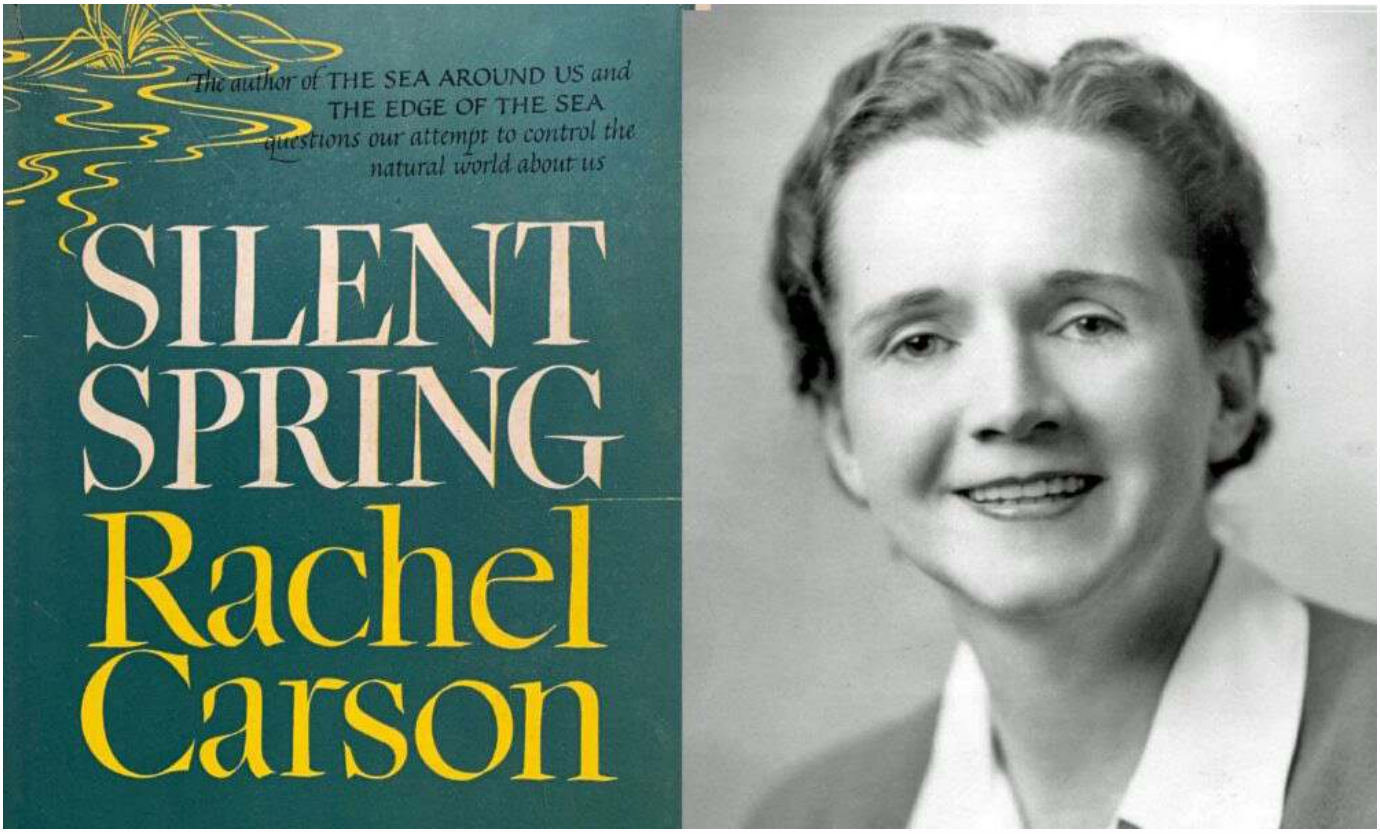
भा.कृ.अनु.प.
ICAR

Success Stories of Integrated Pest Management

for Sustainable Agriculture



भा.कृ.अनु.प.-राष्ट्रीय समेकित नाशीजीव प्रबंधन अनुसन्धान संस्थान
राजपुर खुर्द, नई दिल्ली -110 068
ICAR-National Research Institute for Integrated Pest Management
Rajpur Khurd, New Delhi-110 068


The author of THE SEA AROUND US and
THE EDGE OF THE SEA
questions our attempt to control the
natural world about us
SILENT
SPRING
Rachel
Carson


PREVENTION
MONITORING
TREATMENT
MONITORING
INTEGRATED
PEST
MANAGEMENT

SUCCESS STORIES OF INTEGRATED PEST MANAGEMENT FOR SUSTAINABLE AGRICULTURE

Ajanta Birah
Meenakshi Arya
Anoop Kumar
Rekha Balodi
Neelam Mehta
Raman Thangavelu

ICAR-National Research Institute for Integrated Pest Management
Rajpur Khurd, New Delhi- 110068

Compiled and edited by

Ajanta Birah

Meenakshi Arya

Anoop Kumar

Rekha Balodi

Neelam Mehta

Raman Thangavelu

Citation

Birah Ajanta, Arya Meenakshi, Kumar Anoop, Balodi Rekha, Mehta Neelam and Thangavelu Raman (Eds). 2026. Success Stories of Integrated Pest Management for Sustainable Agriculture, ICAR-NRIIPM, New Delhi-110 068 India, x+112pp.

Published by

Dr Raman Thangavelu
Director
ICAR- National Research Institute for Integrated Pest Management
Rajpur Khurd, New Delhi -110 068

Ph.: 011-26303936, 20907410
e- mail: director.nriipm@icar.org.in
Website: https://nriipm.res.in

© 2026 ICAR-NRIIPM, New Delhi. All rights reserved. The content of this book, including text, images, graphics, and other material, is protected by copyright law. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, including electronic, mechanical, photocopying, recording, or otherwise, without prior written permission.

ISBN No. : 978-81-999165-4-8

Laser Type setting and printed at : Alpha Printographics (India), New Delhi
Mob.: +91 98111 99620, 99990 39940

ICAR
डॉ. देवेन्द्र कुमार यादव
उप महानिदेशक (फसल विज्ञान)
Dr. Devendra Kumar Yadava
Deputy Director General (Crop Science)

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान एवं शिक्षा विभाग
कृषि एवं किसान कल्याण मंत्रालय, भारत सरकार
कृषि भवन, नई दिल्ली-110001
Indian Council of Agricultural Research
Department of Agricultural Research & Education
Ministry of Agriculture and Farmers Welfare
Govt. of India, Krishi Bhawan, New Delhi-110001



FOREWORD

Integrated Pest Management (IPM) has emerged as a cornerstone of sustainable agriculture, balancing the twin imperatives of productivity and environmental stewardship. In the face of escalating challenges such as climate variability, pesticide resistance, biodiversity loss, and concerns over food safety, IPM offers a science-based, ecologically sound, and economically viable pathway for crop protection. The Indian Council of Agricultural Research – National Research Institute for Integrated Pest Management (ICAR-NRIIPM) has played a pivotal role in advancing this approach through research, innovation, capacity building, and stakeholder engagement.

The present book, *'Success Stories of Integrated Pest Management for Sustainable Agriculture'* brings together a rich compilation of real-world experiences that demonstrate how IPM technologies and strategies have translated from laboratories and experimental fields to farmers' fields across diverse agro-ecological regions of the country. These success stories reflect the collective efforts of scientists, extension personnel, farmers, policymakers, and industry partners who have worked together to promote need-based, judicious, and environmentally responsible pest management practices. Each case documented in this book illustrates the tangible benefits of IPM adoption—reduction in pesticide use, lower cost of cultivation, improved crop yields, enhanced natural enemy populations, and safer food and ecosystems. Beyond numbers and outcomes, these narratives highlight the importance of farmer participation, local adaptability, and continuous knowledge exchange in ensuring the long-term success of IPM programmes. They also underscore the value of institutional support and coordinated action in scaling up proven technologies.

I commend the efforts of the authors and contributors for meticulously documenting these success stories and presenting them in an accessible manner. I am confident that this publication will be a valuable reference and a catalyst for advancing sustainable pest management in India.

