein mosaic disease of okra. The experimental was laid out, four rows of each genotype in three replications with 60 cm row to row and 20 cm plant to plant distance and two rows of susceptible check (*cv*. Pusa sawani) were sown to provide adequate virus source to the vector. All the recommended cultural practices were followed to raise the crop in good condition and no plant protection measures were followed. Data on disease scoring was collected on an individual plant basis at the end of the cropping season based on the 0-5 scale. None of the cultivated species are free from yellow vein mosaic and only seven wild species i.e. A. enbeepeegeerense (IC-582757), A. *canaf, A. monihot* and three unknown species collected from Rajasthan and one unknown species collected from Odisha are showed free from the virus infection.

PROJECT 15: Outreach Programme on *Fusarium* Wilt of Tomato and Chilli

M Loganathan, V Venkataravanappa and S Saha

Pathogenic variation in *Fusarium* isolates through amplification and sequencing of *endo polygalacturonase* gene: Seventeen isolates of FOL confirmed by ITS sequences were subjected to PCR with *endo* polygalacturonase gene specific primer PGLENDO-F (CCAGACTGCGCATACCGATT) and PGLENDO-R (AAGTGTTGGTAGGATAGTTG) amplification. Out of 17 isolates of FOL, 13 showed positive amplification with *pgl* (*endo* polygalacturonase gene) primer and yielded 1.5 kb gene fragment. The fragments were eluted, cloned in plasmid and sequenced. All sequence information's submitted to NCBI and obtained accession numbers (Table 84). To compare the evolutionary relationship among the *endo polygalacturanase* gene of *F. oxysporum* f.sp. *lycopersici* a phylogenetic tree was constructed. The tree showed major two clusters, in which one *Fusarium* isolate (FWT 77) was in one group and rest of the isolates were in another major cluster. In the later one was having two sub clusters comprising two isolates FWT71 and FWT5 in one and rest all in other

Table 84: List of FOL isolates showed PCR amplification with *endo* polygalacturonase gene

S No.	Isolate	Organism	ITS sequence Accession no	*Pgl* Acc no
1.	FWT-5	*Fusarium oxysporum* f.sp. *lycopersici*	KC478624	KP404100
2.	FWT-8	*Fusarium oxysporum* f.sp. *lycopersici*	KC478622	KP404101
3.	FWT-15	*Fusarium oxysporum* f.sp. *lycopersici*	KC478640	KP404102
4.	FWT-20	*Fusarium oxysporum* f.sp. *lycopersici*	KC478621	KP404112
5.	FWT-56	*Fusarium oxysporum* f.sp. *lycopersici*	KC478635	KP404103
6.	FWT-60	*Fusarium oxysporum* f.sp. *lycopersici*	KC478634	KP404104
7.	FWT-71	*Fusarium oxysporum* f.sp. *lycopersici*	KC478633	KP404105
8.	FWT-77	*Fusarium oxysporum* f.sp. *lycopersici*	KC478626	KP404106
9.	FOL-3	*Fusarium oxysporum* f.sp. *lycopersici*	KC478618	KP404107
10.	FOL-14	*Fusarium oxysporum* f.sp. *lycopersici*	KC478631	KP404108
11.	FUSVNS-1	*Fusarium oxysporum* f.sp. *lycopersici*	KC478620	KP404109
12.	FUSVNS-3	*Fusarium oxysporum* f.sp. *lycopersici*	KC478629	KP404110
13.	FUSCO-3	*Fusarium oxysporum* f.sp. *lycopersici*	KC478630	KP404111

Identification of races in *F. oxysporum* f.sp. *lycopersici*: For identification of races in FOL isolates, tomato differentials (Bonny Best-susceptible line; UC82-L-Resistance to race 1; MH1-Resistance to Race 1 and Race 2; I3R1-resistance to Race 3) were imported from AVRDC, Taiwan. Seed multiplication of the same is in progress.

Host plant resistance: Grafting with resistance root stock is an easy technique to import resistance in desirable cultivar. Hence a brinjal root stock (EG219) resistance to *Fusarium* wilt, bacterial wilt and nematode was imported from AVRDC, Taiwan. Standardized grafting technique to establish seedlings with brinjal as root stock and tomato (cv. Kashi Amman) scion.

IDM: Different components such as talc based formulation of *Trichoderma* isolates (Phyto 1-15) two fungicides and botanicals (Datura and Garlic extracts) have been evaluated against *Fusarium* wilt of chilli and tomato under field conditions. In tomato, all the *Trichoderma* isolates showed significant reduction of wilt severity, however, Phyto 13 (Table 85) followed by Phyto 1, Phyto 3, Phyto 7, Phyto 4 showed significantly higher yield than other treatments and others. Chilli trial is in progress.

Table 85: Effect of biocontrol agents, botanicals and chemicals on *Fusarium* wilt and yield of tomato under field conditions

S. No.	Treatment	Wilt incidence (%)	Yield Q/ha
1.	Phtyo-1	8.78 (17.21)	221.10
2.	Phyto-2	10.34 (18.71)	188.78
3.	Phyto-3	9.71 (18.14)	217.03
4.	Phyto-4	8.30 (16.74)	202.40
5.	Phyto-5	7.99 (16.31)	171.64
6.	Phyto-6	12.31 (20.54)	196.68
7.	Phyto-7	10.04 (18.46)	214.06
8.	Phyto-8	11.06 (19.41)	156.86
9.	Phyto-9	11.87 (20.11)	183.42
10.	Phyto-10	11.75 (20.02)	151.00
11.	Phyto-11	13.55 (21.58)	167.93
12.	Phyto-12	13.87 (21.85)	157.62
13.	Phyto-13	11.22 (19.57)	240.15
14.	Phyto-14	10.49 (18.91)	198.65
15.	Phyto-15	11.99 (20.22)	159.50
16	Carbendazim+mancozeb	10.11(18.51)	196.24
17.	Carbendazim	11.19 (19.54)	163.90
18.	Datura extract	8.57 (17.02)	152.13
19.	Garlic extract	10.25 (18.62)	146.30
20.	Control	22.87 (28.53)	138.82
	CD 5%	2.14	11.11
	CV	14.16	16.19

PROJECT 16: Synthesis and Validation and Sustainable and Adaptable IPM Technologies for Cucurbitaceous Vegetables

Jaydeep Halder, S Saha, B Mahesha and C Sellaperumal

The major IPM technology that followed in bitter gourd fields of selected farmers in the villages Mahagaon, Araziline (Sultanpur) Varanasi and Basratpur, Mirzapur for the management of insect pests and diseases is as follows - Seed treatment with *Trichoderma* @ 5g/kg of seed; spraying of neem @ 5 ml/lit against red pumpkin beetle; installation of cue lure traps for fruit flies for wider area management @ 10/acre; wooden plywood blocks were dipped in solution of Ethanol : Cuelure : Insectcicide (DDVP) @ 8:2:1 for 48 hours; raking of soil for exposing fruit fly to sunlight and predatory fauna; need based application of insecticides like Malathion @ 2 ml/lit or Deltamethrin @ 0.75 ml/lit or *Bt* @ 2 g/lit against cucumber moth, *Diapahnia indica* in bitter gourd, need based application of systemic fungicides Metalaxyl+Mancozeb against mildews *viz*., powdery mildew and downy mildew. It has been recorded that the IPM adopted fields suffered lowest fruit fly damage as compared to Non-IPM fields where farmers' practices were followed. In case of bitter gourd the fruit damages were 12.87 per cent which were significantly lower than the Non-IPM fields (23.12%). Same trend was also observed in case of cucumber moth and Hadda beetle infestations on bitter gourd. Only 11.39 *Diaphania indica* larvae per plant were recorded IPM adopted fields where the corresponding value for non-IPM fields was 23.56 per plant. IPM adopted fields also harboured minimum hadda beetle population (3.75/plant) than the non-IPM fields.

In contrast, natural enemy population recorded highest in number on IPM adopted fields as compared to farmers' practices and untreated control. Number of lady bird beetle, spiders population were higher (5.87, 3.27 numbers per plant) in IPM adopted fields than the non-IPM fields (1.53, 0.87). The IPM farmers registered higher B:C ratio (1:2.19) as compared to the non-IPM farmers (1:1.70).

Nematological studies revealed that the regions are mostly infected with root knot nematode (RKN) in cucurbitaceous vegetables. The population range is more than ETL (at 2-3 nematodes/g of soil) have been observed in many fields. The other phytonematodes *i.e. Rotylenchulus reniformis*, *Pratylenchus* spp and *Tylenchorhynchus* sp were also encountered and seems to be attacking the vegetables.

Similarly, pathological studies showed that Downy mildew caused by *Pseudoperonospora parasitica* is the major, in all the locations. Three applications of Metalaxyl 8% + Mancozeb 64%-72WP @ 2.5g/litre of water were done and significant disease reduction was observed only after the second and third spray. In case of bitter gourd, maximum disease reduction was observed in Mahgaon followed by Basaratpur with PDI values of 7.35 and 8.67 respectively.

PROJECT 17: NICRA Project on Real Time Pest Dynamics (RTPD) in Tomato

MH Kodandaram, S Saha and AB Rai

Real time pest surveillance was carried out in tomato crop at nursery and fields of IIVR main centre

and ten fixed farmer fields covering two districts viz., Varanasi and Mirzapur during Kharif and Rabi seasons. Real time data on insect pest and disease incidence was recorded for 21 weeks (from 29 to 3rd standard weeks) and 23 weeks (36 to 13th standard weeks) for Kharif and Rabi seasons, respectively under both protected and unprotected conditions at IIVR main center. 26 weeks (from 39th to 12th standard weeks) pest observations was recorded at fixed farmers' field. Daily weather parameters were also recorded for entire cropping season. All real-time data collected were uploaded in the NICRA client software maintained by NCIPM, New Delhi.

Fig. 122: Tomato Leaf Curl showing different symptoms

During kharif Season, bacterial leaf spot is the major problem at the nursery and 40% of the plants succumbed due to the disease. Damping off was also present, but the incidence (18%) was lesser than that of bacterial spot. In the main field condition there was no significant difference in case of viral maladies in both protected and unprotected conditions. Leaf curl (11.61%) and mosaic (10.95%) incidence was slightly lesser in protected condition than that of unprotected condition where they registered a value of 13.61% in both cases (Fig. 122). The reason could be due to high relative humidity i.e. 78-86% during December to January, 2014-15 which was conducive to the disease. The temperature ranges of 15-20°C also favored the development of the disease. The incidence of early blight was 11.53% in unprotected condition while in protected condition it was approximately 8%. The relatively low incidence of early blight may be attributed to low rain fall during October – December, 2014. Bacterial spot incidence was relatively low in both protected and unprotected condition as compared to nursery stage. Among insect pests, aphid and whitefly were major sucking pests observed with average number of 3.27/spot and 2.46/spot in protected fields, whereas in unprotected fields the average number was 3.99 and 3.17, respectively.

Fig. 123: Tomato Mosaic Disease

During Rabi Season at main field, both damping off and bacterial spot incidence was high at nursery stage. Light showers with a humidity of 69-70% predisposed the plant towards the diseases. Early blight was the major disease in the main field condition both in protected and unprotected conditions, with incidence of 15.2% and 26% respectively. Although rainfall was present in February, late blight incidence

Fig. 124: GBNV infected plant

was not very high and 7.26% incidence was observed in unprotected condition. The incidence of leaf curl was almost same as that of Kharif, in both protected (11.04%) and unprotected (14.3%) conditions. However mosaic incidence was lower than that of Kharif season. Bacterial spot incidence in the main field was sporadic and negligible. During rabi season, the infestation of aphids (3.68/spot) and whitefly (2.98/spot) in unprotected field was relatively high as compared to Kharif season, indicating higher incidences of leaf curl and mosaic diseases. The highest trap catches of *Spodoptera litura* (91 moth/trap) and *Helicoverpa armigera* (34 moth/trap) was recorded during 48 and 5 SMW, respectively.

Fig. 125: Early Blight of Tomato

At fixed farmer fields, early blight is the major constraint in all the locations and disease incidence ranged from 19.1% to 25.3%. The highest incidence was in Chaudharipur (25.36%) followed by Movaiya (24.40%) and Mangraha (24.16%). In comparison to early blight, late blight incidence was considered low with maximum incidence being in Arazilines (6.29%) Parsupur recorded a minimum incidence of 0.78% late blight. The incidence of bacterial spot was more or less similar in all the 10 locations ranging from 0.83% to 1.46%. Both the viral diseases i.e. leaf curl and mosaic had almost same trend of incidence in all the locations. Highest incidence of leaf curl was in Choudharipur (13.7%) while that of mosaic was in Nakkupur (12.3%). This may be correlated with high infestation of whitefly in these villages during the rabi season. The major insects pests recorded at fixed fields were whitefly (3.11/spot), aphids (4.09/spot) and leaf miner (3.04/spot) at Prasupur, Mangraha and Araziline, respectively. However the incidence of *Spodoptera litura* larvae was not so high with maximum of 1.95 larvae/spot at Marahach and Parsupur village. The highest trap catches of *H. armigera* (23 moth/trap) and *S. litura* (134 moths/trap) was recorded during 48 and 49 SMW, respectively at Marahach village similar to main center when the average temperatures were 26.5 °C (Fig. 123, 124 and 125).

All India Coordinated Research Project
(Vegetable Crops)

Achievements of All India Coordinated Research Project on Vegetable Crops

During the year 2014-15, 1471 trials were conducted at 29 regular centres and 28 voluntary centres of AICRP on Vegetable Crops (Table 86)

Table 86: Details of the trials conducted during 2014-15 through AICRP (VC)

Trials		No. of Trials	No. of trials conducted by the centre
Crop Improvement	Plant Genetic Resources	26	75
	Varietal trials	52	614
	Hybrid trials	45	371
	Resistant varietal trials	8	128
Crop Production	Vegetable production trials	24	95
	Seed production trials	20	59
	Physiology & biochemistry trials	7	17
Crop Protection	Integrated pest management	15	49
	Integrated Disease management	10	63
Total			**1471**

The following recommendations under Crop improvement, Crop production and Crop protection were made during 32nd Group Meeting of AICRP (VC) held at IGKV, Raipur from 24-27 June, 2014 (Table 87,88 & 89).

Vegetable Improvement

Table 87: Varieties identified for release and notification

Crops	Name of entry	Actual Name	Source	Rec. Zone
Kale	2011/KLVAR-4	KTK-64	IARI,RS, Katrain	I (J&K,H.P. and Uttarakhand)
Cauliflower (early)	2011/CUEVAR-2	SECF-102	BAU, Sabour	VII (M.P., Maharashtra and Goa)
Cauliflower (early)	2011/CUEVAR-5	DC-31	IARI, New Delhi	IV (Punjab, U.P., Bihar and Jharkhand)
Tomato (Indeterminate)	2011/TOINDVAR-5	DARL-68	DIBER, Pithoragardh	III (Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunachal Pradesh and Andaman & Nicobar Islands)
Tomato (Determinate)	2011/TODVAR-1	Punjab Ratta	PAU, Ludhiana	IV (Punjab, U.P., Bihar and Jharkhand)
Ash Gourd	2011/ASGVAR-3	DAG-12	IARI, New Delhi	VIII (Karnataka, Tamil Nadu, Kerala and Pondicherry)
Chilli	2011-CHIVAR-9	LCA-620	APHU, Lam	V (Chhattisgarh, Orissa and A.P.)

Hybrids Trials

Table 88: Hybrids identified for release and notification

Crop	F_1 Hybrid	Original name	Source	Rec. Zone
Okra	2011/OKHyb-7	JOH-0819	JAU, Junagadh	VI (Rajasthan, Gujarat, Haryana and Delhi) & VII (M.P., Maharashtra and Goa)
Brinjal Long	2011/BRL Hyb-6	PBHL-52	PAU, Ludhiana	IV (Punjab, U.P., Bihar and Jharkhand)
Tomato Det.	2011/TODHyb-2*	-	Krishidhan	I (J&K,H.P. and Uttarakhand)
Tomato Det.	2011/TODHyb-6	Improved Bhagya	Nuziveedu Seeds	IV (Punjab, U.P., Bihar and Jharkhand), VII (M.P., Maharashtra and Goa)

**Code could not be opened as the testing fee not paid by the source company.*

Table 89: Resistant Variety identified for release and notification

Crops	Entry	Original Name	Source	Zone recommended
Okra	2011/OKYVRES-4	VRO-25	IIVR	IV (Punjab, U.P., Bihar and Jharkhand)

Vegetable Production

Integrated Nutrient Management

1. In Broccoli, the maximum head yields (104.37 q/ha) with higher B:C ratio (2.90) was obtained at **Hyderabad** with application of Poultry manures (5.0 t/ha) along with half recommended NPK.
2. Application of recommended dose of NPK (50:30: 50 kg/ha) gave the maximum fruit yield of 330.2 q/ha with BC ratio of 3.92. This can be recommended for bottle gourd (BBOG 3-1) under **Bhubaneswar** conditions.

Micronutrient studies

3. Micronutrient study in tomato conducted at **Kalyanpur** demonstrated that 3 foliar sprays of Multiplex (Commercial formulation) @ 4 ml/lit. of water produced the maximum fruit yield (264.64 q/ha) with highest B:C (2.96).
4. **At Bhubaneswar**, in Broccoli (cv. CBH 1), application of boric acid + MnSo4 @ 100 ppm each, three sprays at 10 days interval from 30 days after transplanting gave the maximum yield of 192.72 q/ha with higher BC ratio (3.5)
5. **At Hyderabad**, in Broccoli, application of three foliar sprays of boric acid + copper sulphate in Rabi season gave maximum head yield (112.54 q/ha) and B:C ratio (3.64). Micronutrient study in cowpea (Kashi Kanchan) at **Faizabad** revealed that treatment comprising 3 foliar sprays of molybdenum (50 ppm)+ soil application of sulphur (15 kg/ha) exhibited maximum pod yield of 108.68 q/ha with B:C ratio (2.03).

Organic vegetable production

6. At **IIVR**, the maximum green leaf production (161.17 q/ha) in amaranth was recorded with application of FYM (20 t/ha) + PSB and Azospirillum (each at 5 kg/ha), whereas at **Faizabad** the maximum yield to the tune of 204.65 q/ha was noticed under recommended NPK practice (100:50:50 kg/ha).

Protected cultivation

7. Experiment conducted at **Srinagar** on two cherry tomato cultivars with two spacing revealed that cultivar NS 6667 produced maximum mean fruit yield (771.1 q/ha) and B:C (3.52) when spaced at 100 x 45 cm and also pinched and trained.

Drip irrigation

8. Experiments on drip irrigation scheduling in broccoli concluded at **IIVR** and **Durgapura** revealed that drip irrigation at alternate day with 100% of Pan Evaporation (PE) registered maximum head yield (122.4 q/h and 149.1 q/ha respectively) and BC ratios (2.45 and 3.29 respectively) at both centres.
9. In hybrid tomato, at **IIVR** and **Srinagar** drip irrigation scheduled at 0.7 bars coupled with black plastic mulching gave maximum fruit yield

of 820.9 and 927.83 q/ha respectively with the BC ratio of 2.85**. At Coimbatore,** drip irrigation scheduled at 0.5 bars coupled with black plastic mulching noticed maximum fruit yield of 796.5 q/ha with the BC ratio of 2.80 in hybrid tomato CO 3.

Inter-cropping

10.Experiments on intercropping of vegetables with seed spices were concluded at **Durgapura** and **IIVR**. At both the centres, the maximum vegetable equivalent yield and income was generated under Carrot + Fennel or Carrot + Ajwain cropping system. **At Hyderabad**, intercropping in carrot with fennel recorded higher yield of 250.7 q/ha with BC ratio 1.63.

Seed Production

1. Based on three years data from **PAU, Ludhiana**, it is recommended that sowing the palak cv. All Green in the month of October and with one cutting recorded maximum seed yield (29.31q/ha), 100 seed weight (1.46g), seedling vigour index-I (1166.03) and seedling vigour index-II (1.34).
2. Based on three years data from **PAU, Ludhiana**, it is recommended that treat the seeds of bottle gourd cv. Punjab Komal with Potassium dihydrogen phosphate 10^{-1}M for 24 hours before sowing to get maximum seedling emergence (81%) and seedling dry weight and vigour indices
3. Based on three years data from **PAU, Ludhiana,** it is recommended to treat the seeds of bitter gourd cv. Punjab-14 with Potassium dihydrogen phosphate 10^{-3}M /GA_3 100 ppm for 48 hours before sowing to get maximum germination (78.89%) and seedling vigour indices.
4. On the basis of three years data from **Solan**, it is recommended to treat the seeds of pea cv. before sowing with combination of carbendazim(@ 2g/kg + Imidacloprid@2m/kg+ Micronutirent mixture @20g/kg to increase germination (81.87%) .The growth parameters such as roots, shoot length, dry weight as well as seedling vigour –I and II were also better with this treatment.
5. On the basis of three years data from **Solan**, it is recommended to treat pea seed cv. Azad Pea-1 either with plant extracts of *Mentha piperata, Allium sativum, Tagetes erecta, Curcum longum* or *Adhatoda vasica, A.cepa* @ 30% to control the storage fungi during storage of seed.
6. On the basis of three years data from **PAU, Ludhiana**, it is recommended to treat pea seed cv. Pb.-89 either with plant extracts of *Allium sativum, Melia azadirachta, vitex negunda* and *Allium cepa* @ 30% to control the storage fungi of pea
7. Based on pooled data of two years on hybrid seed production of okra (Seed parent Ankur-40 and pollen parent Arka Anamika) under **IIHR, Bangalore** conditions, it is recommended that simultaneous emasculation at yellow bud stage on the day of anthesis before dehiscence and pollinating with yellow bud stage pollen is the easiest and efficient pollination method for higher seed yield of 57% and saving in the time taken for crossing of 65% over the conventional method of crossing.

