Research Highlights - Vegetable Protection

PROJECT 1: Integrated Insect Pest Management of Major Vegetables for Safer Vegetable Production

- **Flonicamid 50% WG @ 0.4 g/L** emerged as the most effective newer molecule for managing sucking pests (jassids and whiteflies) in brinjal, achieving 70-76% reduction over control.
- **Integrated pest management module (M2)** showed the best overall performance against thrips and mites in chilli, with 60.96% reduction in black thrips while conserving higher populations of natural enemies (spiders and lady bird beetles).
- **Chlorantraniliprole 18.5% SC @ 150 g ai/ha** effectively controlled radish flea beetle (*Phyllotreta striolata*), reducing shot holes by 72% compared to control, with a short half-life of 1.49-2.99 days ensuring food safety.
- **DNA barcoding** identified *Liriomyza sativae* as a new invasive leaf miner species (distinct from *L. trifolii*) attacking vegetables in Varanasi region, and *Cotesia vestalis* was identified as a promising biocontrol agent for diamondback moth with peak parasitization of 48.57%.

PROJECT 2: Characterization and Integrated Management of Plant Pathogens (Diseases) of Vegetable Crops

- **Alternaria isolates** from tomato were molecularly identified as *Alternaria tenuissima* (NCBI Accession: PP 716526) and *A. alternata* (PP 716527), while **Phomopsis blight** isolates from brinjal were identified as *Diaporthe vexans* (PP 716500) and *D. phoenicicola* (PP 716519).
- **Azoxystrobin @ 1 ml/kg seed treatment + 0.1% foliar spray** proved most effective for nursery disease management, achieving highest germination (70.81% in brinjal, 82.59% in chilli) with lowest damping-off incidence (5.19% and 7.30% respectively).
- **Chemical & Biological integrated module** (copper oxychloride + bacterial endophyte PGL-B 22 + Actinomycetes + streptocycline) was most effective against *Xanthomonas* bacterial blight, yielding 37.60 t/ha in tomato and 18.10 t/ha in cauliflower with only 5-10% disease incidence.
- **Trichoderma isolate TCV-1** (*T. pseudokoningii*) showed highest antagonistic activity (74.6%) against *Rhizoctonia solani*, and artificial screening protocols were standardized for *Sclerotium rolfsii* (using sorghum meal-sand inoculum @ 1g/plant) and *Fusarium* wilt of pea.

PROJECT 6.4: Bio-intensive Management of Root-Knot Nematode in Vegetable Crops

- **Resistant germplasm identified:** Three brinjal genotypes (GB-6 as Resistant; GB-11 and GB-14 as Highly Resistant), ten brinjal rootstocks (including *Solanum torvum*, Surya, and IC-111056 as Highly Resistant), and seven okra wild relatives (*Abelmoschus caillei*, VRO-W-TP-19, and TPM-39 as Highly Resistant) were identified with resistance to *Meloidogyne incognita*.
- **Potent biocontrol agents isolated:** Rhizobacterial strains ORB6 (*Pseudomonas aeruginosa*), ORB8 & ORB10 (*Stenotrophomonas maltophilia*), and CURB10 (*Priestia megaterium*) showed 82-93% juvenile mortality, while Actinomycetes strains NIORA1 and NIORA4 achieved 100% mortality of second-stage juveniles at 100% cell-free filtrate concentration.
- ***Trichoderma asperellum* Tasp emerged as the best biocontrol agent:** Under field conditions, nursery drenching + enriched vermicompost application + soil drenching of *T. asperellum* Tasp resulted in highest reduction in root galls (69.7%), egg masses (76.4%), and nematode population (52.9%), with maximum yield of 610 q/ha (19.9% increase over control).
- **PLFA profiling revealed enhanced soil health:** *Trichoderma asperellum* Tasp treatment showed the highest viable microbial biomass content (591.7 ηmoles/g) compared to untreated control (340.5 ηmoles/g), indicating improved rhizosphere microbial diversity and soil health conducive to nematode suppression.

PROJECT 6.5: Residue Analysis and Risk Assessment of Pesticides in Vegetable Crops

- **Lantana biochar developed for pesticide remediation:** Invasive weed (*Lantana*)-derived biochar achieved up to **97.04% removal of chlorantraniliprole** from sandy loam soil at 0.5% dose through spontaneous, exothermic chemisorption (Langmuir isotherm), providing dual benefits of weed management and environmental protection.
- **Dissipation kinetics established for major insecticides:** Half-life of chlorantraniliprole, cyantraniliprole, thiamethoxam, imidacloprid, and indoxacarb in bitter gourd fruit and soil ranged from **1.96-3.04 days**, with residues reaching below the limit of quantification (0.01 mg/kg) by the 5th day after application.
- **Market surveillance revealed pesticide contamination:** Analysis of 58 pesticides in vegetables from Varanasi markets detected **five compounds above MRL** (chlorantraniliprole, chlorpyrifos, spinetoram, spiromesifen, and

acephate), with chlorpyrifos showing the highest residue levels (982-2914 µg/kg).

- **Household decontamination method standardized:** Washing vegetables with **2% sodium bicarbonate ($NaHCO_3$) solution removed 89.34%** of chlorantraniliprole residues from tomato, outperforming veggie wash (84.81%), ascorbic acid (51.91%), and other household preparations.

PROJECT 6: Integration of Compatible Components to Develop Crop-Specific Module for IPDM in Vegetables

- **IPDM module most effective in cabbage:** The integrated module (trap crop + seed treatment + bioagents + selective chemicals) achieved **87.86% reduction in aphids, 81.28% in *Spodoptera*, and 82.66% in DBM** populations, with significantly reduced *Alternaria* leaf spot (PDI 5.5) and highest yield of 11.34 kg/10 plants compared to 1.60 kg in untreated control.
- **IPDM module outperformed in cowpea:** The integrated module recorded **81.72% reduction in pod borer (*Maruca vitrata*), 84.32% in aphids, and 84.44% in Hadda beetle** populations, while maintaining higher populations of natural enemies (coccinellids: 2.63/plant; spiders: 2.40/plant) unlike the chemical module.
- **Pollinator safety data generated:** Kaplan-Meier survival analysis revealed **Thiamethoxam was highly toxic to honey bees** (*Apis mellifera*) with significant mortality within 10 days ($\chi^2 = 400.0$, $p < 0.0001$), while Spinetoram showed comparatively safer profile, guiding pesticide selection in pollinator-dependent vegetables.
- **Disease management integrated successfully:** Both IPDM modules in cabbage and cowpea significantly reduced damping-off (*Pythium*) incidence (3.12% and 3.67% mortality vs. 8.20% and 11.84% in control) and *Cercospora*/*Alternaria* leaf spot (PDI 3.25-5.5 vs. 11.0-14.0 in control) through bioagent integration.