Dated: February 9, 2026
Place: New Delhi

(D. K. Yadava)

E-mail : ddgcs.icar@nic.in, dkygenet@gmail.com Phone : 91-11-23382545, 23046560, Mobile : 9868537641

Dr. P.K. Chakrabarty, PhD, FNAAS
Former Member (Plant Sciences), ASRB &
Former ADG (Plant Protection & Biosafety), ICAR
DARE, MoA&FW, GoI,
New Delhi

February 07, 2026



Foreword

Agriculture has long been the mainstay of our national economy, sustaining livelihoods and ensuring food and nutritional security. Yet, the sector is increasingly challenged by recurring pest outbreaks, invasive species, pesticide resistance, climate variability, and the growing need to adopt sustainable practices that protect both productivity and the environment. These emerging challenges call for crop protection approaches that are effective, economically viable, and ecologically responsible.

In this context, Integrated Pest Management (IPM) has emerged not merely as a strategy, but as a philosophy of balance-harmonizing scientific innovation with ecological sustainability. By integrating cultural, mechanical, biological, and need-based chemical interventions, supported by pest surveillance and economic threshold-based decision-making, IPM minimizes pesticide risks, conserves natural enemies, enhances biodiversity, and contributes to safe and sustainable food production. As agriculture moves towards climate-resilient pathways, the relevance of IPM becomes even more pronounced.

The ICAR–National Research Institute on Integrated Pest Management (NRIIPM) has played a pivotal role in advancing this national mission. Through pioneering research, development of bio-intensive IPM modules, field demonstrations, and farmer-centric extension initiatives, NRIIPM has successfully transformed IPM from a scientific concept into a widely accepted movement. Its contributions extend beyond pest management, empowering farmers to reduce dependence on indiscriminate pesticide use, lower the cost of cultivation, improve yields, and strengthen the ecological balance of farming systems.

This publication, *"Success Stories of Integrated Pest Management for Sustainable Agriculture"*, is a testimony to that remarkable journey. The chapters compiled herein reflect the dedication of scientists, the resilience of farmers, and the collaborative spirit that drives agricultural progress. These success stories highlight tangible outcomes such as enhanced productivity, improved farm profitability, reduced pesticide load, and healthier agro-ecosystems. They also demonstrate how scientific knowledge, when translated into practical and locally adaptable solutions, can deliver measurable impact on the ground.

I commend the ICAR-NRIIPM team for their efforts in documenting these achievements in the form of this IPM technology compendium. I am confident that this publication will serve as a valuable reference for policymakers, researchers, extension workers, students, and farmers, and will inspire wider adoption of IPM as a cornerstone of sustainable and environmentally responsible agriculture.

(P K Chakrabarty)

डॉ. पूनम जसरोटिया
सहायक महानिदेशक
(पादप संरक्षण एवं जैव सुरक्षा)

Dr. Poonam Jasrotia
Assistant Director General
(Plant Protection and Biosafety)

भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, भारत सरकार
क.सं. 215, कृषि भवन, नई दिल्ली, भारत

Indian Council of Agricultural Research
Ministry of Agriculture & Farmers Welfare, Govt. of India
R.No. 215, Krishi Bhawan, New Delhi 110001, India

☎: 91-11-23384414; 🖷: 91-11-23046550
✉: adgpp.icar@nic.in; poonam.jasrotia@icar.org.in



FOREWORD

Integrated Pest Management (IPM) lies at the heart of sustainable and climate-resilient agriculture, providing a scientifically sound and economically viable framework for managing pests while minimizing risks to the environment, human health, and beneficial organisms. By integrating cultural, biological, mechanical, and need-based chemical control measures, IPM promotes judicious pesticide use, enhances ecosystem services, and contributes to long-term agricultural sustainability and farm profitability.

ICAR-National Research Institute for Integrated Pest Management (ICAR-NRIIPM) has played a pioneering role in the development, validation, and dissemination of IPM technologies across diverse agro-ecological regions and cropping systems of the country. Through sustained research, capacity building, and close collaboration with stakeholders, the Institute has significantly contributed to strengthening national efforts in sustainable crop protection and reducing the ecological footprint of agriculture. The publication, ***"Success Stories of Integrated Pest Management for Sustainable Agriculture"***, will bring together a rich collection of well-documented field-level success stories that reflect the effective adoption of IPM practices by farmers. These case studies vividly demonstrate how IPM interventions have led to reduced dependence on chemical pesticides, improved crop yields and quality, enhanced profitability, and restoration of ecological balance. Importantly, the success stories underscore the critical role of farmer participation, convergence of research and extension systems, and institutional support in scaling up IPM technologies.

This compilation will serve as a valuable reference for researchers, extension professionals, students, planners, and policymakers by showcasing practical, evidence-based solutions for sustainable pest management. It also reinforces the relevance of IPM in addressing emerging challenges such as pesticide resistance, climate-induced pest dynamics, and the demand for safe and residue-free agricultural produce.

I commend the sincere efforts of the authors and contributors for systematically documenting these impactful experiences. I am confident that this publication will inspire wider adoption of Integrated Pest Management practices and strengthen collective efforts toward sustainable, environmentally responsible, and resilient Indian agriculture.

(Poonam Jasrotia)

Dr. Raman Thangavelu
Director
ICAR-National Research Institute for
Integrated Pest Management
New Delhi – 110 001



Preface

Integrated Pest Management (IPM) represents a holistic and sustainable approach to crop protection, integrating biological, cultural, mechanical, and need-based chemical methods to manage pest populations below economic threshold levels. Over the years, IPM has gained increasing relevance in Indian agriculture due to rising concerns over pesticide resistance, environmental contamination, residue-related trade barriers, and the health of farmers and consumers. Application of modern technologies such as Artificial Intelligence (AI) and Information and Communication Technology (ICT) can automate and speed up the process of regular and systematic wide-area pest surveillance.

The Indian Council of Agricultural Research – National Research Institute for Integrated Pest Management (ICAR-NRIIPM) has been consistently engaged in developing, validating, and disseminating IPM technologies for major crops across diverse agro-ecological regions of the country. Through collaborative research, frontline demonstrations, capacity-building programmes, and partnerships with state departments, Krishi Vigyan Kendras, and other stakeholders, the institute has facilitated large-scale adoption of IPM practices.

The present book, '*Success Stories of Integrated Pest Management for Sustainable Agriculture*' is an effort to document and showcase selected success stories where IPM interventions have made a measurable impact at the field level. These case studies highlight reductions in pesticide use, improvements in crop yield and quality, enhanced activity of natural enemies, and increased economic returns to farmers. The experiences shared in this compilation reflect not only technological success but also the importance of farmer awareness, participatory approaches, and effective extension mechanisms. This compilation is intended to serve as a reference for researchers, extension personnel, students, planners, and development agencies engaged in sustainable agriculture and crop protection. By presenting practical experiences and lessons learned, the book aims to support the wider scaling-up of IPM technologies and encourage their integration into mainstream agricultural practices.

The Institute's pan-India interventions in major crops demonstrate that timely and location-specific application of IPM strategies results in improved produce quality and substantial reductions in chemical pesticide use. Although limited availability of quality IPM inputs remains a challenge to wider adoption, the success stories presented clearly establish IPM as a practical and sustainable approach that effectively bridges conventional and organic farming systems.

The publication of successful technologies of IPM for various field crops (basmati rice, maize, chickpea, mustard and cotton), vegetable crops (cucurbits, cauliflower, tomato, chilli, radish) and fruit (kinnow and mango) crops, innovative IPM tools, microbial biogels, information and communication technology, and Eco-friendly technologies in IPM. Needful creation of IPM awareness has been the result of hard work by scientists, technical, administrative and supporting staff of ICAR-NRIIPM along with many other researchers and field functionaries engaged in the field of plant protection across the country. The editors sincerely acknowledge the valuable contributions of the farmers, agricultural scientists, extension functionaries, and institutions whose cooperation made this compilation possible. We also place on record our gratitude to the Indian Council of Agricultural Research for its guidance and support. It is hoped that this book will inspire continued innovation and strengthen the adoption of Integrated Pest Management for sustainable and profitable agriculture.



(Raman Thangavelu)

Acknowledgements

The editors and authors of "*Success Stories of Integrated Pest Management for Sustainable Agriculture*" gratefully acknowledge the sincere and active participation of individual researchers, research teams, extension personnel, and farmers across the country in the effective implementation of IPM at the field level.

We extend our appreciation to the co-opted centres, including the Department of Agriculture across diverse crops and States, for their valuable administrative and technical support. The successes of IPM documented in this volume have been made possible through the financial impetus provided by the Ministry of Agriculture and Farmers' Welfare under various schemes and programmes, for which ICAR–NRIIPM, New Delhi, expresses its deep gratitude. The interest and commitment shown by planners, policymakers, and practitioners of IPM, together with the dedicated efforts of field staff engaged in pest observations, have significantly elevated the scope and quality of IPM validations and demonstrations nationwide.