Vegetable Protection

Integrated Disease Management

1. Foliar spray of Difenconazole (0.05%) for three times at 10 days interval from initiation of disease was effective to control anthracnose (*Colletotrichum capsici*) disease (86.6%) in chilli (Utkal Rashmi) and the treatment recorded with maximum BC ratio (1:2.32) at **Bhubaneshwar** and the similar treatment was effective at **Sabour.**
2. Foliar spray of 0.1% Dimethomorph (50% WP)+0.2% Mancozeb (75% WP) for three times at 10 days interval was effective to control early blight (*Alternaria solani*) by 44.72% and late blight (*Phytophthora infestans*) by 65.36% in tomato at **Kalyani** and the treatment recorded highest BC ratio of 1:2.93
3. IDM including, use of white nylon net (40-60 mesh) and soil application of neem cake @ 0.5kg/m^2 in nursery, border crop with two rows of maize and seedling dip of Imidacloprid 0.5ml/l for 60 min followed by four sprays at 10 days interval, first spray with Acephate @ 1.5 g/l + Neem oil 2 ml/l, second spray with Fipronil @ 1.5 g/lit + Neem oil 2 ml/l, third spray with Imidacloprid @ 2 g/ 15l + Neem oil 2 ml/l and fourth spray with Acephate @ 1.5 g/l + Neem oil 2 ml/l under main field, recorded with significant less *Tospo virus* incidence (14.82%) in comparison to control (46.77%) as well as high BC ratio 1:2.89 in tomato (cv. Dhanashree) at **Rahuri.**
4. Application of Streptomycin sulphate (100 ppm) as seed treatment and two foliar sprays starting

from initiation of disease was effective to control 59.2% disease severity of black rot of cabbage (cv. Golden acre) and the treatment recorded the maximum BC ratio 1:2.65 at **Kalyani**.

Insect Pest Management

Brinjal

1. In brinjal for the management of leaf hoppers and shoot and fruit borer *Leucinodes orbonalis*, IPM module comprising of seedling root dip with imidacloprid 17.8 SL @ 1 ml/lit for three hours before transplanting, sowing of maize as border crop, installation of sex pheromone traps @ 100 traps/ha, clipping of infested shoots at weekly interval from 20 days after transplanting and spray of azadirachtin (1500 ppm) @ 3 ml/l and triazophos 40 EC @ 2ml/l alternately twice at an interval of 10 days starting from flowering gave 83.61 and 71.91% reduction in leafhopper and fruit damage, respectively and 38.85% increase in yield over control with maximum 1:21.64 ICBR and 1:1.95 B:C ratio at **Rahuri** conditions.

Okra

2. Foliar application of thiamethoxam25 WG @ 0.35 g/l and spiromesifen 22.9 SC @ 0.8 ml/l proved to be most effective against jassids, *Amrasca bigutulla bigutulla* and whitefly, *Bemisia tabaci* with 39 and 33.53% reduction in the population, respectively as compared to untreated control and recorded lowest incidence of YVMV (22.41%) with 110% increase in yield and maximum ICBR of 1:76.31 at **Anand** conditions,

3. Spraying of thiamethoxam 25 WG @ 0.35 g/l was found superior for the control of jassids, *Amrasca bigutulla bigutulla* (71.05 % reduction) on okra with higher yield (184 q/ha) and cost benefit ratio (1.43 :1.0) under mid hill conditions of **Solan, Himachal Pradesh**.

4. Diafenthiuron 50 WP @ 1g/l and buprofezin 25 SC @ 1 ml/l were most effective against leafhoppers *Amrasca bigutulla bigutulla* with 46.11% and 46.54% reduction, respectively. For whitefly *Bemisia tabaci*, thiamethoxam 25 WG @ 0.35g/l and spiromesifen 22.9 SC @ 0.8 ml/l were found effective with 47.10% and 37.05% reduction. Highest marketable fruit yield with 60.70% increase as compared to untreated control was obtained in diafenthiuron treatment at **IIVR, Varanasi** conditions.

Chilli/Capsicum

5. Chlorfenapyr 10 SC @ 1.5g/l proved to be most effective followed by emamectin benzoate 5 SG @ 0.35g/l against chilli yellow mites, *Polyphago tarsonemus latus* with 69.95 and 63.06 per cent reduction over untreated control. For thrips, *Scirothrips dorsalis* fipronil 80 WG @ 0.35g/l and emamectin benzoate 5 SG @ 0.35g/l were found highly effective with 75.41 and 67.68 per cent reduction of thrips population with highest yield and net returns at **IIVR, Varanasi** conditions.

6. Spray of imidacloprid 200 SL @ 0.5 ml /l was found superior for the control of aphid, *Myzus persicae* on capsicum (*cv.* Bharat) grown under protected cultivation with higher fruit yield (164.0 q/ha) as well as cost benefit ratio (3.07: 1.0) under mid hill conditions of **Solan, Himachal Pradesh.**

Cabbage

7. Pest management module consisting of spray of imidacloprid 200 SL @ 0.5 ml/l at 20 DAT followed by spray of indoxacarb 14.5 SC @ 0.5 ml/l at 30 and 60 DAT and spray of rynaxpyr 18.5 SC @ 0.3 ml/l at 15, 45 and 75 DAT found to be most effective against cabbage aphid, *Brevicoryne brassicae* and gave higher yield (252.6 q/ha) and cost benefit ratio (2.72 : 1) under mid hill conditions of **Solan, Himachal Pradesh**.

Bitter gourd

8. Installation of cuelure baited traps @10 traps / acre and application of bait spray (jaggery solution 100 g + malathion @ 2 ml/l at 250 spots /ha) at 15 days interval from flowering reduced the fruit fly, *Bactrocera cucurbitae* damage to 18-20 % as compared to control with highest yield (21.3 t.ha) during kharif at **Solan**.

Breeder Seed Production

Through Breeder seed production programme conducted under the AICRP (VC) during the year 2013-14 (as indent for 2014-2015), 23033.450 kg breeder seed have been produced against 6502.780 kg indent for 112 varieties in 35 vegetable crops by 21 coordinating centres. During the year 2014-15, an indent of 6893.750 kg breeder seeds for 108 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 under taking the production. Final production details are awaited.

Krishi Vigyan Kendras

ICAR- KRISHI VIGYAN KENDRA, SANT RAVIDAS NAGAR

Trainings Programmes

During 2014-15, KVK organized 39 need based training programmes on various aspects of production and protection technologies of cereals, oilseeds, pulses, vegetables, fruits, soil health, livestock and fisheries involving 834 practicing farmers and farm women. Three (03) employment generating, skill oriented training programmes were conducted for 50 rural youths (Table 90).

Table 90: Training programmes organized by KVK Sant Ravidas Nagar

Clientele	No of Training Programmes	Beneficiaries
Practicing farmers and farm women	39	834
Rural Youths	03	50
Total	**42**	**884**

Frontline Demonstration

554 frontline demonstrations were conducted in an area of 54.06 ha. In addition deworming in sheep & goat was carried out in 219 animals (12 farmers) to avoid endoparasitic load and maintain proper animal health. The details are given here under in Table 91.

The demonstrated varieties are well established due to its higher yield and better economic traits in adopted & neighboring villages (Fig. 126). The important crops *viz.* paddy CSR-36 in salt affected area occupied 35% share. Similarly wheat varieties KRL-19 & KRL-213 (recommended for usar soil), HD-2733, HD-2985, HD-2967 (recommended for normal soil) were adopted in 40, 19, 45, 40 and 45% area, respectively. Presently the pigeon pea variety NA-2 is grown in 45%, mustard variety Pusa Bold in 35% and cowpea variety Kashi Kanchan received 25% area of the adopted villages.

The low cost technology viz. the application of zinc sulphate @ 25 kg/ha to control khaira disease & enhance yield in paddy and application of wettable

Fig. 126: Field Day on Paddy (CSR-36)

Table 91: Frontline Demonstration conducted by KVK Sant Ravidas Nagar

Sl. No.	Crop	Varieties	Area (ha)	Beneficiaries	Yield (q/ha.)		% increase over local
					Demo.	Local	
1	Paddy	CSR-36	5.00	35	54.2	42.5	27.5
		P-834	0.65	06	50.43	40.28	4.52
		P-2511	2.00	10	53.79	35.60	40.69
		PRH-10	5.83	34	56.98	54.50	4.55
2	Wheat	KRL-19	3.00	22	26.55	20.30	30.79
		KRL-213	2.00	15	28.20	20.30	38.92
		HD-2733	2.00	11	32.75	22.40	46.21
		HD-3059	0.40	04	26.60	22.40	18.75
		HD-2985	2.00	13	31.50	22.40	40.62
		HD-3086	0.80	07	29.30	22.40	30.80
		HD-2967	1.20	06	34.12	22.40	52.32
3	Maize	Aishwarya	1.00	16	29.83	25.73	15.93
4	Bajra	Anmol-111	2.00	12	23.50	16.70	40.70
5	Mustard	Pusa Tarak	1.50	07	12.90	12.71	1.49
		Pusa Vijay	4.00	42	13.21	12.71	3.93
		Narendra Rai (ND-8501)	2.50	20	16.21	12.71	27.53
6	Pigeonpea	NA-2	5.00	40	8.10	5.30	52.83
7	Chickpea	Pusa 362	3.00	50	13.40	10.22	31.11
8	Lentil	L-4076	0.325	10	4.20	3.10	35.48
		L-4147	0.60	16	3.90	3.10	25.80
9	Chilli	Kashi Anmol	2.50	34	148.3	128.6	15.32
10	Veg.pea	Kashi Udai	2.50	75	106.2	85.6	24.10
11	Spongegourd	Pusa Pragati	0.163	05	90.00	74.00	21.62
		IVSG-1	0.50	11	198.2	152.5	29.46
12	Berseem	Vardan	0.512	14	715	620	15.32
13	Oat	JHO-822	1.075	20	590	510	15.68
14	Sesame	Pragati	2.00	19	8.90	7.10	26.8
15	Sheep & Goat	Deworming in sheep & goat	219	12	-	-	-
Total			**54.06**	**554**			

sulphur @ 20 kg/ha in mustard are being adopted to an extent of 72.5 and 22% area, respectively. The percent increase yield was recorded 10-12 and 6-8%, respectively.

Technology Assessment & Refinement

- Root weevil infestation in paddy is a major problem particularly in water logged areas. To overcome this problem, an OFT was conducted at five farmer's fields. Seedling treatment with chlorpyriphos @ 3 ml/lit of water and soil application of cartap hydrochloride @ 20 kg/ha reduced the weevil population up to 3.13 larvae and seedling treatment with chlorphyriphos @ 3 ml/lit of water and soil application of fipronil @ 20 kg/ha reduced the weevil population 5.20 larvae in comparison to farmer's practice (32.53 larvae).
- In another on farm trial on management of little leaf disease in brinjal, best result was obtained from the treatment with seedling treated for 20-30 minutes with (Streptomycin sulphate + tetracyclin hydrochloride) @ 150 ppm + destroy the infected plant parts + need based foliar application of streptomycin sulphate + tetracycline hydrochloride @ 150 ppm + imidacloprid @ 0.3 ml/l + installation of yellow sticky trap @ 5-8/ha. The percent plant infested was observed as 28.58 in comparison to 57.63 in farmers practice with corresponding yield 481.02 q/ha and 328.81 q/ha respectively.
- A nutritional garden was designed to get vegetables round the year from 300 m^2 area. Different types of vegetables namely leafy (34 kg), root crops (84 kg), cole crops (73.9 kg), leguminous (4.76 kg), bulbs (47 kg) and others (14.9 kg) were obtained during rabi season. As a result farmers get variety of vegetables for their family during winter season whereas only few in control group.
- In order to improve the quality & quantity production of wool, 10 Merino cross breed lambs were provided to sheep owners for cross breeding among local sheep. The yield of quality wool was 950 g/head in cross bred as against 790 g/head in local breed. The wool was white, fine and 6-8 cm long in cross bred, while it was brown, coarse and 4-6 cm long in indigenous sheep.
- To enhance the kidding size of indigenous goat, selective breeding in 11 flocks, having higher kidding size *i.e.*, twins/triplets was reared for future progeny. The single producing/ born, parents/kids were sold out as when needed by the goat keepers. After about 2 years, the average number of kids born was 139 in selected group while it was 116 in control group per 100 numbers. Rearing of continuous selected stock of higher kidding size will enhance more as proceeding of age.
- To control mastitis in high yielding Murrah buffaloes (>12 lit/day), Vit E and Selinium was supplemented in ration, 30 days before and 60 days after calving. The mastitis was not reported in treated buffaloes; however, 10% buffaloes were infected where no treatment was given.

Extension Activities

KVK planned and executed 05 field days (152 beneficiaries), 02 kisan gosthi (121 beneficiaries), 47 field visit (170 beneficiaries), 73 scientist's visit to farmer's fields, 73 diagnostic visit, 204 farmers visit to KVK, 01 exposure visit, 02 agri-exhibitions, 117 advisory services to sensitize and make farmers aware about the new technological options to raise the productivity of different enterprises. The Mass Media Coverage included 02 Radio talks, 10 TV talks and 66 periodical news in various news papers (Fig. 127).

Field Day on Vegetable Pea (Kashi Udai)

Kisan Mela at KVK, Bhadohi

Fig. 127: Extension activities of KVK, Sant Ravidas Nagar

ICAR- KRISHI VIGYAN KENDRA, DEORIA

Training Programmes

During 2014-15 need based 76 training programmes were organized by the KVK on promotion of high yielding varieties in cereal, oilseed, pulses, vegetable & fruit crops, promotion of farming system approach for sustainable agriculture, entrepreneurship development, promotion of self help groups, integrated pest management, integrated nutrients management, beekeeping, zero energy cool chamber, value addition, drudgery reduction, resource conservation technology etc. in which 1613 farmers & farm women had participated (Fig. 128).

Fig. 128: Off Campus Rural Youth Training on Agarbatti Making

For income generating activities to the rural youth/school dropouts, 19 on/off campus vocational training were also organized in which 265 rural youth had participated. Apart, 04 training courses were organized for extension functionaries of the district in which 89 extension functionaries were participated (Table 92).

Table 92: Training Programmes organized by KVK Deoria

Sl. No.	Training	No of courses	No. of participants
1	Practicing Farmers	76	1613
2	RY/ school dropouts	19	265
3	Extension functionaries	4	89

Frontline Demonstration

Considering the agro climatic condition of the district, FLDs were conducted on oilseeds, pulses, cereals, fodder, resource conservation technologies (DSR, zero tillage sowing of wheat and sowing on raised bed), vegetables and zero energy cool chambers at 329 farmers' fields in 70.26 ha area (Fig. 129). Under Fodder crops FLDs were conducted at 25 farmers' field in 4.74 ha area. To check post harvest losses of fruits & vegetables during storage, zero energy cool chambers were demonstrated at 5 farmers/ farm women field and one at KVK campus to popularize the technology (Table 93).

Fig. 129: FLD on Cowpea (Var. Kashi Kanchan)

Technology Assessment and Refinement

On the basis of problems diagnosed, following 07 OFTs on pest and disease management, integrated nutrient management, integrated crop management, drudgery reduction and kitchen gardening were conducted at 48 farmers' field for assessment and refinement of technology (Fig. 130 and 131).

Fig. 130: Field Visit at Farmer Field

I. Application of Bio-fertilizer in paddy was assessed at five farmers field. Use of Blue Green Algae+120 kg N+ 60 kg P_2O_5 + 40 kg K_2O/ha gave maximum (56.3 q/ha) yield in paddy whereas without Blue Green Algae+120 kg N+ 60 kg P_2O_5 + 40 kg K_2O/ha 49.6 q/ha yield was obtained.

II. Application of sulphar in rabi onion was assessed at ten farmer fields. Use of sulphar @ 22 kg +120 kg N+ 60 kg P_2O_5 + 60 kg K_2O/ha gave maximum yield i.e. 290 q/ha in paddy and

Table 93: Frontline demonstrations conducted by KVK, Deoria

Sl. No.	Crop	Name of Technology Demonstrated	Area (ha)	No. of Farmer	Yield (q/ha)		Increase over local check (%)	B:C Ratio	
					Demo	Local		Demo.	Local
1.	Pigeon pea	Sowing on raised bed system (Narendra Arhar 1)	7.8	26		12.5	39.2	2.9:1	2.1:1
		HYV(Pusa 2002)	0.4	2	18.7	12.5	49.6	3.0:1	2.1:1
	Lentil	HYV(Pusa Vabhav)	0.6	03	19.8	16.9	17.8	3.5:1	3.1:1
		HYV(Pusa Shivalika)	0.72	05	17.8	16.9	17.1	3.1:1	3.1:1
2.	Mustard	HYV(Pusa Vijay)	2.48	9	20.4	16.2	25.9	2.5:1	2.0:1
		HYV(Pusa Tarak)	1.6	4	21.8	16.2	34.5	2.7:1	2.0:1
		HYV(M 27)	12	30	18.3	16.2	12.2	2.2:1	2.0:1
3.	Paddy	Narendra-359	14	5.4	57.1	56.1	1.6	4.0:1	2.0:1
		Pusa-44	07	2.4	56.2	55.6	1.0	2.9:1	1.8:1
		Pusa-834	05	1.4	34.6	34	0.5	1.7:1	1.1:1
		HYV (JK RH 401)	3.12	9	61.8	58.2	6.1	2.2:1	2.0:1
		Introduction of scented rice (PRH 10)	2.4	6	654.1	61.8	5.33	2.2:1	1.8:1
4.	Wheat timely sown	HYV (HD2733)	1.6	4	57.6	49.2	17.07	2.7:1	2.3:1
		HYV (HD 3086)	1.2	3	56.2	44.2	27.4	2.6:1	2.07:1
		HYV(HD 2967)	0.8	2	58.7	44.2	32.8	2.7:1	2.0:1
		HYV(HD 2967)	3.0	6	57.2	53.6	6.7	2.4:1	2.3:1
		HYV(HD 2733)	2.0	4	56.7	46.2	22.7	2.4:1	2.0:1
		HYV (DBW 17)	3.5	7	56.1	48.7	15.1	2.4:1	2.1:1
		HYV(PBW 502)	1.5	3	49.6	46.2	7.3	2.1:1	2.0:1
	Wheat late sown	HYV (HD 2985)	2.0	5	41.2	38.4	7.27	2.0:1	1.9:1
		HYV (HD 3059)	0.4	1	49.2	42.4	14.9	2.3:1	2.0:1
5.	Bottle gourd	HYV (Narendra Rashmi)	0.5	12	236	160	47.7	5.08:1	3.22:1
	Cowpea	Seed treatment with Bio- control agent Trichoderma @ 5 gm/kg seed + use of trichoderma in field @ 5kg/ha	1.0	19	123	115	6.96	1.87:1	1.83:1
		Seed treatment with Bio- control agent Trichoderma @ 5 gm/kg seed + use of trichoderma in field @ 5kg/ha	1.0	24	131	118	11.01	2.15:1	2.04:1
		HYV (Kashi Kanchan) in Zaid 2014	1.0	19	121	93	30.11	3.81:1	2.97:1
		HYV (Kashi Kanchan) in kharif 2014	1.0	22	108	88	22.7	4.4:1	3.6:1
		HYV (Kashi Harit)	0.5	16	312	230	35.65	4.48:1	3.48:1
	Tomato	Use of resistant variety+seed treatment with imidacloprid @ 2.5g/per kg + Spray of imidacloprid @ 0.3 ml/liter of water	1.0	12	351	300	17.0	5.30:1	4.82:1
	French bean	HYV (Kashi Param)	0.5	3	116	80	36.47	4.7:1	3.3:1
	Brinjal	Regular clipping of infested twigs fruits + use of pheromone trap@ 100 trap/ ha + spray of Ranyxpyr @ 150 ml/ha)	1.0	15	295	251	17.5	5.68:1	5.22:1
	Vegetable pea	HYV (Kashi Udai)	0.31	2	98.3	73	26.2	5.2:1	4.2:1
		HYV (Kashi Nandani)	0.31	6	95.8	78	22.82	5.1:1	4.2:1
		HYV (Kashi Pragati)	0.125	4	94.6	78	21.28	5.1:1	4.2:1
	Okra	HYV (Kashi Pragati)	5	9	138	104	32.69	3.58:1	2.73:1
	Potato	HVY (Kufari Pukharaj)	0.22	6	406.2	355	14.42	3.5:1	3.2:1
		HYV (Kufari Arun)	0.14	3	382.5	285.4	34.40	3.4:1	2.5:1
		HYV (Kufari Khyati)	0.02	1	410	355	15.45	3.5:1	3.2:1
		HYV (Kufari Chip Sona)	0.02	1	325.6	272	19.70	2.8:1	2.4:1
TOTAL			**80.26**	**329**					

Fig. 131: Director ICAR-IIVR Visited FLD on Brinjal (Kashi Sandesh)

without sulphar +120 kg N+ 60 kg P_2O_5 + 60 kg K_2O/ha it was only 261 q/ha.

III. OFT on management of fruit fly through IPM in bottle gourd was conducted at 3 farmers' field. The treatment was farmer practices (use of chemical pesticide) and IMP technologies i.e. use of pheromone trap @ 50/ha. + spray of 1500 ppm neem oil + spray of imidaclorprid @ 0.5 ml/liter water. It was observed that 68 fruit flies was trapped in pheromone trap and 16 % fruit damage was observed in IPM technology whereas 22 % fruit damage was recorded in farmer practices and 13.03% yield was increased over farmer practices.

IV. Chilli crop is severely affected by leaf curl disease; therefore an OFT on seed and seedling treatment with imidaclorpid along with farmer practices was conducted at nine farmer's fields. Disease incidence of leaf curl was observed up to 9 % in seed and seedling treated field while 22% in farmer practices (no seed and seedling treatment). Similarly the green chilli yield of 128 q/ha was obtained in seed and seeding treated field while 104q/ha was recorded in farmer practices.

V. Trial on seed treatment of wheat with Azotobacter @ 200 gm/10 kg seed and use of NPK liquid fertilizer (19:19:19) resulted in yield increase of the wheat by 4.3% and 5.1 %, respectively.

VI. Trail of nutritional kitchen garden was organized at 10 farmers / farm women fields to assess production of vegetables in kharif, rabi, zaid season, 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 area, 1456 g/day vegetables can be harvested which would fulfill 97.06% of the vegetables requirement of 5 members (1500 g/day) @ 300 g/day/member.

VII. Wheat harvesting is a major problem and it is done mostly by the farm women. Harvesting of crops is to be done timely and carefully otherwise the matured grains shatter from the panicle. Trial on harvesting of Zero tillage sown wheat was conducted by improved serrated sickle for drudgery reduction. The results indicate that use of Naveen Darati increased working efficiency by 9.77 % during harvesting of wheat.

Extension Activities

For horizontal spread of scientific technology 12 village level field days on different agriculture crops and 17 kisan gosthi were organized in which 282 farmers/farm women and 1826 farmers/extensions personal respectively had participated (Fig. 132). Apart from 15 diagnostic visits by KVK scientist, 9 SHG were formed for different income generation training programmes which 127 SHGs women member were benefited. This KVK continuously send 42 agriculture related voice message to 100 registered farmers. 250 members of 25 kisan club get regular knowledge and skill improvement training from the KVK scientist during above mentioned period and 30 news were covered in different local news paper.

Fig. 132: Field Day on Wheat

KRISHI VIGYAN KENDRA, KUSHINAGAR

Training Programmes

KVK, Kushinagar organised 102 need based on and off- campus training programmes under human resource development comprising diverse aspects of production and protection technologies of cereals, oilseeds, pulses, vegetables, livestock, soil health management and value addition, household food security, rural craft and women empowerment benefitting a total of 2804 participants including 395 female and 2409 male farmers, rural youth and extension functionaries (Fig. 133 & Table 94).

Fig. 133: Need based on and off- campus training programmes

Table 94: Training Programmes organized by KVK, Kushinagar

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	94	2119	351	2470
Rural youths	4	52	23	75
Extension functionaries	2	28	21	49
Sponsored Training	2	210		210
Total	**102**	**2409**	**395**	**2804**

Frontline demonstration

Front line demonstrations were conducted in 66.38 ha area at 306 farmers field on wheat, mustard, toria, lentil, maize, cowpea, cauliflower, Paddy, onion, oyster mushroom, maize Sheller and nutritional garden (Table 95).

Table 95: Frontline demonstration at KVK, Kushinagar

Enterprise	No. of farmers	Area (ha)	Units / Animals
Oilseeds	67	25	
Pulses	21	3.5	
Cereals	134	27.15	
Vegetables	31	3	
Total	**253**	**58.65**	
Other enterprises	53	7.73	3
Total	**53**	**7.73**	**3**
Grand Total	**306**	**66.38**	**3**

Technology assessment and refinement

During the reporting period KVK, Kushinagar conducted seven on-farm trials (OFT) for assessment of technologies at 64 farmer's field on paddy, sugarcane and nutritional security (Table 96).

Table 96: On-farm trials for assessment of technologies at KVK, Kushinagar

Category	No. of technology Assessed & Refined	No. of trials	No. of farmers
Technology assessed			
Crops	6	59	59
Other enterprises	1	5	5
Total	**7**	**64**	**64**

Biological management of borers in sugarcane

Sugarcane is an important commercial crop of District Kushinagar. However, there is high incidence of borer infestation due to lack of awareness and indiscriminate use of pesticides resulting in high yield losses. KVK, Kushinagar conducted an on-farm trial to assess the eco-friendly control measure of borer using trichocards i.e. 2 card/ acre or 50000 eggs/ha reduced the percentage of pest infestation from 8.6, 14.2 and 10.3 to 4.7, 4.4, and 3.9 respectively for top borer, inter node borer and stalk borer. Yield increased by 37.72 per cent.

Effect of seed treatment in rice diseases management

KVK conducted an on-farm trial to see the effect of seed treatment, a practice not so common among the concerned masses against various diseases prevalent in the region. A maximum of 14.1 % increase in yield was observed with seed treatment of tebuconazole. Seed treatment with carboxin + thiram was most efficient as the least blight and brown spot percentage was recorded as 3.9 and 7.3 while 3.2 and 1.7 % disease incidence was recorded in seed treatment with tebuconazole.

Performance of paddy transplanter vs. manual transplanting in paddy

An on-farm trial on performance of paddy transplanter was conducted in transplanted rice under both puddled and unpuddled conditions with manual transplanting as check. Using paddy transplanter under puddled conditions maximum yield of 4.62 t/ ha was obtained with a B: C ratio of 2.71 followed by unpuddled i.e. 4.16 t/ha as compared to manual transplanting i.e. 3.45 t/ha.

Nutrient management in paddy

KVK also assessed the technology of nutrient management in paddy and it was found that application of 90 kg N, 50 kg P, 40 kg K, application of sulfur 20 kg /ha and green manuring with sesbania gave highest yield of 33.40 q/ha besides improving soil health.

Varietal evaluation of scented rice

KVK assessed the technology of introducing and evaluation of different scented rice varieties in Kushinagar. The variety Pusa Sugandha- 5 was found best suited for the farmers in this district due to short duration and average yield of. 45.35 q/ha as compared to 40.75 q/ha of Pusa Sugandha- 6 and 30.05 q/ha of Kala Namak 3

Varietal evaluation of paddy under upland condition

A varietal evaluation of paddy was conducted under upland conditions. The variety Sarjoo 52 was found most suitable due to short duration and highest yield i.e. 28.46 q/ha and this variety is becoming more popular among the farmers of the area.

Nutritional Garden for nutritional security

An on farm trial on nutritional garden was conducted in Zaid 2014 in 3 villages and it was found that systematic nutritional garden gave higher yield of vegetables i.e. 348 kg while the farmer practice gave the yield of vegetables only 291 kg from the nutritional garden and net saving of Rs. 1880 was obtained.

Other Extension Activities

To expedite the process of transfer of technology programme KVK, Kushinagar, organized two kisan gosthi with a participant of 172 farmers, advisory services was provided to 1427 farmers (Fig. 134). Eighteen field days were organized covering 643 farmers for demonstration of technologies (Table 97). One kisan mela was organized and 8 others were attended by the KVK personnel benefitting 6100 farmers. A total of 1030 farmers benefited from 936 diagnostic visits of KVK personnel in upgrading their knowledge and skill. Two self help group of 21 members were formed. In addition extension services were provided through 5 TV talk, 1 Radio talk, 40 news items and 3 popular article.

Fig. 134: Kisan Gosthi organized by KVK, Kushinagar

Table 97: Performance of frontline demonstration conducted by KVK, Kushinagar

Sl. No.	Crop	Variety	Area (ha)	No. of Farmers	Yield (q/ha)		% increase in yield
					Demo	Local	
1	Mustard	Pusa mahak	8.0	25	8.50	7.45	14.10
2	Mustard	NDR- 8501	4.0	13	8.45	7.50	12.67
3	Toria	PT- 303	13	29	7.05	4.80	46.87
4	Lentil	HUL- 57	3.5	21	8.25	5.45	51.38
5	Paddy	Line transplanting HYV BPT 5204	1.0	3	45.15	40.25	21.73
		Improved variety BPT 5204	1.0	3	27.33	19.45	40.51
		Improved variety P 44	0.5	05	36.25	23.25	55.91
		Hybrid PRH 10	1.5	04	37.25	24.35	52.98
		Improved variety P 2511 (PS 5)	5.0	42	39.55	23.35	69.38
6	Maize	HYV. Hybrid (BIO 9637)	10.0	60	62.65	47.95	30.66
7	Cauliflower	Seasonal vegetable HYV Sabour agrim	1.0	8	223.5	198.6	25.37

Institutional Activities

TRAINING PROGRAMMES AND OTHERS

ADG (Seeds), ICAR Visited ICAR-Indian Institute of Vegetable Research, Varanasi

Dr. J.S. Chauhan, ADG (Seeds), ICAR, New Delhi visited the ICAR-Indian Institute of Vegetable Research, Varanasi on 30th December, 2014. He visited the demonstration block and appreciated the technologies developed by the Institute. Dr. Chauhan interacted with Dr B. Singh, Director, and scientists regarding research activities of the institute. He visited brinjal, chilli, tomato breeding block and seed production block and was highly impressed by the varieties and advance lines developed by the institute. During his visit to transgenic glass house he appreciated the transgenic lines developed at institute for abiotic stress tolerance.

Kisan Mela Organized at Krishi Vigyan Kendra, Bejwan, Sant Ravidas Nagar

A Kisan mela and agricultural exhibition was organized at KVK Bejwan, Bhadohi on 23rd Feb. 2015, where Hon'ble MP, Bhadohi, Sri Virendra Singh (Chief Guest); Director, IIVR, Varanasi, Dr Bijendra Singh; Coordinator of KVKs Dr R N Prasad; DDA (Ag), DHO, CVO, Manager Lead Bank and other officials of line

departments participated. A joint team of 08 Scientists from Pusa, IARI, New Delhi, CIRB, Hissar and IVRI, Bareilly also participated in Kisan Mela. About 600 farmers, farm women and rural youths actively assembled. Twenty stalls were setup from official / private companies e.g. Department of Agriculture, Horticulture, A.H. & Veterinary Services, Fisheries, Food Processing, Irrigation & Water Resource Management, Dayal Fertilizer, Bayer Crop Sciences, Indofil, Natural Remedies, etc. where they displayed their technologies. The chief guest emphasized to promote the dairy and poultry farming, fruit and vegetable production to eradicate the poverty and generate employment. Director, IIVR, Varanasi advised KVKs to work in collaborative manner for the welfare of rural people. The officials of district line departments threw the light on welfare schemes pertaining to the farmers. The distinguished scientists delivered talk on production and protection technologies on various aspects of agricultural and animal husbandry. The interactive session was held in context to milk production, buffalo farming and artificial insemination to improve the dairy breed, production of quality seed, organic farming and loan facilities from Lead Bank by the guest speakers of various related departments.

Deputy Director General (Crop Science), ICAR Visited ICAR-IIVR, Varanasi

ICAR-Indian Institute of Vegetable Research, Varanasi warmly welcomed Dr. S.K. Dutta, Deputy Director General (Crop Science), ICAR, New Delhi on December 28th, 2014. Dr. Dutta was greeted and briefed about the activities and achievements of the institute. He interacted with scientists of the institute and discussed the issues like constraints in hybrid seed production and commercialization of the technologies. The DDG (CS) expressed his concern over the competition posed by the private sector in vegetable production.

The DDG (CS) was overwhelmed with the basic, strategic and applied research work being carried out

at the institute. He visited the farm area and keenly observed the progress of research on an array of crops being carried over by the institute. Dr. Dutta appreciated the biotechnological interventions being used by the institute to overcome various constraints in vegetable production. He was very happy to see the transgenic lines developed at IIVR using gene constructs Cry *1 Ac, Cry 1 Aa3*, for insect resistance and *Bc ZAT12* and *AtDREB 1A* for abiotic stress.

National Farmers' Fair cum Vegetable showcasing organized at ICAR-Indian Institute of Vegetable Research, Varanasi

Smt. Durgawati Devi, Gram Pradhan of Jayapur village which is located about 4 km from the Institute presided over the inaugural function. Being a representative of the village adopted by Hon'ble Prime Minister under Sansad Aadarsh Gram Yojana, she welcomed all the farmers. She highlighted the contribution of IIVR in the development of vegetable cultivation in this region which has led to improved productivity and income generation for the farmers. She emphasised on the adoption of modern production technologies developed by various research organization to make agriculture more profitable.

Dr. N. K. Krishna Kumar, Deputy Director General (Horticultural Science), Indian Council of Agricultural Research, New Delhi in his inaugural address, highlighted that horticulture fetches higher income, thus more and more farmers are shifting to this sector

from traditional cultivation. He emphasized that more focus should be on development of new varieties of vegetables suitable for diverse and changing climatic conditions. Further, he voiced his concern that despite having plentiful irrigation facilities, vegetable production in the eastern region is less as compared to states like Maharashtra and Gujarat having limited irrigation facilities. He urged farmers to follow scientific water management practices to produce more crops per drop.

He highlighted the need to promote cultivation of hybrid varieties for increasing production. There is also a need for establishment of radio station dedicated to agriculture for dissemination of information related to vegetable cultivation in particular and horticulture as a whole. Speaking about the 'Swachh Bharat Abhiyan' initiated by Hon'ble Prime Minister, he pleaded farmers to make their villages clean and plastic free.

Earlier, Dr. B. Singh, Director, IIVR, Varanasi welcomed the farmers, dignitaries and participants and informed the gathering about the activities and achievements of the institute.

More than 50 stalls related to vegetables, potato, onion, garlic, seeds, fertilizer, animals, fisheries, etc. displayed by various research Institutes under the aegis of ICAR, Agricultural Universities, Government, NGOs and Private Sectors. More than five thousand farmers from different states participated in the fair.

Four progressive farmers, Deepak Mandal (West Bengal), Santosh Kumar (Bihar), Manjeet Singh Saluja (Chattisgarh) and Baijnath Mahto (Jharkhand) at National level and 4 farmers, Bindra Prasad, Chavi Raj Prasad, Ram Raksha Singh and Mukesh Kumar Singh at the state level have been honoured during the fair on the basis of merit.

This fair was organized on 30th and 31st January 2015 by Indian Institute of Vegetable Research in collaboration with Association for Promotion of

Innovations in Vegetables (APIV) to educate the farmers regarding agricultural gamut and modern vegetable production technologies.

ICAR-IIVR Celebrates 85th ICAR Foundation Day in the Tribal Belt of Sonbhadra District of Uttar Pradesh

85th ICAR foundation day was celebrated on 16th July, 2014 at Dahakudandi village of Chopan block of Sonabhadra district in UP. The celebration was attended by about 700 farmers. Indian Institute of Vegetable Research has adopted 1000 tribal households in Chopan block of Sonbhadra district under Tribal Sub Plan (TSP) programme for improving their nutritional and livelihood securities. The major activities under TSP are distribution of improved seeds of drought resistant varieties of cereals, pulses, vegetable kitchen garden packets, saplings of fruit plants, promotion of backyard poultry and water conservation activities.

During celebrations, the Director, IIVR, Varanasi informed that we were unable to feed 35 crore population of the country at the time of independence. ICAR with 99 research institutes and 55 Agricultural Universities are making concerted efforts to develop improved varieties/breeds and efficient agricultural production technologies. Due to these research efforts, government policies and innovativeness of Indian farmers, we could enhance food grain, horticultural, fish, milk and egg production by 4, 6, 9, 6 and 27 folds, respectively during the last 66 years and are surplus for many agricultural commodities after feeding a population of more than 121 crores.

On this occasion vegetable kitchen garden packets, seeds of pigeon pea and saplings of fruit plants were distributed to the tribal households. Vegetable kitchen garden packets consisted seeds of improved varieties of vegetables like Kashi Anmol (Chilli), Kashi Vishesh (Tomato), Kashi Taru (Brinjal), Kashi Pragati (Okra) etc.

Shri Radha Mohan Singh, Union Minister of Agriculture Visits ICAR-IIVR, Varanasi

Shri Radha Mohan Singh, Union Minister of Agriculture visited ICAR-Indian Institute of Vegetable Research, Varanasi on 21st September, 2014. He appreciated the basic, strategic and farmer-oriented research activities of the institute and emphasized to develop farmer and environment friendly organic technologies. Shri Singh interacted with the representatives of KVKs of the region and reviewed the manpower and infrastructural support. Agriculture Minister also interacted with the scientists and called upon to strengthen the research to develop climate-resilient vegetable technologies to minimize the risk of crop failure. To promote organic agriculture, the Ministry is in the process of initiating "Bhartiya

Paramparagat Krishi Vikas Yojna, he added. In this programme, one lakh villages of eastern India will also be selected as organic villages.

Agriculture Minister also interacted with vegetable growers of the tribal regions of District Sonebhadra and distributed the seeds and planting materials to selected farmers under Tribal Sub Plan (TSP) programme. He advised them to adopt improved cultivars and agro-techniques developed by IIVR to increase the vegetable productivity and profit. The Agriculture minister recognised the importance of horticulture as life line of agriculture and urged the farmers to adopt Integrated Agriculture System in which 33% area should be utilized for food grain production, 33% for horticulture, 33% for animal husbandry and remaining 1% for forestry.

Dr. Bijendra Singh, Director, welcomed the Minister and briefly outlined the achievements and ongoing research activities of the institute.

Farmers of Jayapur Village Encouraged to Grow More Vegetables

Indian Institute of Vegetable Research, Varanasi being a pioneer research institute has developed 46 improved varieties in 16 vegetable crops and also a number of production and protection technologies. Since 2005, the institute is regularly involved in dissemination of these vegetable technologies through various extension activities for betterment of the farmers. Today the institute organized a farmers' meeting at one of its adopted village Jayapur of Varanasi in which 50 farmers participated. They were apprised about the technical know-how on improved vegetable production technologies in general and on pea & onion in particular. Besides, seeds of pea (Kashi Udai) and onion (Agrifound Light Red) were provided to 22 and 32 farmers, respectively. Kashi Udai is an early maturing variety of pea that bears 7-9 pods per plant with an average yield of 110 q/ha and picking in this variety starts from 60-65 days after sowing. The farmers were also encouraged for their seed production.

ICAR-IIVR, Varanasi Celebrates National Science Day

ICAR-Indian Institute of Vegetable Research, Varanasi celebrated the National Science Day on 28th February, 2015 to commemorate and honour the discovery of the Raman Effect by Indian physicist and Nobel Laureate Sir Chandrasekhara Venkata Raman on the same day in 1928. Prof. K. P. Singh, Emeritus Professor, Department of Botany, Banaras Hindu

University, Varanasi graced the occasion as Chief Guest and delivered a science day lecture on "Environmental awareness: issues and challenges". In his address, Dr. Singh, stressed for optimization and efficient use of natural resources with special reference to water in order to save the planet. On this occasion, IIVR organized various competitions such as essay writing, debate competition and science quiz in which more than 150 students from different schools and colleges participated with great enthusiasm. Students also displayed their scientific ideas through poster.

Dr. B. Singh, Director welcomed the gathering and briefed about the Institute's research and related activities. In his deliberation, he highlighted the significance of vegetable in nutritional security of the country. He also educated, inspired and motivated the students to learn the lesson from Sir Chandrasekhara Venkata Raman for high thinking, hard work and commitment for the Nation Building. Dr. A. B. Rai, Head, Division of Plant Protection and co-ordinator of this programme proposed the vote of thanks.

ICAR-IIVR, Varanasi Started "Swachh Bharat Abhiyan"

In compliance with the message of Hon'ble Prime Minister on 'Swachh Bharat', a special cleanliness drive was started under the leadership of Dr. B. Singh, Director, Indian Institute of Vegetable Research, Varanasi on 25th September 2014, where in, all the staff members of the institute participated in cleanliness programme covering the institute's premises and surrounding areas. The employees were also motivated to dedicate 100 hours every year towards 'Swachh Bharat Abhiyan'. The employees of IIVR, Varanasi including SPC, Sargatia and 3 KVKs will take 'Swachhta Shapath' (cleanliness oath) on 2nd October 2014 in specially organized functions.

A special meeting was organized on 30.12.2014 under the chairmanship of Shri Virendra Singh, Member of Parliament (Lok Sabha) and Co-Chairman, Parliamentary Committee on Agriculture with progressive farmers, staff of KVK and officials from district administration to review and set new directions to improve the livelihood of the farmers through increased agricultural productivity of Bhadohi District (Sant Ravidas Nagar) in Uttar Pradesh.

Member of Parliament and Co-Chairman, Parliamentary Committee on Agriculture to ICAR-IIVR, visited KVK, Sant Ravidas Nagar (Bhadohi) ,UP

Dr. Bijendra Singh, Director ICAR-IIVR, Varanasi welcomed and briefed about the IIVR and the centre. The coordinator of the KVK presented the progress report of the centre which was appreciated by the Hon'ble MP and other dignitaries.

Hon'ble MP emphasized that the KVK, Bhadohi should be one of the best KVK in the country. He emphasized the benefits of dairy farmers through Intensive Dairy Plan for overall development of animal husbandry and stressed that KVK should explore the resources for diploma courses in veterinary/skill development programme. He also wanted to generate some of the basic facilities for KVK by the District Administration and promised to raise this issue on 2.1.2015 during the work plan meeting of Bhadohi district. He also suggested initiating reasonable steps towards the expansion of seed village concept, promotion of organic agriculture, certification of organic produce and establishment of soil testing laboratories. Dr. Singh, Director of the institute assured every possible help to the centre for execution of the programs within the frame work of ICAR as suggested by Hon'ble MP and assured that this KVK shall reach new heights in future.

Demonstration block at IIVR for exhibiting technologies

A demonstration block has been established at the entrance of the IIVR research farm in an area of 5000 m^2 area for exhibition of vegetable technologies to the farmers, visitors and other stakeholders of vegetable sector. Improved vegetable varieties developed by the institute as well as other popular varieties have been demonstrated in the demonstration block with recommended scientific package of practices. From November 2014 the following crops have been demonstrated in the demonstration block.