We record our profound appreciation for the constant guidance and encouragement of Dr. M.L. Jat, Secretary DARE & DG, ICAR; Dr. D.K. Yadava, DDG (Crop Science), ICAR; and Dr. Poonam Jasrotia, ADG (PP&BS), ICAR. Commendations are also due for the stewardship provided by the erstwhile research managers of ICAR–NRIIPM, namely Dr. Chirantan Chattopadhyay and Dr. Subhash Chander. We gratefully acknowledge the contributions of resource persons from ICAR institutes, State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), State Departments of Agriculture (SDAs), suppliers of IPM inputs—including biocontrol laboratories, seed, fertilizer, and pesticide industries—as well as non-governmental organizations, all of whom have played a pivotal role in promoting IPM across the country.

Finally, we express our heartfelt thanks to the administrative, technical, and supporting staff, research associates and senior research fellows of ICAR–NRIIPM and associated institutions, who have joined hands in various programmes for the cause of plant protection in selected agricultural and horticultural crops. Their contributions to IPM trainings, demonstrations, and exhibitions, past and present, remain invaluable to the success of this collective endeavour.

Editors and Authors

Contents

i.	Foreword	iii-v
ii.	Preface	vi-vii
iii.	Acknowledgements	viii
1.	INTEGRATED PEST MANAGEMENT IN BASMATI RICE Anoop Kumar, MK Khokhar, Mukesh Sehgal, Subhash Chander, SP Singh, Rakesh Kumar, Rashid Parvez and JPS Dabas	1-7
2.	ECO-FRIENDLY PEST MANAGEMENT IN MAIZE MK Khokhar, Anoop Kumar, Mukesh Sehgal, Deepak Jain, Suby SB and Richa Varshney	8-13
3.	IPM STRATEGIES FOR CHICKPEA PRODUCTION Jitendra Singh, Ritu Mishra, Rajanish Mishra, Vister Joshi, Rajiv K Singh, Adesh Kumar and Nishi Roy	14-17
4.	IPM STRATEGIES FOR BT COTTON Ajanta Birah, Licon K Acharya, Anoop Kumar, MK Khokhar, AG Mitkari, Rishi Kumar and Satish Parsai	18-30
5.	TRANSFORMING MUSTARD CULTIVATION THROUGH IPM MS Yadav, JC Gupta, SK Singh, Rekha Balodi, KV Raghvendra, AS Yadav, Jagender Singh, Pradyumn Singh and Neelam Mehta	31-36
6.	IPM FOR FRUIT FLY IN CUCURBITACEOUS VEGETABLE CROPS Devaramane Raghavendra and MN Bhat	37-42
7.	PEST MANAGEMENT TECHNOLOGIES IN RAINY SEASON CAULIFLOWER SP Singh, MN Bhat, Satyendra Singh, Bharat Singh and Anamika Sharma	43-49
8.	INTEGRATED PEST MANAGEMENT IN CHILLI Narayana Bhat M, Vinay Kumar MM, PS Ajjappalavar, Ravikumar B and M Abdul Kareem	50-54
9.	SUSTAINABLE MANAGEMENT OF STRIPED FLEA BEETLE IN RADISH Kerur Vishwanath Raghavendra, Rekha Balodi and Subhash Chander	55-58
10.	IPM FOR TRANSFORMING TOMATO CULTIVATION Kerur Vishwanath Raghavendra, Rekha Balodi, Ramakrishnappa Manjunatha, Maddireddy Papireddy, Peeru Saheb Y, K Manjula, Srinivasulu A, GS Panduranga, Reshu Singh, Subhash Chander, Mukesh Sehgal, Ajanta Birah and Raman Thangavelu	59-71
11.	IPM TECHNIQUES FOR MANAGEMENT OF MAJOR PESTS OF MANGO Devaramane Raghavendra and PN Meena	72-76
12.	INTEGRATED PEST MANAGEMENT IN KINNOW MANDARIN PN Meena and Devaramane Raghavendra	77-81
13.	MICROBIAL BIOGELS: TOOL FOR PEST MANAGEMENT IN PULSE CROPS Jitendra Singh, Ritu Mishra, Anoop Kumar and Raman Thangavelu	82-85
14.	INNOVATIVE IPM TOOLS Surender Kumar Singh	86-91
15.	STRENGTHENING INTEGRATED PEST MANAGEMENT THROUGH ECO-FRIENDLY TECHNOLOGIES Sumitra Arora	92-99
16.	ICT-BASED PEST SURVEILLANCE & ADVISORY SYSTEM: A PATH BREAKING INITIATIVE Niranjan Singh, OM Bambawale, S Vennila, DB Ahuja, HR Sardana, P Jeyakumar, Manoj Choudhary, Mukesh Khokhar, Meenakshi Malik, Anoop Kumar, Rakesh Kumar, PN Meena, D Raghvendra, Ajanta Birah and SK Singh	100-108
	ABBREVIATIONS	109-111

Integrated Pest Management in Basmati Rice



Anoop Kumar[1], MK Khokhar[1], Mukesh Sehgal[1], Subhash Chander[1], SP Singh[1], Rakesh Kumar[1], Rashid Parvez[2], JPS Dabas[2]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]ICAR-Indian Agriculture Research Institute, New Delhi

Rice is staple food crop that supports the livelihoods of millions of farmers worldwide. India is the second-largest producer and the first-largest exporter of rice in the world. Indo Gangetic plains in North India is the major basmati rice-producing pocket. The yield potential of rice is severely hampered by many biotic stresses, especially by insect-pests and diseases, for management of these biotic stresses farmers' resort to chemical pesticides. Basmati being an export commodity is always under pressure from European Union and USA, due to indiscriminate pesticide application and accumulation of pesticide residue. Many a times export consignment has been rejected, therefore, to reduce pesticide load and meeting the Maximum Residue Limit (MRL) parameters for export purpose, there is a need to bring the maximum area of Basmati rice under integrated pest management (IPM). ICAR-NRIIPM has validated IPM module at village level in Taraori Basmati rice in Panipat Haryana, Pusa Basmati-1121 in Bambawad,Uttar Pradesh and Dehradoon Basmati in parts of Uttarakhand Due to the implementation of IPM, farmers are fetching additional premium price of their produce over and above market price, farmers from Rohtak (Haryana) district approached ICAR-NRIIPM for understanding the IPM technology and requested for its validation and implementation in their area in farmers' participatory mode.



Survey conducted in Rohtak district of Haryana indicated that the area which was earlier occupied by the cotton crop has been shifted to rice because of the severe pest problems in cotton and availability of canal water for irrigation. Farmers are growing Pusa basmati 1121, Pusa basmati 1718 and Pusa basmati 1509. Bakane, blast, Bacterial Leaf Blight (BLB), Sheath Blight, yellow stem borer, Brown Plant Hopper, leaf folders are the important pest problems in the area. Farmers were totally dependent upon the advice of pesticides dealer and usually go for 4-6 sprays of different pesticides including tank mix of multiple pesticides.

Therefore, considering the problems and interest of rice farmers and the large area under basmati rice (>30000 ha) in Rohtak district, the project was Initited to validate and promote IPM module in farmers' participatory mode in village Nidana (28°57'13.5"N, 76°29'14.1"E), Rohtak district of Haryana during year 2020. The baseline information collected from the village revealed that the village has about 1000 ha cultivated land with 100% irrigation (Canal 50%; Tube well 50%) facility. About 800 ha is under rice, with >90% of the area under *basmati* rice. Pusa Basmati 1718, PB 1121, and PB 1509 are the main varieties grown in the area. Pusa Basmati 1718 was grown in >50% of the area in the village, whereas Pusa Basmati 1121 and PB 1509 occupied <40% and <10% of the area, respectively. Key pest problems faced by the farmers included Bakane (*Fusarium moniliforme*), blast (*Magnaporthe grisea*), bacterial leaf blight (*Xanthomonas oryzae pv. oryzae*), sheath blight (*Rhizoctonia solani*), brown plant hopper (*Nilaparvata lugens*), yellow stem borer (*Scirpophaga incertulas*), and leaf folder (*Cnaphalocrosis medinalis*). Farmers were fully (100%) dependent on pesticide dealers and company representatives for plant protection advisories. Knowledge about IPM, pest identification, and natural enemies was lackingl. A calendar-based blanket application of pesticides was the scheduled activity in the village, which included granular application of chlorantraniliprole, spray of Pymetrozine, tricyclazole, tebuconazole + trifloxystrobin, chloropyriphos, lambdacyhalothrin, and acephate. High doses of nitrogenous fertilizers (urea 450 kg/ha), no green manuring, no seedling treatment; neglecting pest monitoring, and resorting to 3–5 sprays of tank mix of chemical pesticides. The expenditure on control of insect pests and diseases was >Rs 12,500/ha. The average paddy yield was about 40-45 q/ha. Planting of 1 seedling per spot with 35 to 40 days old nursery was the common farming practice followed in the village.