Sl.No.	Vegetables	No. of Varieties demonstrated	Sl.No.	Vegetables	No. of Varieties demonstrated
1.	Tomato	07	18.	Pointed Gourd	02
2.	Cherry Tomato	01	19.	Chilli	04
3.	Pea	08	20.	Chenopodium	01
4.	Summer Squash	02	21.	Bitter Gourd	01
5.	Capsicum	01	22.	Bassela	01
6.	French Bean	02	23.	Amaranth	02
7.	Radish	05	24.	Long Melon	01
8.	Beet root	01	25.	Cucumber	02
9.	Sem	03	26.	Sponge Gourd	02
10.	Mustard leaf	01	27.	Musk Melon	04
11.	Methi	01	28.	Ridge Gourd	02
12.	Carrot	03	29.	Pumpkin	02
13.	Broccoli	01	30.	Okra	06
14.	Cabbage (Red)	01	31.	Bottle Gourd	05
15.	Cabbage	03	32.	Cowpea	05
16.	Chinese Cabbage	01	33.	Water Melon	01
17.	Cauliflower	01			

AWARDS, HONOURS AND RECOGNITIONS

1. Dr. B. Singh received Dr. Biswajeet Choudhary Memorial Award for outstanding Vegetable Scientist during National conference on pre/post-harvest losses & value addition in vegetables July 12-13, 2014 at IIVR, Varanasi.
2. Drs. Satyendra Singh, A.B. Rai and R.K. Singh received Harbhajan Singh Memorial Award for Best Research Paper -2011 entitled, "Bio-management of root-knot disease of chilli (*Capsicum annum*) caused by Meloidogyne incognita, Vegetable Science 39 (1): 63-67 during National conference on pre/post-harvest losses & value addition in vegetables July 12-13, 2014 at IIVR, Varanasi.
3. Dr. D.R. Bhardwaj received Dr. Rajendra Prasad Puraskar for best Hindi Book " Sabji Anusandhan evam Utpadan Pradaugiki" on the occasion of ICAR Foundation Day on 29th July, 2014 by Hon'ble Minister of Agriculture, Govt. of India at NAAS, Complex, New Delhi.
4. Dr. D.R. Bhardwaj was selected Fellow 2013 for Indian Society of Vegetable Science during National conference on pre/post-harvest losses & value addition in vegetables July 12-13, 2014 at IIVR, Varanasi.
5. Dr. D.R. Bhardwaj was selected Fellow 2013 for Indian Society of Plant Genetic Resources, New Delhi on 05.03.2015 at NBPGR, New Delhi.
6. Awarded First position for demonstration of ICAR-IIVR stall in National Farmer's Fair at ICAR-DSR, Mau on March 2, 2015. (Exhibitors: Dr. Shubhadeep Roy, Dr. A.K. Chaturvedi, Sh. Pankaj Kr Singh)
7. Awarded Third position for demonstration of ICAR-IIVR stall in Northern Zone Regional Agricultural Fair at ICAR-IVRI, Izatnagar during March 17-20, 2015. (Exhibitors: Dr. Shubhadeep Roy, Dr. B. K. Singh, Sh. Pankaj Kr Singh)
8. Dr. Shailesh K. Tiwari received "Best Oral Presentation Award" for "Do Indian legislations efficiently address the menace of biopiracy?" in National Seminar on Challenges and opportunities for agricultural crop productivity under climate change. College of Agriculture, Rewa (JNKVV, Jabalpur). September 21-22, 2014.
9. Dr. Shailesh K. Tiwari was selected as Fellow Member of the Society for Applied Biotechnology (FSAB).
10. Dr. Shailesh K. Tiwari, Dr. Rajesh Kumar and Dr. Major Singh received "Best Poster Award" for "Quantitative changes in antioxidant compounds of tomato fruits at different ripening stages under extreme temperature" in National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, July 12-13, 2014, held at IIVR, Varanasi.
11. Dr. Rajesh Kumar and Dr. Major Singh received "Best Poster Award" for "Identification of tomato genotypes for better post-harvest attributes and high temperature tolerance" in National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, July 12-13, 2014, held at IIVR, Varanasi
12. Dr. S.K. Sanwal received best oral presentation award "Screening of wild and cultivated okra germplasm against yellow vein mosaic disease" on the paper presented in international conference on horticulture for nutritional, livelihood and environmental security in hills: opportunity and challenges held at UBKV, Kalimpong, West Bengal during May 22-24, 2014.
13. Dr. S.K. Sanwal and Dr. Rajesh Kumar received an appreciation letter from Director, IIVR for significant contribution in compilation of EFC document resulting to a fruitful approval of the document.
14. Dr. T. Chaube received "Scientist of the Year-2014 award" on the occasion of International Symposium on Peri Urban Agriculture for Improving Livelihood Opportunities organized by Samagra Vikas Welfare Society, Lucknow from November 25-26, 2014.
15. Dr. T. Chaube awarded First position for oral presentation of paper entitled "Varietal Characterization of tomato based on DUS descriptors" during the International Symposium

on Peri-Urban Agriculture for Improving Livelihood Opportunities organized by Samagra Vikas Welfare Society, Lucknow from November 25-26, 2014.

16. Drs. T. Chaube, B. Singh, Sudhakar Pandey and A. Jha awarded First position for the poster presentation of paper entitled "Varietal Characterization of cucumber varieties/ genotypes using DUS characters" during the National Symposium on Precision Horticulture for Small and Marginal Farmers organized by Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh from 24-27 June, 2014.

17. **Kodandaram MH, Rai AB**, Halder Jaydeep and Manjunath M. **2014**. Received **best poster award** for the paper entitled "Effect of insecticide rotational strategies for control of pre-harvest loses by fruit and shoot borer, *Leucinodes orbonalis* in brinjal. In: *National conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables.* Organized by Association of Promotion of Innovations in Vegetables at IIVR, Varanasi from July 12-13, 2014.

18. Loganathan M, Venkataravanappa V, Saha S, Tripathi S, Verma MK and **Rai AB. 2014** received **best poster award** for the paper entitled Molecular pathogenic variability of Fusarium species infecting tomato and chilli. *In: National Conference on Pre-/Post-harvest Losses & Value Addition in Vegetables,* 12-13th July, 2014**,** IIVR, Varanasi-221305.

19. Saha Sujoy, Loganathan M, Pandey Atul Kumar and **Rai AB. 2014**. received **best paper award** for the paper entitled Role of a new fungicide Zoxamide 33%+Cymoxanil 33% WP in the management of early blight of tomato and its compatibility with Trichoderma sp. *In: National seminar on Climate Change and Environmental Threat to Public health & Sustainable Agriculture***,** 30-31st August, Sunbeam College for Women , Varanasi-221005, U.P.

HUMAN RESOURCE DEVELOPMENT

1. Training/seminar/symposium/conference/workshop attended (National/International)

Name of the scientist	Title of training/seminar/ symposium/ conference/ workshop	Duration	Held at
Anant Bahaduar	Innovations in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviation	October 16-18, 2014	BBAU, Lucknow
Anant Bahaduar	Horticulture for Nutritional, Livelihood and Environmental Security in Hills: Opportunity and Challenges	May 22-24, 2014	Kalimpong, Darjeeling
B Singh	Asian solanaceous round table meet - 2014	September 9-10, 2014	Asia-Pacific Seeds Association, ICAR, IIHR and Society for Promotion of Horticulture, Bangalore
Chaurasia, SNS	Pew/Post Harvest Losses & Value Addition in Vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi
Chaurasia, SNS	Innovations in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviations	October 16-18, 2014	BBAU, Lucknow
Chaurasia, SNS	Peri Urban Agriculture for improving livelyhood Opportunities, org. Samagra Vikas Welfare Society (SVWS)	November 25-26, 2014	Lucknow
DK Singh	Pre-/Post-Harvest Losses & Value Addition in Vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi
DK Singh	Consortia Research Platform on Water	March 25-26, 2015	ICAR-IIWM, Bhubaneswar
HC Prasanna	Asian solanaceous round table meet-2014	September 9-10, 2014	Asia-Pacific Seeds Association, ICAR, IIHR and Society for Promotion of Horticulture,Banglore
Lama, TD	One day training & awareness workshop on JGate@CeRA	September 29, 2014	NASC, IASRI, Pusa, New Delhi
P K Singh	32nd Group meeting of AICRP (VC)	June 24-27 , 2014	IGKV, Raipur
P Karmakar	National Conference on Pre-/post harvest losses and value addition in vegetables	July 12-13, 2014	ICAR- IIVR, Varanasi
P Karmakar	CAFT training programme on, "Breeding by Design"	August 7-27, 2014	CAFT , Genetics & Plant Breeding, PAU, Ludhiana
Rajesh Kumar	Theme-wise Expert Committee under the theme 'Horticulture including Pest Dynamics and Pollinators'	April 4, 2014	ICAR- IIHR, Bangalore
Rajesh Kumar	Third Annual Workshop of National Initiative on Climate Resilient Agriculture (NICRA)	July 3-5, 2014	NASC Complex, New Delhi
Rajesh Kumar	National Conference on Pre-/post harvest losses and value addition in vegetables	July 12-13, 2014	ICAR- IIVR, Varanasi
S Roy	Pre/ post-harvest losses and value addition in vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi
S Roy	7th National Extension Education Congress-2014 on Translational Research Extension for Sustainable Small Farm Development	November 8-11, 2014	ICAR Research Complex for NEH Region, Umian, Meghalaya
S Roy	XII Agricultural Science Congress	February 3-6, 2015	ICAR-NDRI, Karnal
S Pandey	National seminar cum workshop on 'Strategies for improvement, enhancing productivity and utilization of cucurbits'	August 8-10, 2014	Central Horticultural Experiment Station (IIHR), Bhubaneswar, Odisha
S Pandey	2nd UP Agricultural Science Congress on " Technological and governance strategis for advancement of agricultural education, research and extension in Uttar Pradesh"	June 14-16, 2014	UPCAR and held at IISR, Lucknow
S Pandey	XXXIIth AICRP-Veg. Crops Group Meeting	June 24-27, 2014	IGKV, Raipur
S Pandey	National conference on 'Pre-and post-harvest losses & value addition in vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi

Name of the scientist	Title of training/seminar/ symposium/ conference/ workshop	Duration	Held at
S Pandey	State Level workshop on " Improving productivity and livelihood in Eastern Uttar Pradesh"	February 27-28, 2015	Integrated Research and action for development (IRADe) at Lucknow
S Pandey	"Innovation in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviation"	October 16-18 , 2014	Department of Applied Plant Science, BBA University, Lucknow
S Pandey	Hi-tech. Horticulture: challenges and opportunities	February 26-27, 2015	Department of Applied Plant Science, BBA University, Lucknow
SG Karkute	National Conference on Pre-/Post-Harvest Losses and Value Addition in Vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi
SG Karkute	Three months professional attachment training	July 14 – October 14, 2015	BHU,Varanasi
SG Karkute	Recent trends on Bioinformatics and its applications in Agriculture	January 2-13 2015	ICAR-NAARM, Hyderabad
SK Tiwari	National Seminar on Challenges and opportunities for agricultural crop productivity under climate change	September 21-22, 2014	College of Agriculture, Rewa
SK Tiwari	Workshop on redefining priorities in national action plan for management of genetic resources	December 23-24, 2014	ICAR-NBPGR, New Delhi
SK Tiwari	Horticulture Industry Interface meet	February 10, 2015	ICAR-IIHR, Bangalore
SK Tiwari	National Conference on Pre-/post harvest losses and value addition in vegetables	July 12-13, 2014	ICAR- IIVR, Varanasi
TK Koley	Horticulture for nutritional, livelihood and environmental security in hills: opportunity and challenges	May 22-24, 2014	Kalimpong, Darjeeling, India
TK Koley	Pre-/ Post-harvest Losses and Value Addition in Vegetables	July 12-13, 2014	IIVR, Varanasi
T Chaubey	National Symposium on Precision Horticulture for Small and Marginal Farmers	June 24-27, 2014	IGKV, Raipur
T Chaubey	National Conference on Pre-/Post-Harvest Losses & Value Addition in vegetables	July 12 -13, 2014	ICAR- IIVR, Varanasi
T Chaubey	Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture	May 28-31, 2014	NAU, Navsari, Gujarat
T Chaubey	XXXII Group Meeting of AICRP on Vegetable Crops	June, 24-27 2014	IGKV, Raipur
T Chaubey	International Symposium on Innovations in Horticulture for Nutritional security, Conserving Biodiversity and Poverty Alleviation	October 16-18, 2014	BBAU, Lucknow
T Chaubey	International Symposium on Peri-Urban Agriculture for Improving Livelihood Opportunities	November 25-26, 2014	Samagra Vikas Welfare Society, IFMT&R, Indira Nagar, Lucknow
YS Reddy	Pre-/post harvest losses and value addition in vegetables	July 12-13, 2014	ICAR-IIVR, Varanasi
SG Karkute	International conference on recent Advances on the role of Basic sciences in Ayurvedic Medicine	October 18-19, 2014	BHU, Varanasi

2. Training imparted

Training	Duration	Number of participants
MTC on Pesticide: Application and Residue Management in Vegetable Crops	November 11-18, 2014	24
Commercial Production and Protection Technologies in Vegetable Crops	December 20-24 ,2014	23
Improved Production Technologies in Vegetable Crops	January 16-23, 2015	20
Improved Production Technologies in Vegetable Crops	February 3-5, 2015	44
Improved Production Technologies in Vegetable Crops	March 2-3, 2015	16
Commercial Production and Protection Technologies in Vegetable Crops	March 10-13, 2015	10
Improved Production Technologies in Vegetable Crops	March 17-19, 2015	42
Improved Production Technologies in Vegetable Crops	March 26-28, 2015	30

PUBLICATIONS

Research Papers

1. Ali, S., Kumar S., Saxena S.N., Sharma R., Singh P.K. and Singh G. (2014). Assessing biochemical and molecular diversity in Ker (*Capparis decidua*): A multipurpose shrub of Thar Desert. *International J. Seed Spices* **4** (2): 53-61.
2. Arivalagan, M., Bhardwaj, Rakesh, Ranjan, Pragya, Prasad, T.V. and Gangopadhyay, K.K. (2014). Variability in minerals composition of cucumber genotypes collected from Northern India. *Indian Journal of Horticulture*. **71** (4): 505-510.
3. Attri, B.L., Krishna, Hare, Das, B., Ranjan, J.K., Pragya and Ahmed, N. (2014). Effect of salicylic acid and calcium on the shelf-life of peach cultivars. *Indian J. Hort*. **71** (1): 92-98.
4. Bahadur Anant, Lama T.D. and Chaurasia S.N.S. (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 J. Agric. Sci.* **85** (2): 224-28.
5. Bhardwaj, N.K., Singh, V., Tiwari, S.K. and Singh, M. (2014). Phenotyping of recombinant inbred lines for phomopsis blight in brinjal. *Vegetable Science*, **41** (2): 195-197.
6. Chaudhary, R.P., Singh, A.K., Singh, S.K., Goyal, V. and Singh, I.P. (2014). Association of characteristics of farmers with adoption of improved chickpea production technology. *Annals of Agricultural Research*, **35** (2): 224-226.
7. Chaudhary, R.P., Pandey, R., Chaturvedi, A.K. and Prasad, R. (2014). Enhancing yield and economics of field pea through front line demonstration. *Agriculture Update*, **9** (4): 494-498.
8. Chaudhary, R.P., Pandey, R., Chaturvedi, A.K. and Prasad, R. (2014). An appraisal of production sustainability of brinjal. *Journal of Agricultural Extension Management* **15** (1): 77-88.
9. Choudhary, B.R, Pandey, S. Singh, P.K. and Pandey, V. (2014). Genetic diversity for quantitative traits in hermaphrodite ridge gourd (*Luffa acutangula*). *Indian J.Hort.*, **71** (2): 284-287
10. Gautam, H.K., Singh, N.N. and Rai, A.B. (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.
11. Gautam, H.K., Singh, N.N. and Rai, A.B. (2014). Non–Pesticidal Management of okra shoot and fruit borer (*Earias vittella* Fab.) by Changing dates of sowing. *Vegetable Science*, **40** (2): 214-216.
12. Gautam, H.K., Singh, N.N., Rai, A.B. (2014). Screening of okra against shoot and fruit bores *Earias vittella* (FAB.). *Indian Journal of Agricultural Research*, **48** (1): 72 -75.
13. Gujjar, R.S., Akhtar, M. and Singh, M. (2014). Transcription factors in abiotic stress tolerance. *Indian Journal of plant physiology*, **19**: 306-316.
14. Gujjar, R.S., Akhtar, M., Rai, A. and Singh, M. (2014). Expression analysis of drought induced genes in wild tomato line (*Solanum habrochaites*). *Current Science*, **107** (3): 496-502.
15. Halder, J., Pramanik, A. and Rai, A.B. (2014). Is bougainvillea a more preferred host to leaf cutter bee, Megachile sp. (Hymenoptera: Megachilidae) than rose? *Pest Management in Horticultural Ecosystems*, **20** (1): 105-106.
16. Halder, J., Rai A.B., Kodandaram, M.H. (2014). Parasitization preference of *Diaeretiella rapae* (Hymenoptera: Braconidae) among different aphids in vegetable ecosystem. *Indian Journal of Agricultural Sciences*, **84** (11): 1431-1433.
17. Halder, J., Sanwal, S.K., Rai, A.K., Rai, A.B., Singh, B., Singh, B.K. (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*, **85** (2): 278–82.
18. Karmakar, P., Munshi, A.D., Behera, T.K. and Sureja, A.K. (2014). Heterosis in ridge gourd (*Luffa acutangula* Roxb.) using hermaphrodite lines. *Indian Journal of Horticulture*, **71** (1): 61-6.
19. Karmakar, P., Munshi, A.D., Behera, T.K., Sureja, A.K. and Pati, K. (2014). Hermaphroditism: A primitive sex form for improving plant architecture, earliness and yield traits in monoecious ridge gourd (*Luffa acutangula* Roxb.). *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, **84** (3): 473–480.
20. Kumar A, PK Singh, N Rai, GP Bhaskar and D Datta (2014). Genetic diversity of French bean (*Phaselous vulgaris* L.) genotypes on the basis of morphological traits and molecular markers. *Indian Journal of Biotechnology*, **13**: 207-213.

21. Kumari A.R., 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.

22. Kumari, A. R., Sanwal, S. and Shekhar, S. (2015). A comparative on Apiculture Technology among Trained & Untrained Women. *International Journal on Recent and Innovation Trends in Computing on Communication*, **3** (1): 140-143.

23. Kumari, A.R. and Laxmikant (2015) Role of Farm Women in Agricultural activities. *Agriculture update*, **10** (1): 31-35.

24. 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.

25. Lal, H, Singh, P.M., 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.

26. Lal, H., Bhardwaj, D.R., Vishwa Nath and Singh, R. (2014). Character association and genetic divergence studies in cowpea (*Vigna unguiculata* L. Walp.). *Annals of Plant and Soil Research*, **16** (3): 186-191.

27. Lal, H., Bhardwaj, D.R., Vishwa Nath and Singh, R. (2014). Hierarchical clustering and path analyasis in cowpea (*Vigna unguiculata* L. Walp.). *Annals of Plant and Soil Research*, **16** (2): 159-163.

28. Lama, T. D., Singh, R. K., Saikia, U. S. 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.

29. Loganathan M, Garg R., Venkataravanappa V, Saha S and Rai AB. (2014). Plant growth promoting rhizobacteria (PGPR) induces resistance against *Fusarium* wilt and improves lycopene content and texture in tomato. *African Journal of Microbiology Research,* **8** (11): 1105-1111.

30. Loganathan, M., Venkataravanappa, V., Saha, S., Rai, A.B., Tripathi, S, Rai, R.K., Pandey, A.K. and Chowdappa, P. (2014). Morphological, pathogenic and molecular characterizations of *Alternaria* species causing early blight of tomato in northern India. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* DOI 10.1007/s40011-014-0446-0.

31. Pradhan, N., Prakash, P., Manimurugan, C., Tiwari, S.K., Sharma, R.P. and Singh, P.M. (2015). Screening of tomato genotypes using osmopriming with PEG 6000 under salinity stress. *Research Environment and Life Sciences*, **8**(2): 245-250.

32. Pradhan, N., Prakash, P., Tiwari, S.K., Manimurugan, C., Sharma, R.P. and Singh, P.M. (2014). Osmopriming of tomato genotypes with Poly Ethylene Glycol 6000 induces tolerance to salinity stress. *Trends in Biosciences,* **7**(24): 4412-4417.

33. Prasad, R., Singh, A.K. and Chaudhary, R.P. (2014). Economic traits of indigenous goats of Bundelkhand region of Uttar Pradesh under range management. *Annals of Agricultural Research*, **35** (4): 445-450.

34. Prasad, R. N., Singh, R.K., Yadava, R.B. and Chaurasia, S.N.S. (2014). Yield and Yield attributes of cowpea in relation to phosphorus levels and bio-inoculants. *Vegetable Science*. **41** (1): 96-97

35. Prasanna, H. C., Kanakala, S., Archana, K., Jyothsna, P., Varma, R. K., Malathi, V. G. (2014). Cryptic species composition and genetic diversity within *B. tabaci* complex in soybean in India revealed by mtCOI DNA sequence. *J. of Integrative Agriculture*, DOI: 10.1016/s2095-3119(14)60931-x.

36. 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.

37. Prasanna, H. C., Sinha, D. P., Rai, G. K., Krishna,R., Kashyap, S. P., Singh, N. K., Singh, M. and Malathi, V.G. (2014). Pyramiding Ty-2 and Ty-3 genes for resistance to monopartite and bipartite tomato leaf curl viruses of India. *Plant Pathology*, 2014, DOI: 10.1111/ppa.12267.

38. Rai, A.B., Halder, J. and Kodandaram, M.H. (2014). Emerging insect pest problems in vegetable crops and their management in India: An appraisal. *Pest Management in Horticultural Ecosystems,* **20** (2): 113-122.

39. Rai, N., Rai, K.K., Tewari, G. and Kumar, Sanjeev (2014). Nutritional and anti-nutritional properties and their inter-relationship with pod

characters in an underutilized vegetable Indian bean. *Indian Journal of Agricultural Sciences*, **84** (9):1051-56. I0022)

40. Rai, N., Rai, K.K., Tewari, G. and Singh, P.K. (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)

41. Rai, V.P., Kumar, Rajesh, Singh, S.P., Kumar, Sanjay, Kumar, Sanjeet, Singh, M. and Rai M. (2014). Monogenic recessive resistance to Pepper leaf curl virus in an interspecific cross of Capsicum. *Sci. Hortic*. **172**: 34-38.

42. Ranjan, Pragya, Gangopadhyay, K.K., 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.

43. Reddy M.K., Srivastava, A., Kumar, S., Kumar, R., Chawda, N., Ebert, A.W. and Vishwakarma, M. (2014). Chilli (*Capsicum annuum* L.) breeding in India: An overview, *SABRAO J. Breeding and Genetics,* **46** (2): 160-173.

44. Reddy, M.K., Srivastava, A., Lin, S.W., Kumar, R., Shieh, H.C., Ebert, A.W., Chawda, N. and Kumar, S. (2015). Exploitation of AVRDC's Chilli Pepper (*Capsicum* spp.) germplasm in *India. J. Taiwan Soc. Hort. Sci*., **61** (1): 1-9.

45. Roy Shubhadeep, Singh Baldeo, Padaria R.N. and Singh Neeraj. 2014. Activities and Institutional Mechanism of MNREGA and its Effectiveness in West Bengal. *Indian Journal of Extension Education*, **50** (1&2): 18-23.

46. Roy Shubhadeep, Singh Baldeo, Padaria R.N. and Singh Neeraj. 2014. Grass Root Constrictions in Implementation of MNREGA in West Bengal. *Indian Journal of Extension Education,* **50** (1&2): 24-27.

47. Saha, S., Garg, R., Venkataravanappa, V., Mishra, P.K., Rai, A.B. and Singh, R.P. 2014. Molecular and Cultural Characterisation of *Alternaria brassicae* Infecting Cauliflower in Uttar Pradesh, India. Proc. *Natl. Acad. Sci., India, Sect. B Biol. Sci.* 1-11. DOI 10.1007/s40011-014-0470-0

48. Saha, S., Manjusha, R., Jadhav, T.P., Ahammed, S., Banerjee, K., Sharma, B.K., Loganathan, M. and Rai, A.B. (2014). Safety assessment and bioefficacy of Fluopyram 20% +Tebuconazole 20 %-40 SC in chilli, *Capsicum annum* L. against Anthracnose disease *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* DOI 10.1007/s40011-014-0450-4.

49. Saha, S., Shabeer, A., Purath, T., Manjusha, R., Jadhav, T.P., Loganathan, M., Banerjee, K. and Rai, A.B. (2014). Bioefficacy, residue dynamics and safety assessment of the combination fungicide trifloxystrobin 25% + tebuconazole 50%-75 WG in managing early blight of tomato (*Lycopersicon esculentum* Mill.), *Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes*, **49** (2): 134-141.

50. Saha, S., Rai A.B., Garg, Ruchi and Singh, A. (2014). Revalidation of efficacy of Zineb 75% WP against diseases of tomato and chilli in terms of dose, disease control and yield. *Pestology,* **38** (2): 54-56.

51. Sanwal, S.K., Singh, M., Singh, B. and Naik, P. S. (2014). Resistance to Yellow Vein Mosaic Virus and Okra Enation Leaf Curl Virus: challenges and future strategies. *Current Science*, **106** (11): 1470 - 1471.

52. Singh Shamsher and Singh M.K. (2014). Impact on front line demonstration on cabbage (Brasica olerasia Var. Capitata) yield improvement in South. *Hort Flora Research Spectrum*, **3** (2): 158-161.

53. Singh, B.K., Ramakrishna, Y. and Ngachan, S.V. (2014). Spiny coriander (*Eryngium foetidum* L.): A commonly used, neglected spicing-culinary herb of Mizoram, India. *Genetic Resources and Crop Evolution,* **61** (6): 1085-1090 DOI 10.1007/s10722-014-0130-5.

54. 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.

55. Singh, N., Roy, S., Rai, A.B. and Singh, B. (2014). Garden pea harnessing high remuneration leads to livelihood security in eastern Uttar Pradesh. *Vegetable Science*. **41** (1): 19-21.

56. Singh Neeraj, Roy Shubhadeep, Singh B and Rai A.B. (2015). Impact of Improved Vegetable Technologies in Disadvantaged Districts of Uttar Pradesh. *Indian Journal of Extension Education*, **51** (1&2): 56-59.

57. Singh, A.K., Kumar, S., Singh, H., Rai, V.D., Singh, B.D. 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.

58. Singh, B., Chaubey, T., Upadhyay, D.K., Jha, A. and Pandey, S.D. (2014). Assessment of distinctiveness, uniformity and stability of French bean (*Phaseolus vulgaris* L.) genotypes/varieties based on morphological descriptors. *Indian J. Hort.*, **71** (3): 345-348.

59. Singh, B., Chaubey, T., Upadhyay, D.K., Jha, Aastik and Pandey, S.D. (2014). Morphological characterization of vegetable pea (*Pisum sativum* L. spp. Hortense) genotypes and their application for distinctiveness, uniformity and stability testing. *Legume Research*, **37** (5): 547-551.

60. Singh, B., Singh, P.M. Sanwal, S.K. and Pal, A.K. (2014). Standardization of cost effective hybridization technique for hybrid seed production in okra (*Abelmoschus esculentus*). *Indian Journal of Agricultural Sciences*, **84** (9): 1111–4.

61. Singh, B.K. and Ramakrishna Y. (2014). Indian collections of turmeric (*Curcuma longa* L.): Genetic variability, inheritance, character association and performance. *Indian Journal of Plant Genetic Resources*, **27** (3): 263-270. DOI 10.5958/0976-1926.2014.00024.2.

62. Singh, B.K., Deka, B.C. and Ramakrishna, Y. (2014). Genetic variability, heritability and interrelationships in pole-type French bean (*Phaseolus vulgaris* L.). *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, **84** (3): 587–592.

63. Singh, P.M., Singh, R. and Bhardwaj, D.R. (2014). Effect of training system on seed yield and quality of bitter gourd cv. Kalianpur Baramasi under herbicide managed crop. *Annals Pl. & Soil Res.*, **16** (2):155-158.

64. Singh, Pramod K., Rai, N., Lal, H., Singh, D.V. and Rai, K.K. (2015). Genetic analysis for quantitative traits in Indian bean (*Lablab purpureus*). *Indian Journal of Agricultural Sciences*, **85** (3): 361-364.

65. Singh, R.K., Rai, N., Singh M., Singh, S.N. and Srivastiva, K. (2014). Selection of tomato genotypes resistant to tomato leaf curls virus using biochemical and physiological markers. *Journal of Agricultural Sciences* (Cambridge), 153: 645-655.

66. Singh, R.K., Rai, N., Singh, Major, Singh, R. and Kumar, P. (2015). Effect of climate change on tomato leaf curl virus (ToLCV) disease in tomatoes. *Indian Journal of Agricultural Sciences*, **85** (2): 142-144.

67. Singh, S., Pandey S., Raghubhansi, R., Pandey, V. and Singh, M. (2015). SSR analysis for fruit and quality characters in infra-specific mapping population of melon. *Indian Journal of Agricultural Sciences*, **85** (1): 32-37.

68. Singh, Sudhir; Singh A K and Rai, Ashutosh (2014). Effect of different thickeners on quality assurance and consumer preference in tomato ketchup. *Indian Journal of Agricultural Sciences*, **84** (8): 1014-1017.

69. Upadhyay P., Rai, A., Kumar, R., Singh, M., Sinha, B. (2014). Differential expression of pathogenesis related protein genes in tomato during inoculation with *A. solani*. *J Plant Pathol Microb.*, **5**: 217. DOI:10.4172/2157-7471.1000217.

70. Upadhyay, A.K., Singh, J., Bahadur, Anant, Singh, V. K. and Singh, S.K. (2015). Impact of integrated nutrient management on yield, quality traits and economics of cabbage (*B. Oleracea* var. capitata). *Progr. Hort.*, **47** (1): 113-117.

71. Venkataravanappa, V., Reddy, C.N., Lakshminarayana, Swarnalatha, P., Mahesha, B., Rai, A.B. and Reddy, M. Krishna (2014). Association of Tomato leaf curl Joydebpur virus and a betasatellite with leaf curl disease of eggplant. *Phytoparasitica* **42**: 109–120.

72. Venkataravanappa, V., Prasanna, H. C., Lakshminarayana Reddy, C.N. and Krishna Reddy, M. (2014). Evidence for two predominant viral lineages, recombination and subpopulation structure in begomoviruses associated with yellow vein mosaic disease of okra in India. *Plant Pathology*, DOI: 10.1111/ppa.12292.

73. Yadav, Rashmi, Rana, J. C. and Ranjan, J. K. (2015). Analysis of variability parameters for morphological and agronomic traits in grain amaranth (*Amaranthus* sp) genotypes. *The Bioscan*, **9** (4): 1661-1665.

74. Rao, M., Sendhil, R., Singh, N., Rajagopal, V., Mandal, S., Shukla, M., Karmakar, P. and Tripathi, A. (2014). Water harvesting through application of social marketing strategy - A case study in Banwar village, Madhya Pradesh, India. *Journal of Water Resource Engineering and Management*, **1** (2): 35-42.

75. Rao, M., Singh, N., Mandal, S., Shukla, M., Karmakar, P., Tripathi. A., Sendhil, R. and

Rajagopal, V. (2014). Indigenous technical knowledge associated with ethnomedicinesin Banwarvillage (Gwalior district), Madhya Pradesh, India. *Research & Reviews: A Journal of Pharmacognosy*, **1**(2): 1-5.

Popular Articles

1. Anant Bahadur, DK Singh, SNS Chaurasia. (2014). Efficient water utilization technologies for vegetable production. *Kisan World*, **41** (7): 59-62.
2. Chaubey, T., Singh, Bijendra, Bhardwaj, D.R., Singh, P.K. and Singh, Major (2014). Chikani torai ki vaosayeka kheti. *Kishan Bharti*, **45** (7): 15-17.
3. Chaubey, T., Singh, Bijendra, Srivastava, R.K. and Bhushan, C. (2014). Pharash bean ki vagyanik kheti se paye bharpur utpadan. *Kishan Bharti*, **45** (8): 15-18.
4. Chaubey, Tribhuvan; Singh, Bijendra and Prashana, H.P. (2014). Tamater ki kheti. *Kishan Jyoti - Rajbhasha Patrika,* **4** (4): 47-49.
5. Chaubey, Tribhuvan; Singh, Bijendra; Singh, P.M. and Prasanna, H.C. (2014). Pattedar Sabjion Ka Poshan evm Aushadiy Mahatva. *Kishan Jyoti - Rajbhasha Patrika,* **4** (4): 56-60.
6. Chaubey, Tribhuvan; Singh, Bijendra; Singh, P.M. and Prasanna, H.C. (2014). Subjio ka beej bhandaran. *Kishan Jyoti - Rajbhasha Patrika,* **4** (4): 78-81.
7. Chaurasia, S.N.S, Singh, B. (2015). Singhara Ki Byawasayik Kheti. *In: Smarika- Mandaliya Shakbhanji, Phal avom Pushp Pradershini, Company Garden, Varanasi*, pp: 28-31.
8. Chaurasia, S.N.S., Prasad, R.N., Anant Bahadur and Naik P.S. (2015) Niyantrit Vatavaran Men Sabjiyon Ki Kheti. *In: Smarika- Mandaliya Shakbhanji, Phal avom Pushp Pradershini, Company Garden, Varanasi*, pp: 5-8.
9. Choudhary, B.R., Singh, P.K., Pandey, S., and Singh, M. (2014). Satputia Kashi Khushi to make farmers cheer. *Indian Horticulture*, pp: 11-12.
10. Halder, J., Rai A.B. and Pramanik, A. (2014). Incidence of leaf-cutter bee on ornamental plants and its eco-friendly management. *Floriculture Today*, pp: 62-63.
11. Halder, Jaydeep, Rai, A.B. and Reddy, Yerasu Suresh (2014). The Miracle Tree: Moringa olifera, Vatika, pp: 26-29.
12. K Ajitabh and Tiwari SK (2014). Biopiracy *vis-à-vis* Indian Legislations. *Lex Witness*, **5** (11): 60-62.
13. K Ajitabh and Tiwari SK (2014). Biopiracy *vis-à-vis* Indian Legislations. A series of Biopiracy: Part-2. *Lex Witness*, **5** (12): 22-24.
14. Karkute, S.G. and Pandey, S. (2015). Ash gourd-the future vegetable. *Kurukshetra*, **63** (3): 40-41.
15. Kumar Rajesh (2014). Hybrid seed production in chilli and capsicum. *In: Compendium on Natl Training on Quality seed production of vegetable crops, organized by NSRTC (GoI), Varanasi*, pp: 45-49.
16. Kumar Rajesh (2015). Tamatar, baigan, mirch ki vaigyanik kheti. *In: Sabzi pathshala (Eds. Chaurasia et al., 2015)*, pp: 27-29.
17. Kumar, Y. Bijen, Halder Jaydeep and Rai, A.B. 2014. Obsolete Pesticides: Environmental concerns and measures. *Vumiputra* (12): 67-69.
18. Kumari, A.R., Kumari, P and Meena, K. (2015) Saral Vidhi Se Phal Ewam Sabjiyo Ka Prarikshan. *Bind Krishi*, **9** (2): 74-84.
19. Kumari, A.R., Maurya, S. and Mala, K., (April. 2014). Santulit Ahar Jivan Ka Adhar. *Rajsthan Kheti Pratap*, **11** (9): 20-22.
20. Kumari, A.R., Meena, K and Singh, S. (Oct, 2014) Madhumakkhi Palan: Swarojgar ewam Aya Ka Srout. *Prasar Dut.*, pp: 16-20.
21. Kumari, A.R., Meena, K., Kumari, P. and Maurya S. (2015). Soyabean Prasanskaran. *Bind krishi*, **9** (2):4-15.
22. Meena, K. and Kumari, A.R., (2015). Makka utpadan ki unnat Kheti. *Kisan Jyoti*, pp: 20-25.
23. Meena, K., Kumari, A.R. and Tiwari, A. (2014). Suryamukhi ki unnat Kheti. *Prasar Dut.*, pp: 37-40.
24. Patel, V.K., Tiwari, S.K. and Prasad, R.N. (2014). Aisey kareyn varsha kaaleen paudhshala se swasth paudhon ki taiyari. *Mrida Darpan*, **10**: 55-59
25. Patel, V.K., Tiwari, S.K. and Singh, U. (2015). *Singhadey ki kheti se atirikt aay*. *Kheti*, **36** (1): 16
26. Pradeep, K., Singh, P.K and Lepcha Boniface (2014). Phul-Tarul: a potential tuber – crop of Darjeeling and Sikkim in ICAR News, pp: 11-12.
27. Rai, A.B. and Saha, S. (2014). Have a plate full of chemical-free vegetables. *Indian Horticulture*, **59** (1): 5-7.
28. Reddy, Y.S., Roy, S., Tiwari, S.K. (2014). New technologies in vegetable production. *Kurukshetra*, **62** (8): 20-23.

29. Roy, S., Koley, T.K. and Singh, N. (2014). Vegetable based family farming in India. *Kurukshetra*. Vol. **62** (7): 19-22.

30. Sanwal, S.K. and Singh, B. (2014). Kashi Kranti : new okra variety. *Indian Horticulture*, **59** (2): 3-4.

31. Sanwal, S.K. and Singh, P.M. (2014). In Okra: Harvesting seed at optimum stage pays. *Indian Horticulture*, **59** (4): 16-17.

32. Sanwal, S.K. and Kumar Rajesh (2014). Kashi Ageti enriches vegetable basket. *Indian Horticulture,* 59 (5): Cover II.

33. Singh, B. and Kumar Rajesh (2015). Importance of seed testing. *In: Compendium on National Training on Seed testing - Conventional & Non-conventional methods, organized by NSRTC (GoI), Varanasi*, pp: 5-7.

34. Singh, B.K. and Ramakrishna, Y. (2013). Spiny coriander (*Eryngium foetidum* L.): spicing the cuisines of Mizo tribes (India). *Allium and Umbelliferae Improvement Newsletter*, **23**: 31-33.

35. Singh, B., Chaubey, T. and Srivastava, R.K. (2014). New Vegetable Varieties/Hybrids. *ICAR NEWS,* **20** (3): 20-21.

36. Singh, Bijendra; Chaubey, Tribhuvan; Srivastava, R.K. and Bhushan, Chandra (2014). Subjion ki Viksita Navin Prajatiya. *Kishan Jyoti - Rajbhasha Patrika,* **4** (4): 39-46.

37. Singh, P.K., Singh, M. and Naik, P.S. (2014). Accepting Soybean as Vegetable. *Indian Horticulture*, 59 (4).

38. Singh, P.M (2014). Quality vegetable seed production under protected conditions. *In: Proceedings of National Workshop cum Seminar on Role of Precision Farming in Quality Vegetable Production, Nov. 13-14, 2014, GBPUA&T, Pantnagar,* pp: 67-71.

39. Singh, P.M; Singh, P.K; Manimurugan, C; Kumar, R; Singh, R. and Singh, B. (2015). Seed Production of Vegetables is Lucrative Horti Business. *Indian Hort*. **60** (1): 20-22.

40. Singh, Santosh Kumar; Chaubey, T. and Jha Aastik (2014). Role and Importance of Information Communication Technology in Agriculture Sector in India. *Indian Former Digest*, **47** (8): 34-36.

41. Singh, B., Singh, P.M. and Pandey, S. (2015). *Pradesh Mein Shakbhaaji Vikas Kee Sambhaavnaayen: Navintam Takniki Evam Sankar Beejon Ka Upyog*. (In) "Smarika" published on the occasion of *Pradeshik Phal, Shakbhaaji evam Pushp Pradarshini* at Rajbhawan Lucknow, 21-22 Feb. 2015, pp : 10-15

42. Singh, P.K. and Singh, M. (2014). Everyone's vegetable Ivy gourd. Kashi Bharpoor to enrich vegetable basket. *Indian Horticulture*, 59 (2).

43. Srivastava, R.K., Singh, B., Bhushan, C. and Chaubey, T. (2014). Subjio mai sansadan prabandhan: yek labhkari vikalp. *Ikshu Rajbhasha Patrika*, **1** (3): 37-44.

44. Tiwari, Ashwani and Chaubey, T. (2014). Arabi ki Unnat Kheti. *Kishan Jyoti - Rajbhasha Patrika,* **4** (4): 63-66.

45. Tiwari, Ashwani and Chaubey, T. (2014). Haldi ki Vaigyanik Kheti. *Kishan Jyoti - Rajbhasha Patrika,* Edition **4** (4): 61-62.

46. Venkataravanappa, V., Saha, S., Garg, R., Loganathan, M. and Rai, A.B. (2014). Detection and management of seed-borne viruses: an appraisal. *SATSA Mukhaptra Annual Technical Issue,* **18**: 58-71

47. Venkataravanappa, V., Saha, S., Mahesh, B. and Rai, A.B. (2014). Strobilurins: A New Generation of Natural Fungicides. *Everyman's Science,* **XLVIII** (5):

Books

1. Chaurasia, S.N.S., Singh, N., Roy, S. and Singh, B. (2015). Sabji Pathshala Pub: IIVR, Varanasi, ISBN: 978-93-5196-871-9, pp: 1-203.

2. Pandey Shalini Mishra, Singh Sudhir and Khemariya Priti. (2014). Nisin –a potential natural antimicrobial. pp 1-104, Lambert Academic Publishing, USA.

3. Patnik HP, Sahu KC, Mohapatra SN, Patel B R, Khalko Surajit, Laskar Nripendra, Roy Ayon, Hath Tapan Kumar, M. L. Kewat, Nayak, R. Pachori, Das SB, Gupta Om, Bhatt Jayant, Rawat AK, Rai HK, Yadava HS, Saha Sujoy, Halder Jaydeep and Rai AB. (2014). The AESA based IPM - Lablab bean (*Lablab purpureus*). National Institute of plant Health Management (NIPHM), Hyderabad, DPQ&S, Faridabad, Haryana and DAC, GOI, New Delhi. pp 59.

4. Patnik HP, Sahu KC, Mohapatra SN, Patel B R, Khalko Surajit, Laskar Nripendra, Roy Ayon, Hath Tapan Kumar, M. L. Kewat, Nayak, R. Pachori, Das SB, Gupta Om, Bhatt Jayant, Rawat AK, Rai HK, Yadava HS, Saha Sujoy, Halder Jaydeep and Rai AB. 2014. The AESA based IPM – Leguminous vegetables (cowpea, cluster bean,

goa bean): National Institute of plant Health Management (NIPHM), Hyderabad, DPQ&S, Faridabad, Haryana and DAC, GOI, New Delhi. pp 55.

5. Singh, Bijendra; Chaubey, Tribhuvan, Singh, P.M. Srivastava, Ranjan K. and Bhutan, Chandra (2014). Four Decades - Accomplishment of AICRP (Vegetable Crops). ISBN: 978-93-5196-872-6, ICAR-Indian Institute of Vegetable Research, Varanasi, pp: 287.

6. Singh, Prabhakar Mohan; Chaubey, Tribhuvan; Karmakar, Pradip; Haldar, Jaydeep; Yadav, R.B.; Singh, Neeraj and Singh, Bijendra (2015). Krishi Mein Sabjion Dwara Vividhikaran (Edited). ISBN: 978-93-5212-271-4, ICAR-Indian Institute of Vegetable Research, Varanasi, pp: 1-298.