IPM strategy

Based on the baseline information and pest problems, IPM strategy was formulated. IPM strategy consisted of (i) green manuring with *Sesbania* or mung bean, (ii) soaking of seeds in 2% salt solution (NaCl) to discard unhealthy seeds, (iii) seed treatment with *Trichoderma harzianum* ($1x10^8$cfu/g) @ 10g /kg seed for bakane and sheath blight management, (iv) seedling root dip in *Pseudomonas fluorescens* (3.0×10^{10} cfu/ml) solution @ 5ml/l of water for 30 minutes against bakane, (v) installation of pheromone traps @ 5/ha for YSB monitoring, (vi) placement of straw bundles for spider conservation after 15 days of rice transplanting @ 20 bundles/ha, (vii) One release of egg parasitoid, *Trichogramma japonicum* @ 1, 50, 000/ha after appearance of moths or egg masses of YSB in paddy fields in the month of September, (viii) Manual and chemical weed management, and (ix) Need-based application of chemical pesticides against insect pests and diseases based on economic threshold level (ETL). The paddy straw bundles were first placed in the sorghum field for 15 days for charging with spiders. Subsequently, in rice fields, these bundles were fixed vertically with bamboo sticks so that the lower portion of the bundle remained 15 cm above the water level.



Implementation of IPM strategy: The IPM programme was initiated in 2020 with participation of 10 farmers in 20 ha *basmati* rice (PB1718) area in the village Nidana (28°57'13.5"N 76°29'14.1"E) of district Rohtak, Haryana. The area coverage under IPM was increased gradually in the consecutive years, *i.e.* making it 100 ha in 2021, 120 ha in 2022 and 200 ha in 2023. The increase in area could be attributed to the success of IPM and an increased awareness about benefits of IPM technology and self-mobilization of a greater number of farmers (48) to adopt IPM technology. Farmers' field schools were organized at regular interval to educate and convince the farmers about the adverse effects of pesticides and pesticide residue problems in export consignment of *basmati* rice, and benefit of IPM in managing pest problems with minimum use of pesticides. Farmers were trained about identification of pests and natural enemies, economic threshold levels of different pests, good agriculture practices, installation of pheromone traps for pest monitoring and straw bundles for spider conservation, spray of? *Pseudomonas fluorescens* at regular intervals in the fields. Critical IPM inputs such as *Trichoderma harzianum, Trichogramma japonicum,* pheromone traps for YSB and neem azadirachtin 1500 ppm were provided to the farmers from the institute.

Refinement of IPM strategy: Based on the response of the farmers during first two years and keeping in mind the availability of critical IPM inputs to make IPM strategy suitable for adoption

in long run by the farmers in the village, the IPM strategy was refined by excluding a couple of interventions such as straw bundle and *Trichocard* and retaining only simple adoptable IPM interventions as per local conditions. The refined IPM strategy thus consisted of soaking of seeds in 2% salt solution (NaCl) to discard unhealthy seeds, seed treatment with *Trichoderma harzianum* 10g/kg seed, green manuring of main field, seedling root dip treatment with *Pseudomonas fluorescens*, balanced plant nutrition and water management, installation of pheromone traps for YSB monitoring @5/ha, regular field monitoring at weekly intervals, application of neem-based pesticides (Azadirachtin 1500 ppm @5ml/litre water) at low level of pest infestation, application of safer chemical pesticides based on economic threshold level (ETL), hand weeding and need based use of weedicides. The refined IPM strategy was further validated and promoted on large scale.

Impact of IPM

Reduction in pest infestation**:** The IPM successfully reduced bakane incidence in IPM over FP was 91.79%, 37.14%, 93.19%, and 88.42% during 2020, 2021, 2022, and 2023, respectively. The incidence of BLB was 75.86%, 37.14%, 93.29%, and 88.42% lower in IPM compared to FP. Blast incidence was negligible in 2020, whereas during 2021 to 2023, it was reduced by 37.14%, 88.64%, and 65.45% over FP. The reduction in seasonal mean infestation of yellow stem borer (YSB) by 27%, 31%, 28%, and 7.5% during the mentioned years (Table 1) The leaf folder population remained below the economic threshold level (ETL) throughout the study except in 2023, where it crossed the ETL during the 37-38 SMW, with a peak population of 33.6% in IPM and 43% in FP. This was managed by one application of recommended insecticide. Brown plant hopper was remained below ETL. IPM module proved effective in managing pest problems.

IPM implementation resulted in a significant reduction (average of 4 years) in the number of pesticide applications by >48% and the amount of active ingredients was reduced by >82% over FP fields (2.5 in IPM and 4.88 in FP). The reduction in pesticide use in FP was attributed to increased awareness among farmers about new insecticide molecules used at lower doses. The population of predatory spiders was significantly higher in IPM (0.95-3.85 per hill) compared to FP (0.22-0.54per hill) throughout the study during most of the SMW (Fig. 2), due to the judicious use of safer pesticides.



IPM implementation resulted in an 8.48% increase in yield, >15.60% reduction in input costs, and 29.51% increase in net return compared to FP. The benefit-cost ratio (BCR) in IPM was 2.8, whereas in FP it was 2.17 (Table 2). Farmer field schools and meetings organized at regular interval in the village helped in developing strong linkages among farmers, scientists and extension workers. Mobile numbers of the farmers, scientist/extension scientist from ICAR-IARI and ICAR-NRIIPM were shared among themselves and through Whatsapp group. This facilitated easy communication between farmers and scientists and increased confidence of the farmers. Farmer field schools and meetings organized at regular interval in the village enabled the IPM farmers to identify the major pests and natural enemies (spiders), and understand the role of monitoring, seed treatment, seedling root dip treatment, field sanitation and weed removal, concept of ETL and need based application of safer pesticides in pest management. The study concluded that the wide area validation of IPM strategy in *Basmati* rice proved ecologically safe, economically viable and adoptable under farmers' field conditions.



Table 1: Scenario of pests and natural enemies in rice IPM and FP fields at Nidana, Rohtak, Haryana during *kharif* 2020 to 2023

Years	Treatments variables	YSB (%)	LF (%)	BPH (No./hill)	Bakane (%)	BLB (%)	Blast (%)	Spider (No./hill)
2020	IPM	1.81±١,١٥	4.99±١,٧	00	0.38±٠,٤٨	1.05±٠,٥٧	00	3.85±٠,١٨
	FP	2.48±٠,٦٧	6.63±٠,٧٤	00	4.63±١,١٧	4.35±١,٩٥	00	0.54±٠,١٩
	% Difference in IPM over FP	-27.02	-24.74	00	-91.79	-75.86	00	612.96
2021	IPM	1.45±0.44	5.17±3.09	1.14±1.73	0.83±0.47	0.51±0.55	1.35±1.90	0.95±0.19
	FP	2.13±0.66	2.62±1.61	2.37±2.56	1.31±0.61	0.81±0.81	2.15±2.61	0.19±0.18
	% Difference in IPM over FP	-31.98	97.21	-51.95	-37.14	-37.14	-37.14	392.00
2022	IPM	0.52±0.38	2.62±1.76	0.83±1.39	0.10±0.16	0.06±0.12	0.10±.22	1.18±0.37
	FP	0.73±0.61	2.08±1.35	1.52±2.02	1.49±0.88	0.68±0.66	0.88±1.35	0.22±0.22
	% Difference in IPM over FP	-28.77	25.96	-45.39	-93.29	-91.18	-88.64	436.36
2023	IPM	2.54±2.13	5.52±9.02	0.62±0.99	0.11±0.15	0.58±1.22	0.19±.0.38	1.23±0.33
	FP	2.74±3.61	5.80±11.70	1.41±1.89	0.95±0.76	2.16±4.01	0.55±0.65	0.36±0.20
	% Difference in IPM over FP	-7.30	-4.83	-56.03	-88.42	-73.15	-65.45	241.67

#Values are the mean of 13 weeks ±standard deviation; YSB: Yellow stem borer, LF: Leaf folder, BPH: Brown plant hopper, BLB: Bacterial Leaf Blight; SMW: Standard Meteorological Week

Table 2: Effect of IPM on reduction of chemical pesticides applications, yield and economics in basmati rice fields

Year	Treatments	Number of chemical pesticides Applications	Amount of active ingredient (g ai/ha)	Yield (q/ha)	Cost (₹/ha)	Gross Income (₹/ha)	Net income (₹/ha)	B-C Ratio
2020	IPM	2	222.75	35.5	53185	88750	35565	1.67
	FP	5	1665.25	33.7	64760	84250	19490	1.31
	Difference (%) in IPM over FP	-60	-86.67	5.34	-17.8	5.34	133	
2021	IPM	3	252.00	38.00	55344	133000	77656	2.40
	FP	5	1250.00	34.70	67998	121450	53452	1.79
	Difference (%) over FP	-50	-79.84	9.51	-18.6	9.51	63.99	
2022	IPM	2.00	142	47.50	58735	199500	140765	3.4
	FP	4.50	1139	43.50	66810	182700	115890	2.7
	Difference (%) in IPM over FP	-55.56	-87.5	9.20	-12.1	9.20	21.50	
2023	IPM	3.00	216.75	46.50	54470	199950	145480	3.67
	FP	5.00	653.25	42.50	63146	182750	119604	2.89
	Difference (%) in IPM over FP	-40	-66.82	9.40	-13.8	9.4	20.68	
Pooled (4 years)	IPM	2.5	208	41.9	55433	155300	99866	2.80
	FP	4.88	1177	38.6	65678	142787	77109	2.17
	Difference (%) in IPM over FP	-48.72	-82.29	8.48	-5.60	8.76	29.51	

IPM: Integrated Pest Management; FP: Farmers practices, Market rate (₹/q) of paddy was ₹ 2500, ₹3500, ₹4200 and ₹4300 in 2020, 2021, 2022 and 2023 respectively. Total cost included labor cost for land preparation, nursery sowing, puddling, transplanting, fertilizer application, hand weeding, pesticide application, etc. and material cost such as seed, fertilizer, pesticides, biocontrol agents, and irrigation.

Eco-Friendly Pest Management in Maize



MK Khokhar[1], Anoop Kumar[1], Mukesh Sehgal[1], Deepak Jain[2] Suby SB[3], Richa Varshney[4]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]Krishi Vigyan Kendra- Udaipur
[3]ICAR-Indian Institute of Maize Research, Ludhiana
[4]ICAR-National Bureau of Agricultural Insect Resources, Bengaluru

Maize (*Zea mays*), also known as corn, is the third most important cereal crop in India, after rice and wheat. It serves as a staple food, livestock feed, and an essential raw material for industries producing starch, ethanol, and biofuels. Maize is highly versatile, grown across diverse agro-climatic zones, and cultivated round the year. Maize cultivation in India faces significant challenges from various insect pests and diseases, which can substantially impact crop yield and quality. Among the major insect pests, the fall armyworm (FAW) (*Spodoptera frugiperda*), first reported in India in 2018, has emerged as a devastating threat, capable of causing 20-80% yield losses by feeding aggressively on leaves, tassels, and cobs. The stem borer (*Chilo partellus*) is another serious pest, particularly in the *Kharif* season, boring into stems and leading to plant wilting and deadheart formation, with potential yield reductions of 26-80%. Other insect threats include the oriental armyworm (*Mythimna separata*), which feeds on leaves and ears, and the cob borer (*Helicoverpa armigera*), which damages kernels, reducing grain quality. In addition to insects, maize crops suffer from severe fungal, bacterial, and viral diseases. Turcicum Leaf Blight, caused by *Exserohilum turcicum*, can cause 50% or more yield loss under favorable conditions. Maydis Leaf Blight (MLB), caused by *Bipolaris maydis*, is another significant foliar disease, with yield losses reaching 40-70%. Banded Leaf and Sheath Blight (BLSB), caused by *Rhizoctonia solani*, is a major concern in humid regions, leading to losses up to 60%. The increasing frequency of these insect pests and diseases, coupled with changing climatic conditions, necessitates the adoption of integrated pest management (IPM) strategy. Therefore, an Integrated Pest Management (IPM) module was synthesized, validated, and promoted under farmers' field conditions to safeguard maize yields and promote sustainable maize production.

The study was conducted *Kharif* 2022–25 in farmers participatory approach at Turgarh village (24°28'40.4" N 73°35'80.02" E) of district Udaipur, Rajasthan. The trial initially covered 8.0 hectares with 30 progressive farming families in 2022-23 and was expanded to 50 hectares with 100 families in 2024-25. Population and incidence of major pests were compared with FP and untreated control plots.





IPM Strategy:

- Seed treatment with *Trichoderma asperellum* @ 10g/kg of seeds,
- Installation of pheromone trap @10/ha for FAW monitoring,
- Spray of azadirachtin 1500ppm @ 5m/lit at 10 days after planting,
- Spray of biopesticide *Metarhizium anisopliae* (1×10^{8}cfu/g @ 10g/litre),
- Release of *Trichogramma chilonis* @ 1 card/acre (16000-20,000 eggs).
- Need based application of chemical pesticides

The neem pesticides were used early in when one moth/ trap was trapped, since they act as oviposition deterrent against egg-laying female moths, and feeding deterrent against the larvae. The chemical pesticide was the last component in the IPM package. Application of bio-pesticide or pesticide treatments started after one week of emergence of seedling, when the *S. frugiperda* infestation built-up and exceeded the economic threshold level (about 1 larvae/plant). The IPM package was compared with the Farmers' practice, and with the untreated control. Farmers' practice (FP) mainly involved calendar-based spraying of chemical pesticides for management of FAW as per the advice of pesticides dealers.

Baseline information about the villages Turgarh was collected, which indicated that the total cultivated area in the village is about 300 ha out of which maize occupies an area of about 150 ha and other crops grown in the area are soybean, mung, ginger and few vegetables. Farmers do not faced any significant pest problem in maize except FAW, which appeared since 2020, and they never required to spray any insecticides or fungicides. The average yield of maize 24q/ha which ranges between 18 to 30 q/ha. Pesticide applications were solely based on recommendations from pesticide dealers. Farmers had limited knowledge of the effects of high nitrogen doses, timely sowing, and an ETL-based approach to plant protection. Key pest problems in the area are fall







armyworm (FAW), stem borer (SB), maydis leaf blight (MLB), post flowering stalk rot (PFSR) and banded leaf and sheath blight (BLSB).

Impact of IPM

IPM interventions significantly reduced FAW infestation which wash 17% in IPM, 32% in Farmer Practice (FP) and 55% in control plots. Maydis Leaf Blight was significantly lower in IPM fields, with an average severity ? of 10%, compared to 28% in FP and 37% in untreated control plots. IPM fields maintained the lowest average severity in the case of BLSB at 7.3%, compared to 11.5% in FP and 18.6% in control plots. Similar is the case of PFSR caused by *Fusarium verticilliodes,* with lowest ncidence in IPM (7.3%) followed by FP (12.3%) and control (15.4%). The overall average population of natural enemies was highest in control (11.9/50 plants), followed by IPM (7.2/50 plants), and lowest in FP (3.6 /50 plants), indicating that IPM supports a higher population of beneficial predators compared to FP. In all three years, the highest population of natural enemies was observed in the control treatment, with the peak recorded in 2023 (13.5/50 plants), followed by 2022 (12.2/50 plants) and 2024 (10/50 plants). The IPM treatment had a moderate predator population, with its highest in 2023 (8.4/50 plants), followed by 2022 (7/50 plants) and a decline in 2024 (6.2/50 plants). The FP consistently showed the lowest population, remaining below 4 in all years, with a slight increase in 2023 (3.9/50 plants) compared to 2022 (3.5/50 plants) and a minor change in 2024 (3.4/50 plants) (Table 1).