Technical Bulletin/Mannuals

1. Kodandaram, M.H., Rai, A.B., Saha, S and Naik, P.S. (2014). *Sabjiyon me keetnashiyon ke prayog kee vivaranika.* IIVR Technical Bullrtin No. 57, IIVR, Varanasi. p:140.

2. Rai AB, Loganathan M, Halder J, Venkataravanappa V and Naik PS. (2014). *Eco-friendly Approaches for Sustainable Management of Vegetable Pests*. Technical Bulletin No 53. ICAR-Indian Institute of Vegetable Research, Varanasi. pp: 104.

3. Rai AB, Singh Neeraj, Saha S, Halder Jaydeep, Kumar Y Bijen and Gupta Sunil(2014). *Pesticide: Application Technology & Residue management in vegetable crops*. Training Manual: 58. ICAR-Indian Institute of Vegetable Research, Varanasi, pp: 152.

4. Singh Neeraj, Roy Shubhadeep, Karmakar Pradip, Chaurasia S.N.S. and Gupta Sunil. *Improved production technologies in vegetable crops*. IIVR Training Manual No. 59. ICAR-Indian Institute of Vegetable Research, Varanasi, India, pp: 268.

5. Singh, N., Lama, T. D., Roy, S. and Pandey, S. (2014). *Improved Production Techniques and Marketing of Vegetables*. IIVR Training Manual No. 54 ICAR-Indian Institute of Vegetable Research, Varanasi, pp: 138.

Book chapters/Proceeding Chapters/ Reviews

1. Anuradha, R.K., Prasad, R.N., Roy, Shubhadeep, Meena, Kamlesh, Singh, Rameshwar and Sahu, R.P. (2014). Mahila swashaktikaran ebam sabji bwabshay. *In: Krishi Mein Subjio Dwara Vividhikaran,* ISBN: 978-93-5212-271-4, ICAR-IIVR, Varanasi. pp: 294-298.

2. Chaubey, T., Tiwari, S. K., Srivastava, M. and Singh A.K. (2015). Paudh ksim aur kisan adhikar sangrakshan adhiniyam. *In: Krishi Mein Subjio Dwara Vividhikaran.* ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi pp: 265-270.

3. Chaubey, T.; Upadhyay, D.K. and Singh, B. (2014). Genetic improvement of Sponge guard (*Luffa cylindrica* Roem.) - A review. *Adv. Res. J. of Crop Improv.* **5** (2): 215-17.

4. Chaubey, T.; Upadhyay, D.K. and Singh, B. (2014). Polymer Coating of Vegetable Seeds- A Review. *Adv. Res. J. of Crop Improv.* **5** (2): 204-07.

5. Chaubey, Tribhuvan (2015). Sabjion ka Sankar Beej Utpadan Kisan Swayem Karein. *Sabji Pathshala (Vegetable School on AIR),* ISBN: 978-93-5196-871-9, ICAR- IIVR, Varanasi pp: 116-118.

6. Chaubey, Tribhuvan, Tiwari, S.K.; Singh, A.K.; Chaturvedi, A.K. and Srivastava, Manoj (2015). Paudha Kism evam Krishak Adhikar Sanrakshan Adhiniyam. *Krishi Mein Subjion Dwara Vividhikaran*, ISBN: 978-93-5212-271-4, ICAR-IIVR, Varanasi, pp: 265-270.

7. Chaubey, Tribhuvan; Singh, P.M.; Munimugan, C; Singh, Rameshwar; Singh, A.K. and Singh, B. (2015). Kaddu Vargiya subjion ki mukt paragit kismon ka gunwatta yukt beej utpadan. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4, ICAR-IIVR, Varanasi pp: 113-122.

8. Chaurasia, S.N.S. (2015). Aloo ki bagyanik kheti. *In*: *Sabji Pathshal*a, ICAR-IIVR, Varanasi. ISBN: 978-93-5196-871-9, pp: 48-51.

9. Chaurasia, S.N.S. (2015). Alpa Upayogi Sabjiyon ka utpadan *In: Sabji Pathshala* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, pp: 192-193.

10. Chaurasia, S.N.S. (2015). Matar ki bagyanik kheti, *In: Sabji Pathshala.* ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi. Pub. pp: 76-78.

11. Chaurasia, S.N.S. (2015). Niyantrit Vatavaran Men Sabjiyon ki kheti. *In: Sabji Pathshala* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 89-92.

12. Chaurasia, S.N.S. (2015). Paan ki baigyanik kheti, In: *Krishi Mein Subjio Dwara Vividhikaran* ISBN: 978-93-5212-271-4. . ICAR-IIVR, Varanasi, Pub. pp: 48-51.

13. Chaurasia, S.N.S. (2015). Sabjion ki khei ke liyekhet ki taiyari, beej ki buai avom bagyanik bidhi se paudh taiyar karana, *In: Sabji Pathshala.* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 13-16.

14. Chaurasia, S.N.S. (2015). Sabjiyon ki jaivik kheti *In: Sabji Pathshala*, ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 186-191.

15. Chaurasia, S.N.S. (2015). Sabjiyon ki kheti par badalate pariwesh ka. *In: Sabji Pathshala* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 183-185.

16. Chaurasia, S.N.S. (2015). Sahijan Eak Swasthya Wardhak Sabji *In: Sabji Pathshala*. ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 133-134.

17. Chaurasia, S.N.S., Prasad, R.N., Yadav, R.B., Sudhir Singh, Lama, R.D., Singh, D.K., Anant Bahadur, Loley, T.K. and Roy, S. (2015). Singhara ki baigyanik kheti, In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, Pub. pp: 230-236.

18. Garg, R., Loganathan, M., Saha, S. and Roy, B.K. (2014). Chilli Anthracnose: A Review of Causal Organism, Resistance Source and Mapping of Gene. In: R.N. Kharwar et al. (eds.), *Microbial Diversity and Biotechnology in Food Security*, DOI 10.1007/978-81-322-1801-2_53, © Springer India.

19. Heera Lal and Chaurasia, S.N.S. (2015). Lobia ke bagyanik kheti, *In: Sabji Pathshala*, ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 20-22.

20. Karkute, Suhas G, Mishra Rajeev, Mayank, Rashmi and Singh, Major (2014). A Bioinformatics Approach to Target Ebola Virus with Curcumin. *Recent Advances on the Role of Basic Sciences in Ayurvedic Medicine*, pp: 55-66.

21. Karmakar, P. and Singh, R. (2015). Grihabatika me parwalugayen. *In: Krishi Mein Sabziyon Dwara Vividhikaran*. ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, Pub, pp: 45-47.

22. Koley, T.K. and Chaurasia, S.N.S. (2015). Sabjion avom hamara swasthya, *In: Sabji Pathshala.* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, Pub. pp: 45-47.

23. Krishna Kumar, N.K., Malhotra, S.K., Pandey, V., Das, M. and Ranjan, J.K. (2014). *Agricultural technology* (Horticulture, Vol. I), ICAR, New Delhi, ISBN: 817164151-2. pp: 148.

24. Kumar Rajesh and Ranjan, J.K. (2015). Mirch ke audyogikaran ki sambhavanayen. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, pp: 66-72.

25. Kumari, A.R (2015). Poshan Suraksha ke liye Grahvatika Kitna Upyogi. *In :Sabji Pathasala (Vegetable school on AIR).* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi, pp: 79-82.

26. Kumari, A.R., Prasad, R.N., Rai, S. Meena, K., Singh, S and Sahu, R.P. (2015). Mahila Sashaktikaran Ewam Sabji Vyavsay, In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, pp: 294-298.

27. Lal, H. and Chaurasia, S.N.S. (2015). Lobiya Kee Vaigyanik Kheti, *In :Sabji Pathasala (Vegetable school on AIR).* ISBN: 978-93-5196-871-9. ICAR-IIVR, Varanasi pp. 20-22.

28. Lama, T.D., Rakshit, A., Sharma, R.P. and Yadava, R.B. (2015). Soil management for sustainable production. In: *Principles of Soil Science* (Rakshit, A., Raha, P., and Bhadoria, P.S. Eds. pp. 482), Kalyani Publishers, New Delhi, India. pp. 292-312.

29. Loganathan M, Rai AB, Singh A, Saha S. (2014). Plant Growth Promoting Rhizobacteria in Vegetable Disease Management. In: *Microbial Diversity and Biotechnology in Food Security* (Eds., RN Kharwar, RS Upadhyay, NK Dubey and Richa Raghuwanshi): pp. 373-382. ISBN: 978-81-322-1800-5. DOI 10.1007/978-81-322-1801-2_33.

30. M. Loganathan, A. B. Rai, A. Singh and S. Saha (2014). Plant Growth Promoting Rhizobacteria in Vegetable Disease Management. In: R. N. Kharwar et al. (eds.), *Microbial Diversity and Biotechnology in Food Security*, DOI10.1007/978-81-322-1801-2_53, © Springer India.

31. Manjunath M., Saha S, Venkataravanappa V. and Rai AB. (2014). Role of Soil Microbes In: Sustainable Soil Health and Agricultural Production, pp: 213-224. In: *Emerging Technologies of the 21st Century* (Ed., AK Roy): 213-223. New India Publishing Agency, 101, Vikash Surya Plaza, New Delhi-110034. India. ISBN 978-93-83305-33-9: 890p.

32. Meena, K., Kumari, A.R., Prasad, R.N., Singh, Shamsher and Sahu, R.P. (2015). Sarason Ewam Toriya Ki Unnat Kheti, In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, pp: 257-264.

33. Pandey, M.K., Kumari, A.R and Meena, K. (2015). Use of Mycorrhiza as Bio-fertilizer and Bio-control agent at farmers field in Microvial Biodiversity a boon for agriculture sustainability (Eds) Asha Sinha, Sweta Srivastav and Ravindra Kumar BHU Varanasi Bio tech books New Delhi. pp: 350-376.

34. Pandey, S. (2015). Petha Kaddoo Kee Baighyanik Kheti. *In*: *Sabji Pathshal*a, ICAR-IIVR, Varanasi. ISBN: 978-93-5196-871-9, pp: 74-75.

35. Pandey, S. and Choudhary, B.R. (2014). Cucumber. In: *Handbook of Vegetable* Vol. III. (Eds. Peter, K.V. and Hazara, P.). Studium Press LLC, USA, Pp.121-149.

36. Pandey, S. and Jha, A. (2014). Scientific cultivation of pumpkin (Cucurbita moschata Duch. ex Poir.). In: Advances in Vegetable Agronomy. PG School, IARI & ICAR, DARE, GOI, New Delhi, pp: 103-111.

37. Pandey, S. and Karmakar, P. (2015). Riverbed cultivation of cucurbitaceous vegetable crops. In: *E-training manual on Improved Production Technologies and Marketing in Vegetable Crops, ICAR-IIVR, Varanasi*, pp: 49-54.

38. Pragya and Ranjan, J.K. (2015). Grih vaatika men Phool Ugayen. , In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi. pp: 145-147.

39. Prasad, R. N. (2014). Sabjiyon ki kheti me sansadhan sarakshan taknik. *In*: *Sabji Pathshal*a, ICAR-IIVR, Varanasi. ISBN: 978-93-5196-871-9. pp: 96-106.

40. Prasad, R. N. (2014). Sabjiyon me kharpatwar niyantran. *In*: *Sabji Pathshal*a, ICAR-IIVR, Varanasi. ISBN: 978-93-5196-871-9, pp: 57-61.

41. Prasad, R.N.; Yadav, R.B.; Singh S; Singh, N.; Lama, T.D.; Singh D.K., Bahadur, A.; Koley, T.K. and Roy, S. (2015). Singara ki baigyanic kheti. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi pp: 83-86.

42. Rai, N. (2015). Pharashbeen kee Vigyaneek Khetti Avam Beej Uttapadan. *In*: *Sabji Pathshal*a, ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi. pp: 71-73.

43. Rai, N. (2015). Sabgiyon Utttapadan me Sankar Beej ka Mahatav Avam Phayade. *In*: *Sabji Pathshal*a,. ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi pp: 124-126.

44. Rajesh Kumar and Ranjan, J. K. (2015). Mirch me audyogikikaran kee sambhavnayen. *In*: *Sabji Pathshal*a,. ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi, pp: 66-72.

45. Roy, S. (2015). Sabji Beej Gram. *In*: *Sabji Pathshal*a,. ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi pp: 147-148.

46. Roy, S., Singh, N. and Singh, Anupam. (2014). Gender dynamics in transfer of technology in agriculture. In: *Advances in Extension Education and Rural Development*, Vol. III *Agrobios* (India): 2014. ISBN: 9788177545319 pp: 5-13.

47. Sanwal, S.K. (2015). Bhindika Beej UtpadanTaknik. *In*: *Sabji Pathshal*a,. ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi pp: 154-156.

48. Singh, Arpita, Saha, Sujoy, Garg, Ruchi, Pandey, Atul K. and Rai, A.B. (2014). Proteins in Plant Defense System: An Overview. In: *Emerging Technologies of the 21st Century* (Ed: AK Roy): 85-102. New India Publishing Agency, New Delhi. ISBN 978-93-83305-33-9: 890p.

49. Singh, B. and Pandey, S. (2014). Vegetable research in India: status and future strategies. *In: Horticulture for Inclusive Growth (Chadha et. al. Eds.), Westville Publishing House, New Delhi*, pp: 201-228.

50. Singh, B., Koley, T.K. and Jha, A. (2015). Vegetables and our health. *In: K.V. Peter (Ed) Horticulture for nutrition security. Astral International Pvt. Ltd. New Delhi,* 67-125 (ISBN 978-93-5123-860-2).

51. Singh, B.K. and Devi, J. (2015). Improved Production Technology for Cole Crops (*Brassica oleracea*). *Improved Production Technologies in Vegetable Crops* in IIVR Training Manual No. 59. ICAR-IIVR, pp: 12-119.

52. Singh, B.K., Karmakar, P., Devi, J. and Koley, T. (2015). Grihabatika me parwalugayen. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi. pp: 134-137.

53. Singh, B.K., Verma, V.K. and Ramakrishna, Y. (2014). Leaf vegetables of Mizoram. In: *Climate Resilient Crops for the Future*. NIPA, New Delhi, pp: 383-404.

54. Singh D.K. 2015. Sabjiyon ki kheti hetu upyogi krishi yantra. In: Sabji Pathshala: 1-203, ISBN: 978-95-5196-871-9. (Eds. SNS Chaurasia, Neeraj Singh, Shubhadeep Roy and Bijendra Singh). Pp. 101-106.

55. Singh, D.K., Chaurasia, S.N.S., Yadava, R.B. and Bahadur, Anant (2015). Sabjiyon Men Boond Boond Sinchai Bidhi. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi. pp: 87-92.

56. Singh, Neeraj, Roy, Shubhadeep, Prasanna, H.C., Sanwal, S.K., Singh, A.K. and Gupta, Sunil. (2015). Sabjiyon ke vikas ebam prasar me Brartiya Sabji Anusandhan Sansthan ki bhumika. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi pp: 138-144.

57. Singh, P.K and Tiwari, S.K. (2015). Sabji Soybean Ki Kheti. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi, pp: 48-50.

58. Singh, P.M; Singh, R. and Singh, N. (2015). Farash Bean Kee Basantkaleen Kheti-Ek Laabhkaari Vyavsay. In: *Krishi Mein Sabziyon Dwara Vividhikaran*, ICAR-IIVR, Varanasi, pp: 42-44. ISBN: 978-93-5212-271-4. ICAR-IIVR.

59. Singh, S. and Koley, T.K. (2015). Gramin Paribesh main sabjiya ka kam lagat main prasankaran. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi pp: 123-126.

60. Singh, Sudhir and Koley, T.K. (2015). Gramin Parvesh me kam Lagat me Prasanskaran. In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, Varanasi pp: 123-126.

61. Tiwari S.K. (2015) Vartmaan parivesh main kisaan ke adhikaar. In: *Sabji Pathshala*, ISBN: 978-93-5196-871-9, ICAR-IIVR, Varanasi, pp: 127-132.

62. Venkataravanappa, V., Mahesha, B. and Rai, A.B. (2014). Plant Products for Management of Plant disease Caused by Fungi, bacteria and viruses. In: *Organic Farming and Management of Biotic stresses*. 353-2379.

63. Yadava, R.B., Lama, T.D., Chaurasia, S.N.S., and Prasad, R.N. 2015. Sabjiyon mein sookshma poshak tatvon ka mahatva In: *Krishi Mein Subjio Dwara Vividhikaran*, ISBN: 978-93-5212-271-4. ICAR-IIVR, pp. 93-98.

64. Yadava, R.B.2015. Sabjiyon mein ekikrit poshak tatva prabandhan. In: *Sabji Pathshala*. ISBN: 978-93-5196-871-9, ICAR-IIVR, pp. 64-70.

Lead/ Invited Papers

1. Chaurasia, S.N.S and Singh, B. (2014). Advances in Nursery raising: Present Scenario, Proc. International Symposium on Innovations in Horticulture for Nutritional Security, Conserving biodiversity and poverty alleviations, Oct., 16-18, BBA University, Lucknow and Indian Society of Horticultural Research and Dev. Dehradun. pp: 205-206.

2. Chaurasia, S.N.S and Singh B. (2014). Nursery raising: Present Scenario and future prospects, Proc. International Symposium on Periurban Agriculture for Improving Livelihood Opportunities, Nov.25-26, Samagra Vikas Welfare Society. pp: 205-206.

3. Pandey Sudhakar (2015). Lead paper on "Hi-tech vegetable production: present status and future prospects" in 2nd national seminar on 'Hitech Horticulture: challenges and opportunity', Feb 26-27, Department of Applied Plant Science, BBA University, Lucknow.

Research Abstracts

1. Bahadur Anant, Kumar Rajesh, Tiwari SK, Rai AK, Singh AK and Singh M. (2014). Screening of tomato (Solanum lycopersicum L.) genotypes to waterlogging tolerance. In: International Conf. on Horticulture for nutritional livelihood and environmental security in Hills: Opportunity and challenges, May 22-24, 2014, Kalimpong, Darjeeling, pp: C-36.

2. Bahadur Anant, Rai A.K., Singh A.K., Kumar R., Tiwari S.K. and Singh M. (2014). Physiological and yield response of tomato plant grafted onto eggplant rootstock under water-logging condition. Oral presentation International Symposium on Innovations in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviation, BBA ,University, Lucknow , October 16-18. pp: 206.

3. Bhardwaj, D.R., Pandey, S., Chaubey, T., Karmakar, P., Singh, P.K. and Singh, M. (2014). Evaluation of bitter gourd to identify suitable genotype for winter season. In: "2nd UP Agricultural Science Congress on Technological and governance strategies for advancement of agricultural education, research and extension in Uttar Pradesh", UPCAR, Lucknow, June, 14-16, pp: 245-246.

4. Chaturvedi Pragya, Kumar Rajesh and Singh VK (2015). Computational identification of defensin genes from assembled transcriptome of two chilli pepper varieties, Poster presented in National Conference on Biotechnology and Human Welfare: New Vistas, March 21-22, Department

of Biotechnology, VBS Purvanchal University, Jaunpur, pp: 277-278.

5. Chaubey, P.K.; Pandey, D.D.; Singh, B.; Chaubey, T.; Jha, A. and Upadhyay, D.K. (2014). Exploitation of heterosis in okra (Abelmoschus esculentus L. Moench.). National Symposium on Precision Horticulture for Small and Marginal Farmers, IGKV, Raipur, June 24-27, pp: 72.

6. Chaubey, P.K.; Pandey, D.D.; Singh, B.; Chaubey, T.; Upadhyay, D.K. and Jha, A. (2014). Screening of okra genotypes and their crosses against OLCV disease. National Symposium on Precision Horticulture for Small and Marginal Farmers. IGKV, Raipur, June 24-27, pp: 280.

7. Chaubey, T. and Singh, P.M. (2014). Post harvest management of vegetable seeds. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 190.

8. Chaubey, T., Singh, B., Pandey, S., Jha, A. and Upadhyay, D.K. (2014). Varietal characterization of cucumber varieties/genotypes using DUS characters. National Symposium on Precision Horticulture for Small and Marginal Farmers, IGKV, Raipur, June 24-27, pp: 35-36.

9. Chaubey, T., Singh, B., Srivastava, R. K. and Bhushan, Chandra (2014). A new high yielding variety of tomato released through AICRP (VC). Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture: Issues and Strategies , NAU, Navsari, Gujarat and the Amit Singh Memorial Foundation, New Delhi , May 28-31, pp: 48-49.

10. Chaubey, T., Singh, B., Srivastava, R. K. and Bhushan, Chandra (2014). Evaluation and identification of ash gourd hybrids through AICRP (VC). Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture: Issues and Strategies , NAU, Navsari, Gujarat and the Amit Singh Memorial Foundation, New Delhi , May 28-31, pp: 62.

11. Chaubey, T., Singh, B., Upadhyay, D.K., Jha, Astik and Pandey, S.D. (2014). Varietal Characterization of Tomato based on DUS descriptors. International Symposium on Peri-Urban Agriculture for Improving Livelihood Opportunities, Samagra Vikas Welfare Society, Lucknow, November 25-26, pp: 136.

12. Gujjar, R.S., Akhtar, M. and Singh M. (2014). Expression profiling of WRKY transcription factors in Solanum habrochaites under water stress. Pre Post Harvest Losses & Value Addition in Vegetables, National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 254-255.

13. Halder, J., Yadava, R.B. and Rai, A.B. (2014). Impact of organic and inorganic management systems on incidence of spotted pod borer, Maruca vitrata (Geyer) on cowpea. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables. APIV, ICAR-IIVR July 12-13,: pp: 159.

14. Karkute, S.G., Solanke, A.V., Kumar P.A. (2014). Bt Brinjal is safe for human consumption: A report from differential expression analysis of Normal and Bt brinjal fruits. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables. APIV, ICAR-IIVR July 12-13,: pp: 259-260.