IPM-treated fields recorded the highest average yield of 36 q/ha and a net return of Rs. 48,780/ha, outperforming both FP fields, which yielded 29.8 q/ha with Rs. 32,334 net return, and control fields, which lagged with 18 q/ha yield and Rs. 14,942 net return. Benefit-Cost (B:C) ratio was highest under IPM, 2.39, while FP (1.87) and control plots (1.27) showed lower BC ratios. In IPM fields, only one chemical pesticide spray were applied in 2023, whereas FP fields increased pesticide use each year, reaching three sprays with 83.25 g/ha of active ingredients in 2024 that was 27.75 g/ha of active ingredients in 2022 (Table 2). Farmers' meetings, Farmers' Field Schools, and IPM Field Days were organized at regular intervals in the village, which helped in strengthening linkages among farmers, scientists, and extension workers. These activities enabled 100% of the IPM farmers to identify major pests and natural enemies (such as spiders and coccinellids), understand the role of pheromone traps in pest monitoring, appreciate the importance of seed treatment, field sanitation, and weed removal in pest management, and gain clarity on the concepts of ETL and the need-based application of safer pesticides.

Table 1: Pest and natural enemy in maize under IPM, FP, and control fields at Turgarh, Udaipur (kharif 2022–2024)

Years	Treatments variables	FAW (%)	MLB (%)	BLSB (%)	PFSR (%)	Predators (No./50 plants)
2022	IPM	17.2±2.08	10.4±2.43	9.18±2.01	8.7±1.61	7.0±1.01
	FP	35.9±4.24	18.6±2.61	12.8±242	14.3±2.25	3.5±1.25
	Control	52.4±4.05	22.8±3.69	12.8±2.78	18.5±3.66	12.2±0.95
2023	IPM	18.2± 2.69	15.5± 1.07	4.53± 1.03	5.63±0.70	8.46± 2.53
	FP	30.0± 4.61	22.4±1.06	8.62± 1.48	10.1±0.99	3.96± 0.94
	Control	58.3± 3.98	30.0±1.71	21.6± 1.73	12.3±1.31	13.5± 1.25
2024	IPM	17.1±1.07	18.0± 1.90	8.4± 1.26	7.6± 0.84	6.2± 1.15
	FP	32.8±1.42	28.7± 2.10	13.2± 1.60	12.5± 1.21	3.4± 0.84
	Control	55.0±2.35	37.7± 2.84	21.3± 2.30	15.3± 1.40	10.0± 1.01
Pooled	IPM	17.5±0.61	14.6±3.87	7.4±2.49	7.3±1.56	7.2±1.15
	FP	32.9±2.95	23.2±5.10	11.5±2.54	12.3±2.11	3.6±0.30
	Control	55.2±2.96	30.2±7.45	18.6±5.00	15.4±3.10	11.9±1.77

#Values are the mean of 10 weeks ±standard deviation; FAW: fall armyworm, MLB: Maydis leaf blight, BLSB: Banded Leaf and sheath Blight, PFSR: Post flowering stalk rot; IPM- Integrated pest management, FP-farmers' practice

Table 2: Economic analysis of IPM, FP and control fields at Udaipur during 2022 to 2024

Variables	2022			2023			2024			Pooled Mean			% I/D*
	IPM	FP	Control	IPM	FP	Control	IPM	FP	Control	IPM	FP	Control	
Chemical pesticide sprays (no.)	0	1	0	1	2	0	0	3	0	0.33	2.00	0.00	-83.5
Pesticide active ingredient (kg/ ha)	0.0	27.75	0	27.75	55.50	0	0.0	83.25	0	9.25	55.50	0.00	-83.3
Yield (q/ ha)	36	30	16	40	32	15	32	27.5	21	36.00	29.83	17.33	20.7
Gross Income (Rs./ ha)*	66600	55500	29600	78480	62784	29430	62784	53955	41202	69288	57413	33410	20.7
Cost of cultivation (Rs./ ha)	28800	29200	26200	29700	30450	26200	28450	32900	26260	28983	30850	26220	-6.1
Net income (Rs./ ha)	37800	26300	3400	48780	32334	3230	34334	21055	14942	40304	26563	7190	51.7
BC Ratio	2.31	1.90	1.12	2.64	2.06	1.12	2.20	1.63	1.56	2.39	1.86	1.27	

Market price of maize Rs 1962/q, IPM- Integrated Pest Management, FP-farmers' practice, % Increase or decrease in IPM over FP

IPM Strategies for Chickpea Production



Jitendra Singh[1], Ritu Mishra[2*], Rajanish Mishra[2*], Vister Joshi[2], Rajiv K Singh[2], Adesh Kumar[3] and Nishy Roy[3]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]Krishi Vigyan Kendra, Jalaun (BUAT, UP)
[2*]University of Allahabad, Prayagraj (UP)
[3]Krishi Vigyan Kendra, Jhansi (BUAT, UP)

The Bundelkhand region of Uttar Pradesh is a water-scarce, rainfed semi-arid zone. The region comprises 14 districts, with seven districts each in Uttar Pradesh and Madhya Pradesh, and is well known for pulse cultivation, often referred to as mini pulse bowl of the country. Further, Bundelkhand region is a major chickpea-producing region of Uttar Pradesh, contributing approximately 69% of the state's total chickpea production and covering about 0.43 million hectares. The average chickpea productivity in Bundelkhand (1.43 t ha^{-1}) is relatively higher than the national average of 1.26 t ha^{-1} (2021–22), yet it remains significantly below the potential yield of 2.0 t ha^{-1}. However, chickpea production in the region is constrained by several biotic and abiotic stresses affecting plant growth and yield. Among the biotic constraints, soil-borne diseases and pod borer infestation cause substantial yield losses. Diseases such as collar rot (*Sclerotium rolfsii*), Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceris*), and dry root





rot (*Rhizoctonia bataticola/Macrophomina phaseolina*) can result in yield losses of up to 100%, while pod borer (*Helicoverpa armigera*) infestation may reduce yields by up to 24.8%. Chickpea growers in the region have limited awareness of scientific pest management practices and largely rely on chemical pesticides. Therefore, the present initiative aimed to disseminate Integrated Pest Management (IPM) strategies among chickpea farmers in the Jalaun and Jhansi districts, in collaboration with KVKs of the region under Banda University of Agriculture and Technology, Banda, Uttar Pradesh.

In addition, chickpea cultivation in the area is constrained by several other factors, including water scarcity, imbalanced fertilizer use, and low adoption of improved cultivation practices such as pest-tolerant/resistant and high-yielding varieties,. However, it was found that the districts of Jalaun, Jhansi, Hamirpur and Mahoba in Uttar Pradesh possess considerable potential for pulse production. Baseline information collected from six villages revealed that approximately 45% of resource-poor farmers were unable to afford costly agricultural inputs, while 56% lacked technical knowledge related to Good Agricultural Practices. Accordingly, a farmer-participatory IPM programme was initiated in October 2018. Three villages viz. Ragauli, Ragauli, and Kukargaon were adopted under KVK Jalaun, while Chokari, Tejpura, and Bilati villages were selected under KVK Jhansi for the implementation of IPM strategies. During the 2018–19 cropping season, the IPM programme was validated over an area of 135 ha, which was subsequently expanded to 710 ha during 2018–21 for large-scale promotion and dissemination of IPM strategies.

IPM module



Adult *H. armigera* (male) trapped in pheromone traps



The chickpea crop was severely damaged by pod borer (*Helicoverpa armigera*) and wilt complex caused by *Sclerotium rolfsii*, *Fusarium oxysporum* f. sp. *ciceris*, and *Macrophomina phaseolina*/ *Rhizoctonia bataticola*, podborer Other crop-damaging pests such as termites, cutworms, Ascochyta blight, and root-knot nematode were observed, but they did not pose an economic threat. The IPM module for the management of soil-borne diseases included the selection of disease-resistant varieties (JG 14, BG 3062, GNG 1320, etc.) and seed treatment with *Trichoderma harzianum* (NRIIPM strain) at 8–10 g kg^{-1} seed. For the management of pod borer, installation of pheromone traps (12 ha^{-1}) and bird perches (50 ha^{-1}), along with foliar application of neem formulation (1500 ppm @ 5 ml L^{-1}) and *Bacillus thuringiensis* (2 × 10^8 CFU ml^{-1} @ 2.0–3.0 ml L^{-1}, applied thrice at 10–15 day intervals from the initiation of flowering). Need-based foliar applications of emamectin benzoate (5% SG @ 3.0 ml L^{-1}) or indoxacarb (14.5% SC @ 0.8 ml L^{-1}) for pod borer management. In contrast, non-IPM practices (FP) involved the cultivation of local varieties without seed treatment and without the

use of pheromone traps, bird perches, neem formulations, or other IPM components.

Insect-pests and disease scenario

The IPM strategies were found to be effective in suppressing pod borer infestation below the economic threshold level (ETL) of 0.2 larvae m^{-1} row length, whereas infestation in FP fields was recorded above the ETL (1.2 larvae m^{-1} row length). At harvest, pod damage was limited to 11.6% in IPM fields compared to 28.4% in FP fields. Collar rot incidence was observed 20–30 days after sowing, while Fusarium wilt and dry root rot incidences occurred during flowering and pod formation stages, respectively. Implementation of the IPM module resulted in significantly lower disease incidence (9–12%) in IPM fields, whereas FP fields recorded 30–40% disease incidence. Infestations of other pests such as termites, cutworms, aphids, and Ascochyta blight remained negligible. The number of pesticide sprays were reduced from six to two under IPM practices. Consequently, IPM farmers achieved significantly higher returns, 23.6% yield increase over FP fields with benefit–cost ratios of 3.61 and 2.52, respectively. The IPM module was validated at both KVKs for two consecutive cropping seasons (2018–19 and 2019–20), covering an area of 135 ha. Subsequently, a group of progressive and potential farmers from the adopted villages was selected for large-scale dissemination and implementation of the IPM programme. During 2020–21, the IPM implementation programme was extended to 16 villages, covering 580 ha. The findings revealed relatively lower pod borer infestation in IPM fields, with pod damage of 9.5%, similar to the previous year, whereas FP fields recorded 32.6% pod damage at harvest. Likewise, disease complex incidence was recorded at 12.5% in IPM fields compared to 33.6% in FP fields.



Collar root disease incience

Economic impact of IPM

The number of pesticide sprays were further reduced from six to three. As a result, IPM growers again achieved attractive returns with a 24.5% higher yield over FP fields, with B:C ratios of 4.61 and 2.82 in IPM and FP fields, respectively. Extension activities such as regular field monitoring, scientist–farmer interactions, training on mass multiplication of microbial bioagents, and distribution and use of IPM inputs were carried out. Farmers showed keen interest in the programme and ensured continued adoption of IPM strategies for sustainable chickpea production. Several farmer field days were conducted during IPM implementation for crop protection, and demonstrations on mass multiplication of microbial bioagents were provided to enable farmers to produce bioagents on their farms for future use. Overall, the implementation of the IPM module significantly minimized disease complex incidence compared to FP fields. Based on the performance of IPM strategies, the programme was further extended to 24 villages, covering approximately 710 ha during 2021–22. Around 70% of the farmers adopted the IPM module for chickpea cultivation in these villages.

They installed pheromone traps (12 traps ha^{-1}) for mass trapping of *H. armigera* (112 ± 24.6 moths per standard meteorological week), used bird perches (50 ha^{-1}) to encourage predatory birds, applied neem formulations against pod borer, and utilized microbial bioagents (*T. harzianum* and *B. thuringiensis*) as effective alternatives to chemical pesticides. IPM fields consistently recorded higher yields compared to FP fields, with B:C ratios of 4.45 and 3.60 in IPM and FP fields, respectively. Hence, farmers adopted IPM strategies for chickpea cultivation, and follow-up activities continued with groups of participating farmers.





IPM Strategies for *Bt* Cotton



Ajanta Birah[1], Licon K Acharya[1], Anoop Kumar[1], MK Khokhar[1], AG Mitkari[2], Rishi Kumar[3] and Satish Parsai[4]

[1]ICAR- National Research Institute for Integrated Pest Management, New Delhi
[2]Krishi Vigyan Kendra, Jalna, Maharashtra
[3]ICAR- Central Institute of Cotton Research, RS, Sirsa, Haryana
[4]RVSKVV, BM College of Agriculture, Khandwa, MP

Insect pests and diseases are the major constraints in *Bt* cotton production. Farmers use heavy doses of chemical pesticides to manage pest incidence that adversely affects naturally occurring predators and parasitoids in the ecosystems. Over-reliance on chemical pesticides has caused harm due to pesticide residue, resurgence, secondary pest outbreak and development of resistance against these chemical molecules. Many of the insect pests infesting cotton in different agro-climatic zones are common but some are more serious in particular zone due to the conditions favouring their buildup. Emerging pest problems like pink bollworm, *Pectinophora gossypeilla* (Saund.) (PBW) threatened cotton production since 2016 onwards. This oligophagous insect is a key pest of *Bt* cotton in all cotton-growing continents and countries. The damage to lint is so severe that often the crop has to be abandoned from picking as the bad seed cotton has no market appreciation. This bollworm threatened farmers so much that integrated pest management in cotton took roots in order to suppress it smartly and with less cost.

Considering that *Bt* cotton covered >95% of total cotton acreage, PBW has evidently come under increasing selection pressure to evolve resistance to Bt protein (s) produced in tissues of Bt cotton plants. Secondly, even as an alternative control method, conventional insecticides have limited efficacy on PBW due to the internal feeding habit of the larvae within the developing cotton boll. The fruiting bodies formed in the later part of the season became prone to the attack of pink bollworm, therefore, the farmers apply chemical insecticides. Under these circumstances, there is a dire need for environmentally sound management practices against major pests of Bt cotton including PBW. Therefore, the present study aimed to develop and validate an adaptable IPM strategy for *Bt* cotton with major emphasis on PBW.

1. Integrated Pest Management for major pests of cotton at Jalna, Maharashtra

Jalna (Maharashtra, India) is considered to be the hot spot of cotton pink bollworm. Wakhari village (N 19 51 46.3 E 76 10 20.9) of district Jalna, Maharashtra was selected for conducting validation trial. Cotton IPM validation trial was initiated in farmer's participatory mode in area of 24 ha covering 30 farmers in 2018, which was extended to 30 ha covering 45 farmers in 2019, 50 ha covering 60 farm families in 2020 and in 80 ha area with 83 farmers in 2021, respectively.

The socio-economic baseline information was collected from four villages viz., Wakhari, Kadegaon, Punegaon and Pokalwadgaon in Jalna district of Maharashtra. In the village 60% area is under Bt cotton and rest of the area is under maize, bajra, urd, mung, groundnut, soybean, grapevine yard etc. It was also indicated that due to the attack of pink bollworm (PBW) during 2017, severe yield decline of about 60-65 % was recorded and yield obtained was 1.5-2, 5-6 and 7-8 q/acre in rainfed, surface irrigated and drip irrigation conditions, respectively. Refugia seeds were not planted by the most of the farmers except few progressive farmers. Most of the farmers in the village apply insecticides based up on the advice of pesticides dealers except few farmers of the village. Usually 5-15 sprays (average 7-8) of pesticides in a cotton crop season are carried out by the farmers which include imidacloprid, thiamethoxam, acephate, fipronil, lambdacyhalothrin, cypermethrin, triazophos, thiodicarb, diafenthiuron, flonicamid, spiromesifen, antrcol, carbendazim etc. Farmers usually applies tank mix of two insecticides along with some growth hormone and foliar fertilizers.

As IPM Strategy

- Sowing in June along with refugia, clean cultivation,
- border crop with bajra/maize/sorghum and intercrop with cowpea for natural enemy conservation,
- foliar application of 2% DAP and 2% Potassium nitrate at flowering,
- pest monitoring at weekly interval by employing a field scout,
- collection and destruction of fallen squares/flowers/bolls,
- installation of pheromone traps (40/ha) for mass trapping of PBW one week prior to flowering,
- release of parasitoid (supplied by NBAIR, Bengaluru team collaborators) *Trichogramma bactrae* (1.5 lakhs/ha) coinciding with the initiation of moth activity,
- need-based application of Azadirachtin (1500 ppm @2.5 l/ha) against sucking pests and PBW,
- need based application of Flonicamid 50 WSG (150 g/ha) for jassids, Diafenthiuron 50 WP (500 g/ha) against whitefly and thrips and Spiromesifen 22.9 SC (500 ml/ha) for whitefly nymphs, Spinetoram 11.7 %SC (420 ml/ha) for thrips, Quinalphos 20 % AF (2 ml/l) or Chlorpyrifos 20 % EC (2.5 ml/l) or Fenvalerate 20 % EC (1 ml/l)] against PBW
- termination of crop by end of December and destruction of crop residues.