15. Karmakar, P., Bhardwaj, D.R. and Singh, M. (2014). Development of high yielding pointed gourd (Trichosanthes dioica Roxb) genotypes with better self-life and transportability. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 255.

16. Karmakar, P., Pandey, S., Bhardwaj, D.R. and Singh, M. (2014). Screening of Indian melon germplasm for fruit quality and TSS. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 239.

17. Karmakar, P., Tiwari, S.K., Mishra, P., Kashyap, S.P., Bhardwaj, D.R. and Singh, M. (2014). Development of RAPD marker for seedless fruit development in pointed gourd (Trichosanthes dioica Roxb.). National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp 257

18. Karmakar, P., Munshi, A.D. and. Behera, T.K. (2014). Antioxidant response of ridge (Luffa acutangula Roxb.) gourd in relation to heterosis breeding utilizing hermaphrodite sex forms. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12-13, pp 247.

19. Kodandaram, M.H., Rai, A.B., Halder, J. and Manjunath, M. (2014). Effect of insecticide rotational strategies for control of pre harvest losses by fruit and shoot borer Leucinodes orbonalis in brinjal. National Conference on Pre-

/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 185.

20. Koley TK, Kumar Rajesh, Mintoo and S.N.S. Chaurasia. (2014). Antioxidant diversity in pepper (Capsicum) fruits of diverse genotype including commercial cultivar, hybrid, wild species and inter-specific derivatives", National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 249.

21. Kumar Rajesh, Chaudhary Rajiv, Loganathan M and Singh Major (2014). Molecular breeding for anthracnose disease of chilli. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 258.

22. Kumar Rajesh, Mintoo, Loganathan M and Singh Major (2014). Interspecific hybridization in Capsicum for management of anthracnose disease. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 176.

23. Kumari, A.R. and et. al. (2015). A Comparative study on Trained and untrained women on Apiculture Technolgy. The 2nd International Conference on Bio-resource and Stress Management, January 7-10, PJTSAU, Rajendranagar, Hyderabad.. pp: 461.

24. Kumari, A.R. and et. al. (2015). Extent of empowerment of elected women Panchayat Samiti members in Panchayati Raj System. The 2nd International Conference on Bio-resource and Stress Management, January 7-10, PJTSAU, Rajendranagar, Hyderabad. pp: 451.

25. Kumari, A.R. and et. al. (2015) Impact of KVK Training Programme on Socio-Economic status and Knowledge of trainees in Deoria District. The 2nd International Conference on Bio-resource and Stress Management, January 7-10, PJTSAU, Rajendranagar, Hyderabad, pp: 477.

26. Lal, H. and Vishwa Nath (2014) Bushy and cowpea golden mosaic virus resistant cowpea varieties for higher yield with low input. In Souvenir & Abstracts: 2nd UP Agricultural Science Congress on "Technological and Governance Strategies for Advancement of Agricultural Education, Research and Extension in Uttar Pradesh" jointly organized by UPCAR, Lucknow; SHIATS ,, Allahabad, CSAUA&T, Kanpur, U.P.Rajya.Krishi Utpadan Mandi Parishad, Lucknow and U.P. Academy of Agricultural Sciences, Lucknow, IISR, Lucknow, June 14-16, pp: 85.

27. Mahesha, B., Venkataravanappa, V., Kodandaram, M.H., and Rai, A.B. (2014). Characterization of Groundnut bud necrosis virus (Genus: Tospovirus, Family: Bunyaviridae) infecting tomato (Solanum lycopersicon L.) at Varanasi, India. In: National conference on pre/post-harvest losses and value addition in vegetables, July 12-13, 2014, IIVR, Varanasi. pp: 181-182.

28. Manjunath, M., Venkataravanappa, V., Loganathan, M., Mahesha, B. and Rai, A.B. (2014). Isolation and characterization of fungal pathogens from cucumber. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 181.

29. Pandey, S. (2014). Intellectual property rights and trade related issues in vegetables: an overview. In: International symposium on "Innovations in horticulture for nutritional security, conserving biodiversity and poverty alleviation", Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, BBAU, Lucknow, October 16-18, pp: 194-195.

30. Pandey, S. and Karmakar, P. (2014). Present status and future breeding strategies for improved cultivation of ash gourd, ivy gourd and creeping cucumber (Melothria). In: "National seminar cum workshop on strategies for improvement, enhancing productivity and utilization of cucurbits" organized by Society for promotion of Horticulture and CHES, Bhubaneswar, August 08-10, pp :112-114

31. Pandey, S. and Ansari, W.A. (2014). Screening of snapmelon genotype for drought stress on the basis of enzymatic activity. In: International symposium on "Innovations in horticulture for nutritional security, conserving biodiversity and poverty alleviation" organized by Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, BBAU, Lucknow, October 16-18, pp: 86.

32. Pandey, S., Ansari, W.A., and Singh, M. (2014). Effect of drought stress on yield and physiological parameters of snapmelon genotypes (Cucumis melo var. momordica). In: "2nd UP Agricultural Science Congress on Technological and

governance strategies for advancement of agricultural education, research and extension in Uttar Pradesh" , UPCAR, Lucknow, June 14-16, pp: 382.

33. Pandey, S., Jha, A., Singh, M. and Kumar, S. (2014). Standardization of manufacturing protocol of petha sweets. In: "2nd UP Agricultural Science Congress on Technological and governance strategies for advancement of agricultural education, research and extension in Uttar Pradesh" , UPCAR, Lucknow, June 14-16. pp: 392.

34. Patel, P.K., Singh, Umesh, Singh, A.K., Kumar, Rajesh and Singh, Major (2014). Identification of tomato genotypes for better post-harvest attributes and high temperature tolerance. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 177.

35. Prasad, R. N., Chaurasia, S.N. S. and Yadava, R.B., Singh, D.K. and Lama, T.D. (2014). Effect of pre-harvest spray of weedicides and use of mulch to reduce yield losses in cauliflower. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 180.

36. Rai, A.B., Kodandaram, M.H. and Halder, Jaydeep. (2014). Development and evaluation of pest management modules to minimize pre-harvest losses due to leaf hopper Amrasca biguttula biguttula. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 143.

37. Roy, Shubhadeep and Singh, Neeraj (2014). Perception analysis of agricultural experts on setting priority for development of agribusiness. In: Compendium, 7th National Extension Education Congress-2014 on Translational research-extension for sustainable small farm development. November 08-11, 2014. ICAR Research Complex for NEH Region, Umiam, Meghalaya. pp: 242-243.

38. Roy, Shubhadeep, Singh, Neeraj and Singh, P.M. (2014). Web based perception analysis of experts regarding priorities for vegetable seed sector in India. In: Compendium, 7th National Extension Education Congress-2014 on Translational research-extension for sustainable small farm development. November 08-11, 2014. ICAR Research Complex for NEH Region, Umiam, Meghalaya. pp: 80.

39. Roy, Shubhadeep, Singh, Neeraj and Vanitha, S.M. and Naik, P.S. (2014). Web based perception analysis of agricultural experts regarding priority setting for post harvest management in vegetables in India. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 265.

40. Sellaperumal, C., Singh, Satyendra, Halder, J. and Rai, A.B. (2014). In-vitro studies of bioefficacy of Dhatura (Datura strmonium) against root knot nematode, Meloidogyne incognita. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13pp: 167.

41. Singh, Ajeet, Mishra, V.K., Kumar, Ashwani, Sharma, Rohan, Tiwari, S.K., Roy, Shubhadeep, Singh, Neeraj, Singh, Sudhir and Singh, P.M. (2014). Promoting agri-preneurship in PPP mode through business planning and development unit. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13 , pp: 265-266.

42. Singh, Pratistha, Kumar, Rajesh and Singh, V.K. (2015). In silico interaction of selected fungicides for anthracnose disease management. National Conference on Biotechnology and Human Welfare: New Vistas, March 21-22. Department of Biotechnology, VBS Purvanchal University, Jaunpur, pp: 247-248.

43. Singh, Sudhir, Koley, T.K., Chaurasia, S.N.S. and Rai, Ashutosh (2015). Studies on carnauba wax edible coating on nutritional and sensory qualities of bitter gourd (*Momordica charantia* L.). National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12-13, pp: 206.

44. Singh, Umesh, Patel, P.K., Awasthi, S., Tiwari, S.K., Kumar, Rajesh and Singh, Major (2014). Identification of moisture deficit stress lines in tomato. Abstract, National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 179.

45. Singh, Umesh, Patel, P.K., Awasthi, S., Tiwari, S.K., Kumar, Rajesh and Singh, Major (2014). Quantitative changes in antioxidant compounds of tomato fruits at different ripening stages under extreme temperature. Abstract & Poster; National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July, 12 -13, pp: 241.

46. Singh, B. and Pandey, S. (2014). Hi-tech Production of vegetable: status and future

prospects. In: "2nd National seminar on Hi-tech Horticulture:challenges and oppurtunity" , Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, BBAU, Lucknow, Jan., 26-27, pp: 3.

47. Singh, B., Chaubey, T. and Pandey, S. (2014). Vegetable diversity vis-a-vis nutritional security. In: International symposium on "Innovations in horticulture for nutritional security, conserving biodiversity and poverty alleviation" , Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, BBAU, Lucknow, October 16-18, pp: 3.

48. Singh, B., Pandey, S., Choubey, T., Jha, A. and Upadhyay, D.K. (2014). Morphological characterization of pumpkin varieties/genotypes using DUS characters. In: "2nd UP Agricultural Science Congress on Technological and governance strategies for advancement of agricultural education, research and extension in Uttar Pradesh", UPCAR, Lucknow, June, 14-16, pp: 215-16.

49. Singh, B.; Chaubey, T.; Upadhyay, D.K. and Jha, A. (2014). An assessment of morphological characteristics of brinjal (*Solanum melongena* L.) varieties/genotypes using DUS characters. National Symposium on Precision Horticulture for Small and Marginal Farmers, IGKV, Raipur, June 24-27 pp: 37.

50. Singh, B., Jha, A., Chaubey, T., Upadhyay, D.K. and Pandey, S.D. (2014). Varietal characterization of cauliflower (*B. oleracea* var. botrytis L.) based on DUS characters. 2nd UP Agricultural Science, UPCAR, Lucknow, June 14-16, pp: 219.

51. Singh, B., Pandey, S., Upadhyay, D.K., Jha, A. and Chaubey, T. (2014). Stability of Quantitative traits in bitter gourd. Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture: Issues and Strategies , NAU, Navsari, Gujarat and the Amit Singh Memorial Foundation, New Delhi , May 28-31, pp: 57-58.

52. Singh, A., Mishra, V.K., Kumar, A., Sharma, R., Tiwari, S.K., Roy, S., Singh, N., Singh, S. and Singh, P.M. (2014). Promoting agri-preneurship in PPP mode through Business Planning & Development Unit. National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 265-66.

53. Talukdar, A., Yashpal, Devi, J., Kumar, A., Rathod, D.R., Verma K., Mukherjee K., Lal, S.K. and Singh, K.P. (2014). Development of mapping population and parental polymorphic survey for QTL mapping in soybean. Proceeding of National Symposium on "Crop Improvement for Inclusive Sustainable Development" November 7-9, PAU, Ludhiana, pp: 633.

54. Venkataravanappa, V., Reddy, M. Krishna, and Rai, A.B. (2014). Association of monopartite and bipartite brgomoviruses and Betasatellites with yellow vein mosaic disease of okra in India. In: AZRA silver jubilee international conference on Probing Biosciences for food security and environment safety, CRRI, Cuttack (Odisha), Feb 16-18, pp: 101-102.

55. Yadava, R.B., Chaurasia, S.N.S., Lama, T.D., Singh, Sudhir, Prasad, R.N., and Singh, D.K. (2014). Effect of organic vis-à-vis inorganic management systems on growth, yield and quality of cauliflower National Conference on Pre-/Post-Harvest Losses & Value Addition in Vegetables, APIV, ICAR-IIVR, July 12 -13, pp: 187- 188.

Articles in Souvenir

1. Naik, P.S. and Pandey, S. (2014). Indigenous cucurbits: present status and future prospects. *In: Souvenir: National Seminar cum workshop on "Strategies for improvement, enhancing productivity and utilization of cucurbits" (August 8-10), CHES, Bhubaneswar*, pp: 31-42.

2. Pandey, S. (2014). Petha: Kam Lagat main Labhkari Vyavsai. *In: Souvenir: National Farmers Fair and Vegetable Show (February 1), IIVR, Varanasi*, pp. 102-107.

3. Singh, B., Singh, P.M. and Pandey, S. (2015). Pradesh mai shakbhajee Vikash Kee sambahwnai, nabeentam takneek awam sankar beejo ka upyog. *In: Souvenir: State fruit, vegetable and flower show (February 21-22), Governor House, UP, Lucknow*, pp: 10-15.

Articles in News Letter

1. Chaurasia, S.N.S, Singh, N., Lama, T.D., Pandey, S., Saha, S., Roy, S., Chauturvedi A.K. and Pandey Rakesh (2014). ICAR-IIVR holds hands of 1000 tribal households for sustainable livelihood in Sonebhadra district of Uttar Pradesh under tribal

sub plan. *In: Vegetable Newsletter, ICAR-IIVR,* pp: 10-11.

2. Karkute, S.G. (2014) Vegetable Improvement through Genome editing. Vegetable Newsletter, ICAR-IIVR, 1 (1): pp. 3-4.
3. Lama, T.D., Yadava, R.B., Bahadur, A. and Manjunath, M. 2015. Zero tillage for improving energy use efficiency in vegetable production system. *Vegetable News Letter, ICAR-IIVR,* 1(1) pp. 9.
4. Pandey, S. and Karmakar, P. (2014). River bed cultivation of cucurbits. *Vegetable Newsletter, ICAR-IIVR,* 1(1): 2-3.
5. Singh B, Saha Sujoy, Singh B.K., Roy Shubhadeep, Koley T.K. and Singh Neeraj. 2014. *Vegetable Newsletter*, ICAR-*IIVR*. Vol-1, Issue-1, July-December, 2014.
6. Singh, B.K. (2014). VRFBB-91: A French bean (*Phaseolus vulgaris*) germplasm for earliness. *Vegetable Newsletter*, ICAR-*IIVR*, **1** (1): 5.
7. Verma, V.K., Jha, A.K. and Singh, B.K. (2014). Meghalaya Local: A Natural CMS based hybrid of cauliflower grown in Meghalaya. *Vegetable Newsletter, ICAR-IIVR*, **1** (1): 6.
8. Verma, V.K., Jha, A.K. and Singh, B.K. (2014). Nutritional properties of different fruit parts of popular chow-chow genotype grown in NEH Region of India. *Vegetable Newsletter*, ICAR-*IIVR*, **1** (1): 8.
9. Yadava, R.B., Singh, Sudhir TD Lama, Jaydeep Halder, Manjunath, C Sellaperumal (2015). Organic farming for better quality and safe vegetable production. *Vegetable Newsletter*, ICAR-*IIVR*, 1(1): pp. 8-9.

Extension Folders

1. Pandey Sudhakar, Singh, P.M., Singh Neeraj, Kodandaram, M.H., Saha, S. and Singh A.P. (2015). Petha Kaddu ki Vaigyanik Kheti. *Extension Folder No. 1, ICAR-IIVR.*
2. Bhardwaj, D.R., Pandey, S., Singh, P.K. Rai, A.B., Venkatravanappa, V. and Singh A.K. (2015). Karela Ki Vaigyanik Kheti. *Extension Folder No. 2, ICAR-IIVR.*
3. Pandey S., Singh, Major, Singh Neeraj, Saha, S., Venkatravanappa, V. and Srivastava, R.K. (2015). Kumhada ki Vaigyanik Kheti. *Extension Folder No. 6, ICAR-IIVR.*
4. Tiwari, S.K. Singh, M., Kumar Rajesh, Rai, A.B. Loganathan, M., Kodandaram, M.H., Singh, Neeraj and Goswami Asutosh (2015). Baigan Ki Vaigyanik Kheti. *Extension Folder No. 13, ICAR-IIVR.*
5. Sanwal, S.K., Singh, B., Singh P.M., Devi, J., Halder, J., Venkatravanappa, V., Cellperumal C. and Chandra Subhash (2015). Bhindi Ki Vaigyanik Kheti. *Extension Folder No. 15, ICAR-IIVR.*
6. Sanwal, S.K., Singh, B., Singh P.M., Singh, N., Devi, J., Halder, J., Kumar Y.B. and Chandra Subhash (2015). Sabji Matar Ki Vaigyanik Kheti. *Extension Folder No. 21, ICAR-IIVR.*
7. Chaurasia, S.N.S., Prasad, R.N., Bahadur, A., Singh, N., Srivastva, R.K., Tripathi, P.C. and Rai Rajesh (2015). Sabjiyon Ki Swasth Paudh Taiyaar Karna. *Extension Folder No. 32, ICAR-IIVR.*
8. Chaurasia, S.N.S., Prasad, R.N., Singh, N., S.M., Vanitha, Singh, Y.P., and Tripathi, P.C. (2015). Sabjiyon Ki Swasth Paudh Taiyaar Karne Mein Dhyaan Dene Yogya Baatein. *Extension Folder No. 35, ICAR-IIVR.*
9. Bahadur, Anant, Chaurasia, S.N.S., Prasad, R.N., Roy, Shubhadeep, Singh, Rameshwar, Singh, Y.P. and Tripathi, P.C. (2015). Ekbarshiya Sahajan Ki Unnat Kheti. *Extension Folder No. 31, ICAR-IIVR.*
10. Bahadur, Anant, Singh, D.K., Chaurasia, S.N.S., Roy, Shubhadeep, Srivastava, R.K., Rai Rajesh and Singh, P.K. (2015). Sabjiyon me Sinchai Jal Prabandhan. *Extension Folder No. 30, ICAR-IIVR.*
11. Bhardwaj D.R., Manimurgan, Cellaperumal C., Roy Shubhadeep, Manjunath M. and Singh Ashoke Kumar. (2015). Lauki ki Bayganik Kheti. *Extension Folder No. 03, ICAR-IIVR.*
12. Chaube T., Bhardwaj D.R., Halder J., Venkatravanappa V., Prasanna H.C., Roy Shubhadeep, Karkute S.G. and Goswami Asutosh. (2015). Nasdar Tori ki Bayganik Kheti. *Extension Folder No. 11, ICAR-IIVR.*
13. Chaubey, Tribhuvan; Bhardwaj, D.R.; Haldar, Jaydeep; Venkatravnappa, V.; Prasanna, H.C.; Manimurugan, C. and Rai, R.M. (2015). Chikani Torai Ki Vaigyanik Kheti. *Extension Folder No. 10, ICAR-IIVR.*
14. Chaurasia S.N.S., Prasad R.N., Singh D.K., Bahadur, A., Roy, S., Cellaperumal, C. and Singh, Y.P. (2015). Niyantrit Watabaran Me Sabjiyon Ki Kheti. *Extension Folder No. 33, ICAR-IIVR.*

15. Chaurasia, S.N.S., Koley, T.K., Yadav, R.B., Singh, Neeraj, Rai, R. and Tripathi, P.C. (2015). Poushtik tatwa se bharpur sabjiya. *Extension Folder No. 28, ICAR-IIVR.*

16. Karmakar, P., Bhardwaj, D.R., Halder, J., Singh, S., Roy, S., Singh, R. and Viswanath. (2015). Parwal kee vygyanik Kheti. *Extension Folder No. 05, ICAR-IIVR.*

17. Kumar, R., Ranjan, J.K., Singh, M., Singh P.M., Rai. A.B., Saha, S., Mahesh, B. And Goswami, A. (2015). Mirch kee vygyanik Kheti. *Extension Folder No. 14, ICAR-IIVR.*

18. Lal, H., Singh, M., Singh, P.M., Haldar, J., Kumar, Y. Bijen, Singh, N. and Vishwa Nath (2015). Lobiya Kee Vaigyanik Kheti. *Extension Folder No. 20, ICAR-IIVR.*

19. Pandey Sudhakar, Rai A.B., Loganathan M., Manjunath M., Roy Shubhadeep and Singh Ashoke Kumar. (2015). Khira ki Bayganik Kheti. *Extension Folder No. 04, ICAR-IIVR.*

20. Pandey, S., Karmakar, P., Lognathan, M., Singh, S., Roy, S. and Singh, A.P. (2015). Kharbuj kee vygyanik Kheti. *Extension Folder No. 07, ICAR-IIVR.*

21. Rai, N., Chaubey T., Rai A.B., Singh N., Loganathan, M., Reddy, Y.S. and Rai, R.M. (2015). Sem ki vaignanik kheti. *Extension Folder No.24, ICAR-IIVR.*

22. Rai, N., Chaubey, T., Lal, H., Singh, B.K., Kodandaram, M.H., Sellaperumal, C. and Rai, R.M. (2015). Farashbean (French bean) Kee Vaigyanik Kheti. *Extension Folder No. 23, ICAR-IIVR.*

23. Rai, N., Chaubey, T., Singh M., Prasanna, H.C, Kumar, R., Kodandaram, M.H., Venkataravanappa, V., Reddy, Y.S. and Singh A.K. (2015). Tamater ki vaignanik kheti. *Extension Folder No. 12, ICAR-IIVR.*

24. Ranjan, P., Chaurasia, S.N.S., Tiwari, S.K., Reddy, Y.S., Karkute, S.G. (2015). Hari pathevar sabjionki vaignanik kheti. *Extension Folder No. 22, ICAR-IIVR.*

25. Singh, S., Koley, T.K., Roy, S., Singh, A.K., Singh, R. and Singh, P.K. (2015). Tudai Uprant Sanjoyon ki Prabandhan. *Extension Folder No. 27, ICAR-IIVR.*

26. Singh, S., Koley, T.K., Vanitha, S.M., Singh, A.K., Singh, R. Shrivastava, R.K. and Chandrabhushan (2015). Khadya parirakshan me nicin ka upoyogita. *Extension Folder No. 26, ICAR-IIVR.*

27. Singh, B.K., Singh, B., Karmakar, P., Kdandaram, M.H., Gujjar, R.S., Roy, S. and Gupta, S. (2015). Muli kee vygyanik Kheti. *Extension Folder No. 18, ICAR-IIVR.*

28. Singh, B.K., Singh, B., Ranjan, J.K., Kodandaram, M.H., Saha, S., Manjunath, M. and Gupta, S. (2015). Pattagobhi Ki Vaigyanik Kheti. *Extension Folder No. 16, ICAR-IIVR.*

29. Singh, B.K., Singh, B., Singh, P.K., Devi, J., Saha, S., Mahesha, B. and Chandra, S. (2015). Phoolgobhi Ki Vaigyanik Kheti. *Extension Folder No. 17, ICAR-IIVR.*

30. Singh, B.K., Singh, B., Singh, P.K., Ranjan, J.K., Saha, S., Gujjar, R.S. and Gupta, S. (2015). Gazar Ki Vaigyanik Kheti. *Extension Folder No. 19, ICAR-IIVR.*

31. Singh, P.K., Bhardwaj, D.R., Karmakar, P., Tiwari, S.K., Kdandaram, M.H., Roy, S., Singh, R. and Viswanath (2015). Kundru kee vygyanik Kheti. *Extension Folder No. 09, ICAR-IIVR.*

32. Singh, P.K., Pandey, S., Ranjan P., Loganathan, M., Singh S. and Rai, R. (2015). Tarbooj ki vaigyanik kheti. *IIVR Extension Folder No. 08, ICAR-IIVR.*

33. Singh, P.M., Chaubey, Tribhuvan, Kumar, Rajesh, Manimurugan, C., Singh, Rameshwar, Bhushan, Chandra (2015). Sabji Beej Utpadan Hetu Buwai Ke Samay Ka Mahatva. *Prasar Pustika No. 25, ICAR-IIVR.*

34. Yadava, R.B., Chaurasia, S.N.S., Bahadur, Anant, Lama, T.D., Singh, Neeraj and Gupta, Sunil. (2015). Sabjiyon ki Jaivik Kheti. *Extension Folder No. 34, ICAR-IIVR.*

35. Yadava, R.B., Chaurasia, S.N.S., Lama, T.D., Bahadur, Anant, Singh, Neeraj and Singh, Rameshwar. (2015). Mitti ki urvarashakti evam utpadakta ke liye hari khad. *Extension Folder No. 29, ICAR-IIVR.*

Radio talks : 25

TV Talk : 40

Classified Abstract of Expenditure

Indian Institute of Vegetable Research (plan and non-plan) 2014-15

(Rupees in Lakhs)

Sub-head	Plan		Non-Plan	
	Provision made in RE 2014-15	Expenditure	Provision made in RE 2014-15	Expenditure
Establishment Charges	-	-	850.00	843.31
Wages	-	-	-	-
O.T.A.	-	-	-	-
T.A.	15.00	15.14	4.00	1.91
Other Charges (Contingency)	286.50	280.16	116.00	112.14
H.R.D.	5.00	3.67	-	-
Works	25.00	24.15	-	-
Equipment	14.50	14.74	3.00	3.28
Library	12.00	11.99	-	-
Vehicle	-	-	5.50	-
Annual Repairs/Maintenance	10.00	9.44	-	-
Information Technology	2.00	1.73	-	-
TSP NEH	15.00 15.00	14.72 15.00	-	-
Total	**400.00**	**390.74**	**978.50**	**960.64**

Revenue generation (2014-15)

(Rupees in Lakhs)

Particulars	Revenue generation
IIVR	86.13

Krishi Vigyan Kendra (plan) 2014-15

(Rupees in Lakhs)

KVKs	RE 2014-15	EXPENDITURE
KVK, Kushinagar	81.20	81.65
KVK, Deoria	52.50	52.97
KVK, Sant Ravidas Nagar	87.10	87.10
Total	**220.80**	**221.72**

Externally Funded Projects

Title of the Project	Funding Agency	Year of Start	Year of Completion	Total Allocation (in lakh)	Allocation and Expenditure in 2014-15	
					Allocation	Expenditure
Division of Vegetable Improvement						
Network Project on "Transgenic crops"	ICAR	2005	2015	147.90	20.50	14.79
National initiative on climate resilient agriculture (NICRA)	ICAR	2011	2017	336.00	87.50	57.51
Gene expression studies and development of functional markers for anthracnose disease in Capsicum species	DST	2012	2015	39.30	39.30	17.95
Evaluation of high yielding varieties/hybrids of cucurbitaceous vegetables for river bed (diara land) cultivation and standardization of their agro-techniques	UPCAR	2014	2017	20.988	3.887	2.006
Bio-prospecting of genes and allele mining for abiotic stress tolerance	ICAR	2009	2014	98.43	7.92	8.01
Validation of DUS testing guidelines of cucurbits i.e, muskmelon and watermelon	ICAR	2011	1014	11.62	1.44	1.22
Business Planning and Development Unit of IIVR, Varanasi	ICAR	2013	1014	153.66	5.573	4.977
Genomics assisted selection of *S. chilense* introgression lines for enhancing drought resistance in tomatoes	DBT, India – BBSRC, UK	2015	2018	132.00	74.084	-
Introgression of begomovirus resistance genes in tomato using MAS and genomics approach	DBT	Dec., 2014	Dec., 2019	73.73	21.44	-
Division of Vegetable Production						
A total value chain on commercialization of value convenience processed vegetable products	UPCAR	2014	2017	17.820	2.94	2.86
Network project on organic farming in horticulture crops	ICAR	2014	2017	22.62	3.00	0.80
Network project on micronutrients management in horticultural crops for enhancing yield and quality	ICAR	2014	2017	44.60	19.00	0.583
New initiative project on protected horticulture	ICAR	2014	2017	53.80	26.00	0.704
Network project on phytochemicals/high value compounds	ICAR	2014	2017	141.17	7.5	0.95
Tribal Sub-Plan (TSP) for schedule tribes of Sonbhadra District in Uttar Pradesh	ICAR	2012	2014	100.00	15.00	14.72
Division of Vegetable Protection						
Outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia* diseases in horticultural and field crops	ICAR	2009	2015	48.80	13.26	6.70
NICRA project "Real Time Insect Pest Surveillance (RTPS) in tomato crop"	ICAR	2011	2017	25.00	5.38	3.47

Title of the Project	Funding Agency	Year of Start	Year of Completion	Total Allocation (in lakh)	Allocation and Expenditure in 2014-15	
					Allocation	Expenditure
Establishment of association of begomo virus species with yellow vein mosaic disease in wild cultivated species of okra and identification of source of resistance to the most predominant virus.	NFBS&AR	2013	2014	32.462	10.38	5.33
Development and validation of effective formulation(s) of plant growth promoting rhizobacteria (PGPR) having multicide mechanisms for pest management in vegetables	UPCAR	2014	2017	24.8975	6.459	-
Syntheses and validation of sustainable and adaptable IPM technology for cucurbitaceous vegetable crops	NCIPM	2014	2016	6.00	1.00	0.43854
Consortia research platform (CRP) on borer project	ICAR	2014	2017	68.50	2.40	-
Outreach research programme (ORP) on sucking pest management	ICAR	2014	2017	5.00	5.00	3.00
AICRP (Vegetable Crop)						
Central Sector Scheme for protection of plant varieties and farmers' rights (DUS testing of vegetable crops)	PPVFRA	2009	2016	19.50	19.50	10.699

PERSONNEL (as on 31. 03. 2015)

S.N.	Category	Sanctioned	Staff in	Vacant
SCIENTIFIC				
1.	Scientist	40	27	13
2.	Senior Scientist	18	11	07
3.	Principal Scientist	06	03	03
	TOTAL	**64**	**41**	**23**
TECHNICAL				
1.	T-1	11	10	01
2.	T-2			
3.	T-3	13	09	04
4.	T-4	02	02	0
5.	T-5			
6.	T-6			
7.	T-(7-8)			
	TOTAL	**26**	**21**	**05**
ADMINISTRATIVE				
1.	Senior Administrative Officer	01	01	-
2.	Finance & Account Officer	01	-	01
3.	Asstt. 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.	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**

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 Sant Ravidas Nagar

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**	**13**	**03**

Staff in position (as on 31-03-2015)

Sl. No.	Name	Designation	Email
1.	Dr. Bijendra Singh	Director	directoriivr@gmail.com; bsinghiivr@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. P.M. Singh	Principal Scientist	pmsiivr@gmail.com
5.	Dr. T. Chaubey	Senior Scientist	tchaubay@gmail.com
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7.	Dr. Ranjan Kumar Srivastava	Senior Technical Officer	ranjansrivastava@gmail.com
8.	Dr. A.P. Singh	Senior Technical Officer	apsinghento@gmail.com
Division of Vegetable Improvement			
9.	Dr. Major Singh	Principal Scientist & Head	singhvns@gmail.com
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11.	Dr. Nagendra Rai	Principal Scientist	nrai1964@gmail.com
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Sl. No.	Name	Designation	Email
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19.	Dr. Shailesh Kumar Tiwari	Scientist	tiwarishailu@gmail.com
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21.	Dr. C. Manimurugan	Scientist	manimuruganc@gmail.com
22.	Dr. Yerasu Suresh Reddy	Scientist	yerasusureshreddy@yahoo.co.in
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24.	Mr. Pradip Karmakar	Scientist	pradip9433@gmail.com
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26.	Dr. Jyoti Devi	Scientist	jyoti17iivr@gmail.com
27.	Sh. A.K. Singh	Assistant Chief Technical Officer	ashoksinghiivr@gmail.com
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Division of Vegetable Production			
32.	Dr. S.N.S. Chaurasia	Principal Scientist & Head	chaurasiaiivr@yahoo.com
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Division of Vegetable Protection			
45.	Dr. A.B. Rai	Principal Scientist & Head	abraiiivr@gmail.com
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53.	Sh.Y. Bijen Kumar	Scientist	bijen_ac@yahoo.in
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Administrative Staff			
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73.	Sh. M.L. Vishwakarma	Technical Assistant	-
74.	Sh. Rajendra Kumar	Technical Assistant	-
75.	Sh. Manoj Kumar	Technical Assistant	-
76.	Sh. Ram Ashrey	Technical Assistant	-
Supporting Staff			
77.	Sh. Jagwat Ram	S.S.S	-
78.	Sh. Shiv Kumar	S.S.S	-
79.	Sh. Kailash Singh	S.S.S	-
80.	Sh. S.P. Mishra	S.S.S	-
81.	Sh. Naraini Singh	S.S.S	-
82.	Sh. S.K. Pandey	S.S.S	-
83.	Sh. Arun Kumar	S.S.S	-
84.	Sh. Ramraj	S.S.S	-
85.	Sh. Suresh Kumar Yadav	S.S.S	-
86.	Sh. Shuresh Kumar	S.S.S	-
87.	Sh. Virendra Prasad Gond	S.S.S	-
88.	Sh. Kamlesh Kumar Singh	S.S.S	-
89.	Sh. Anil Kumar Suman	S.S.S	-
90.	Sh. Ram Kunwar Chaubey	S.S.S	-
91.	Sh. Jata Shankar Pandey	S.S.S	-
92.	Sh. Shivajee Mishra	S.S.S	-
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Sl. No.	Name	Designation	Email
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98.	Sh. Ajay Kumar Rai	SMS (PP)	-
99.	Sh. Rajneesh Srivastava	SMS (Hort.)	-
100.	Sh. Yogesh Kumar	SMS (AS)	-
101.	Smt. Anjali Sahu	SMS (HS)	-
102.	Dr. T.N. Rai	SMS (Soil Science)	-
103.	Sh. Arun Pratap Singh	Farm Manager	-
104.	Sh. Prasant Kumar Gupta	Programme Assistant	-
105.	Sh. Pankaj Kumar Singh	Driver	-
106.	Sh. Satish Kumar Singh	Driver	-
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107.	Smt. A. R. Kumari	SMS (HS)	anuradha_rau@rediffmail.com
108.	Dr. Shamsher Singh	SMS (Hort)	-
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112.	Sh. Ajay Tiwari	Farm Manager	ajitiwariiivr@gmail.com
113.	Sh. Motilal Kushawaha	Programme Assistant	motilal.kushwaha@yahoo.com
114.	Sh. Bharat Singh	Driver	-
115.	Sh. Sharad Chand Rai	Driver	-
Krishi Vigyan Kendra, Sant Ravidas Nagar			
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120.	Dr. R. P. Choudhary	SMS (Ag. Extn)	-
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123.	Dr. P. C. Singh	Farm Manager	prabhashiivr@gmail.com
124.	Sh. Roshan Lal	Office Superintendent	-
125.	Sh. D.P. Singh	Programme Assistant	-
126.	Sh. Sanjay K. Yadav	Driver	-
127.	Sh. Pramod Paswan	Driver	-

Appointment and Transfer

1. Dr. Bijendra Singh, Joined the Post of Director, on 1.9.2014 at ICAR-IIVR.
2. Dr. Jyoti Devi joined the post of Scientist (Vegetable Science) on 08.04.2014 at ICAR-IIVR.
3. Sh. S.G. Karkute joined the post of Scientist (Plant Biotechnology) on 09.04.2014 at ICAR-IIVR.
4. Dr. (Mrs.) Pragya, joined the post of Senior Scientist (Horticulture) on 09.09.2014 at ICAR-IIVR after her transfer from NBPGR, New Delhi.

Superannuation

1. Dr. P.S. Naik, Director, ICAR-IIVR superannuated from services on 31.08.2014.
2. Sh. S.P. Singh, Driver, ICAR-IIVR superannuated from services on 30.09.2014.

Annexure I

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) – 562109 Karnataka	Member
Dr. T. Mahapatra Director Central Rice Research Institute Cuttack-753006 Odisha	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. Prabhu Kumar Zonal Project Director Zone-I, PAU Campus Ludhiana-141004	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 II

Institute Management Committee

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 III

List of Ongoing Research Programmes / Projects

A. Institutional

Division of Vegetable Improvement	
MEGA PROGRAMME-1	**INTEGRATED GENE MANAGEMENT**
Sub Project 1.1	Management of vegetable genetic resources including under-utilized crops
Sub Project: 1.2	Genetic improvement of solanaceous vegetables
Sub Project 1.3	Genetic improvement of legume vegetables
Sub Project 1.4	Genetic improvement of gourds
Sub Project 1.5	Genetic improvement of melons, pumpkins and cucumber
Sub Project 1.6	Genetic improvement of okra
Sub Project 1.7	Genetic improvement of cauliflower
Sub Project 1.8	Transgenic and regeneration protocols
Sub Project 1.9	Biotechnological interventions for improvement of selected vegetable crops
Sub Project 1.10	Genetic improvement of underutilized vegetables, including vegetable soybean, leafy and root vegetables
MEGA PROGRAMME-2	**SEED ENHANCEMENT IN VEGETABLES**
Division of Vegetable Production	
MEGA PROGRAMME-3	**PRODUCTIVITY ENHANCEMENT THROUGH BETTER RESOURCE MANAGEMENT**
Sub Project 3.1	Technologies for protected and off-season vegetable production
Sub Project 3.2	Precision farming in vegetable crops
Sub Project 3.4	Impact of organic and inorganic management systems on vegetable productivity, quality and soil health
Sub Project 3.5	Improving soil health and carbon sequestration in vegetable production system through conservation tillage and residue incorporation
Sub Project 3.6	Enhancing water and nutrient use efficiency in vegetable crops
Sub Project 3.8	Performance of vegetable crops under subsurface drip irrigation system
MEGA PROGRAMME-4	**POST-HARVEST MANAGEMENT AND VALUE ADDITION**
Sub Project 4.1:	Shelf life extension for preservation of vegetable
Sub Project 4.2:	Exploration of vegetable nutraceuticals for the development of functional foods
MEGA PROGRAMME-5	**PRIORITIZATION OF R&D NEEDS AND IMPACT ANALYSIS OF TECHNOLOGIES DEVELOPED BY IIVR**
Sub Project 5.1	Research prioritization of vegetable crops
Sub Project 5.2	Impact of improved vegetable technologies developed by iivr
Division of Vegetable Protection	
MEGA PROGRAMME-6	**INTEGRATED PLANT HEALTH MANAGEMENT**
Sub Project 6.1	Bio-intensive management of major insect pests of vegetables in the current scenario of weather change
Sub Project 6.2	Toxicological investigations on the novel insecticide molecules and plant origin insecticides against major insect pests of vegetables
Sub Project 6.3	Biological control of major insect pests of vegetable crops
Sub Project 6.4	Management of important fungal diseases of vegetable crops
Sub Project 6.5	Bio-prospecting of microorganisms associated with vegetable against plant pathogens
Sub Project 6.6	Management of important bacterial diseases of vegetable crops
Sub Project 6.7	Development of diagnostic kits for major viral disease of vegetable crops
Sub Project 6.8	Management of major viral diseases of vegetables
Sub Project 6.9	Management of nematodes infesting major vegetable crops
Sub Project 6.10	Dynamics of pest and diseases and development of forecasting models

B. Externally funded

Name of Projects	Funding Agency
Division of Vegetable Improvement	
Network Project on "Transgenic crops"	ICAR
National initiative on climate resilient agriculture (NICRA)	ICAR
Gene expression studies and development of functional markers for anthracnose disease in Capsicum species	DST
Bio-prospecting of genes and allele mining for abiotic stress tolerance	ICAR
Validation of DUS testing guidelines of cucurbits i.e, muskmelon and watermelon	ICAR
Business Planning and Development Unit of IIVR, Varanasi	ICAR
Evaluation of high yielding varieties/hybrids of cucurbitaceous vegetables for riverbed (diara land) cultivation and standardization of their agro-techniques	UPCAR
Genomics assisted selection of *S. chilense* introgression lines for enhancing drought resistance in tomatoes	DBT, India - BBSRC, UK
Introgression of begomovirus resistance genes in tomato using MAS and genomics approach	DBT
Division of Vegetable Production	
A total value chain on commercialization of value convenience processed vegetable products	UPCAR
Network project on organic farming in horticulture crops	ICAR
Network project on micronutrients management in horticultural crops for enhancing yield and quality	ICAR
New initiative project on protected horticulture	ICAR
Network project on phytochemicals/high value compounds	ICAR
Tribal Sub-Plan (TSP) for schedule tribes of Sonbhadra District in Uttar Pradesh	ICAR
Division of Vegetable Protection	
Outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia* diseases in horticultural and field crops	ICAR
NICRA project "Real Time Insect Pest Surveillance (RTPS) in tomato crop"	ICAR
Establishment of association of begomo virus species with yellow vein mosaic disease in wild cultivated species of okra and identification of source of resistance to the most predominant virus.	NFBS&AR
Development and validation of effective formulation(s) of plant growth promoting rhizobacteria (PGPR) having multicide mechanisms for pest management in vegetables	UPCAR
Syntheses and validation of sustainable and adaptable IPM technology for cucurbitaceous vegetable crops	NCIPM
Consortia research platform (CRP) on borer project	ICAR
Outreach research programme (ORP) on sucking pest management	ICAR
AICRP (Vegetable Crops)	
Central Sector Scheme for protection of plant varieties and farmers' rights (DUS testing of vegetable crops)	PPVFRA

Annexure IV

Distinguished Visitors

Dr. D.P. Ray Ex-VC, OUA&T, Bhubneshwar	12-13.07.2015
Dr. Kirti Singh Ex-Chairman, ASRB, New Delhi	12-13.07.2015
Dr. G Kaloo Ex. DDG (Horticulture) & Ex-VC, JNKVV, Jabalpur	12-13.07.2014
Dr. H.P. Singh Ex. DDG (Horticulture) ICAR, New Delhi	12-13.07.2014
Dr. S.K.Pandey Ex. Director CPRI, Shimla	12-13.07.2014
Dr. Makhan Lal CCS, HAU, Hisar	12-13.07.2014
Dr. N. C. Gautam Vice Chanceller, MGKVV, Chitrkoot	12-13.07.2014
Sh. Radha Mohan Singh Union Minister of Agriculture Ministry of Agriculture Government of India, New Delhi	21.09.2014
Dr. P. Parvatha Reddy Director (Retd.), IIHR,Bengalure-560094	17-18.12.2014
Dr. O.P. Dutta Director (Research), M/s Namdhari Seeds, Bidadi	17-18.12.2014
Dr. T. Mohapatra Director, Central Rice Research Institute, Cuttack, Odisha	18.12.2014
Dr. C.K. Narayana HoD, PHT, IIHR,Bengaluru	17-18.12.2014
Dr. Kaushik Banerjee Principal Scientist NRC for Grapes, Solapur Road, Pune	17-18.12.2014
Dr. Prabhu Kumar Zonal Project Director, Ludhiana	17-18.12.2014
Dr. S.K. Dutta DDG (Crop Science), ICAR, New Delhi	28.12.2014
Dr. J.S. Chauhan ADG (Seeds), ICAR, New Delhi	30.12.2014
Dr. N.K. Krishna Kumar DDG (Horticultural Science) ICAR, New Delhi	30.1.2015
Smt. Durgawati Devi Gram Pradhan, Jayapur	30-31.01.2015
Sh. Virendra Singh MP, Bhadohi	23.02.2015

Shri Radha Mohan Singh, Union Minister of Agriculture visited ICAR-IIVR, Varanasi on 21st September 2014

Dr. P. Parvatha Reddy, Director (Retd), IIHR and Chairman RAC alongwith other committe members visited on 17-18 December, 2014 during 17th RAC of the Institute

Dr. N.K. Krishna Kumar, Deputy Director General (Horticultural Science) visited ICAR-IIVR during National Farmers' Fair cum Vegetable showcasing on 30.01.2015

NOTE

NOTE

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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