शेती दिन




पंचवर्षीय समीक्षा टीम - क्षेत्र दौरा
QRT FIELD VISIT
कपास आईपीएम वैधीकरण पर कृषक-वैज्ञानिक संवाद
Farmers - Scientist interaction on Cotton IPM Validation
Village - Wakhari, District - Jalna (Maharashtra)
Organizers
Collaborators : KVK Jalna, NBAIR Bengaluru & ATARI Pune

Farmer's Field School (FFS) and awareness programmes were organized at 15-30 days interval in adopted villages during each crop season for dissemination of integrated pest management strategies. FFS included the training on identification of insect pests, diseases and beneficial, Economic Threshold Level (ETL) concept, use of biopesticides and bioagents and management tactics including safer pesticides.

Impact of IPM on pest and beneficial scenario

Lower incidence of sucking pests in IPM, as well as fields with farmer practices (FP), were noticed during the entire crop season. Comparison of population per leaf of sucking pests (average of 4 years) indicated lower population of whitefly (adult), jassid and thrips (nymph and adult) in IPM module (0.22, 0.35, and 1.27) as compared to FP (0.48, 0.99 and 2.77) respectively. In IPM fields, application of azadirachtin, flonicamid for jassids, diafenthiuron for whitefly and thrips and Spinetoram for thrips which provided protection from sucking pests. Green boll damage was found significantly lower in IPM fields (15.8, 11.0, 13.9 and 8.35%) with a mean of 12.62% as compared to farmer's practice fields (21.6. 25.2, 30.7 and 18.9%) with a mean of 23.88% with average reduction of 47.15 % over FP during 2018, 2019, 2020 and 2021, respectively.

Significantly, higher population of natural enemies comprising spiders, coccinellids and chrysopa species were observed in IPM as compared to FP. The population of natural enemies remained low in farmer's practice which received more number of insecticides application for pest management. Among beneficials, population of spiders remained higher in IPM (0.05, 0.06, 0.12 and 0.37/plant) with the mean of 0.15 as compared to FP (0.03, 0.02, 0.03 and 0.16/plant) with the mean of 0.15 during 2018, 2019, 2020 and 2021, respectively. Population of lady bird beetle also remained higher in IPM (0.03, 0.05, 0.14 and 0.32/plant) with the mean of 0.14 as compared to FP (0.01, 0.03, 0.04 and 0.24/plant) with the mean of 0.08 during 2018-20. Population of green lacewing also remained higher in IPM (0.09, 0.11, 0.33 and 0.53/plant) with the mean of 0.28 as compared to FP (0.05, 0.05, 0.15 and 0.15/plant) with the mean of 0.10 during 2018-20.

Economics of IPM

The pooled data of four years on yield and economics are depicted in Table 1 revealed that IPM implementation resulted in >28% increase in yield and >42% increase in net profit compared to FP. IPM implementation resulted in 49.74% reduction in number of insecticidal sprays against farmer's practice (Table 1). The benefit-cost ratio in IPM was 2.59, whereas in FP it was 1.87. Increase in yield in IPM fields was mainly because of good agriculture practices which helped in maintaining plant vigour under insect pressure, thereby helped plant to compensate the damage done by the pests. Farmers' field Schools were organized at regular interval and field day were also organized to create awareness and to develop the skill of the farmers about identification of pest and natural enemies, nature of damage and application of IPM components.

Technology certified by ICAR vide ICAR-CS-NCIPM Technology 2024-033.

Cotton IPM technology with major focus on management of pink bollworm (*Pectinophora gossypiella*)

Table 1. Economic analysis and insecticidal sprays in IPM and FP in *Bt* cotton during 2018-21 at Jalna, Maharashtra

Parameters	IPM				FP				Average		I/D*
	2018	2019	2020	2021	2018	2019	2020	2021	IPM	FP	
No. of insecticide sprays	2.8	2.9	2.9	3.2	5.7	5.6	5.9	6.3	2.95	5.87	49.74
Seed cotton yield (q/ha)	12.0	22.5	17.24	18.74	8.80	15.0	11.50	15.10	17.62	12.6	28.49
Cost of cultivation (Rs/ha)	42500	46000	41720	42550	39500	47000	37080	45750	43192	42332	1.99
Gross income (Rs/ ha)	72000	112500	96544	168660	52800	75000	64460	135900	112426	82040	27.03
Net profit (Rs/ha)	29500	66500	54824	126110	13300	28000	27380	90150	69233	39707	42.64
Benefit Cost Ratio	1.70	2.4	2.3	3.96	1.30	1.5	1.74	2.97	2.59	1.87	27.80

*Market rate of seed cotton yield were ₹6000, 5000, 5600, 9000/q during 2018, 2019, 2020 and 2021 respectively ; * % Increase(I) or % decrease (D) in IPM over FP.

2. Integrated Pest Management for major pests of cotton at Khandwa, Madhya Pradesh

The research was conducted in Khandwa district, Madhya Pradesh, a key cotton-growing region located in Central India. The area is characterized by black cotton soils with moderate fertility, a semi-arid climate, and a monsoon-dependent cropping pattern. The average annual rainfall during the study period ranged from 800 to 950 mm, received mostly between June and September. The temperature varied between 22°C and 39°C. The study was implemented over three *Kharif* seasons (2022 to 2024) across three selected villages within the district. Field trial on cotton IPM was conducted at Chichgohan, Bherukheda and Bamjhar villages of Khandwa district in Madhya Pradesh in farmer participatory mode in an area of 20 ha covering 26 farm families in 2022, 40 ha covering 36 farm families in 2023 and 50 ha covering 39 farm families in 2024.

Integrated Pest Management (IPM) components implemented in Bt cotton

- Timely sowing in June along with *refugia* to avoid peak pest infestation.
- Use of pest-tolerant Bt cotton hybrids; deep summer ploughing to expose pupae.
- Border cropping with sorghum/bajra/maize and cowpea intercropping for conservation of predators (ladybird beetles, spiders, green lacewings).
- Installation of pheromone traps @ 5/acre for bollworm monitoring and yellow sticky traps @ 10/acre for whitefly monitoring.
- Collection and destruction of fallen squares/flowers/bolls during early pink bollworm infestation.
- Two sprays of neem oil (Azadirachtin 1500 ppm) @ 5 ml $L^{-1}$for sucking pests and pink bollworm.
- Application of SPLAT (Gossyplure 4% RTU) @ 125 g/acre, applied four times (Aug–Nov); dollops placed at 400–500 spots/acre (3 m apart, zigzag) for mating disruption.
- Removal and destruction of crop residues and infested bolls.
- Selective insecticides applied only when pest levels exceeded ETL.
- Need-based use of flonicamid 50 WG @ 200 g/ha for sucking pests.
- Need-based use of Spinetoram 11.7 SC @ 0.8 ml L^{-1}or Emamectin benzoate 5 SG @ 0.5 g $L^{-1}$for pink bollworm.
- Crop termination by last week of December followed by destruction of all residues.

Impact of IPM on pest and beneficial scenario

IPM fields recorded a significant reduction in sucking pest population over FP and untreated control. During 2022-24, reduction over FP was 45.61%, 55.39% and 26.63% in whitefly, jassid and thrips, respectively. Whereas, the reduction in IPM over untreated control was much higher i.e. 67.08 %, 70.39 %, 56.07 % in whitefly, jassid and thrips, respectively. The results demonstrated that the participatory IPM approach effectively reduced pest populations in cotton crops. Green and open boll damage due to pink bollworm was found significantly lower in IPM fields as compared

to farmer's practice and untreated control. The mean (average of three years) reduction in green boll damage in IPM over farmer's practice and untreated control was to the tune of 73.71 % and 81.48%, respectively. Similarly, open boll damage in IPM recorded 30.52% lower as compared to FP and 62.90 % than untreated control. Significantly higher population of natural enemies comprising spiders, coccinellids and green lacewing species were observed in IPM and untreated control as compared to FP. Among beneficials mean population of spiders, lady bird beetle and green lacewing remained higher in IPM (0.66, 0.75, 0.85 adults/plant) and untreated control (0.89, 1.14, 1.13) as compared to farmers' practice (0.33, 0.28, 0.42 adults/plant) respectively (Fig.1). The population of natural enemies remained low in FP which received a higher number of insecticides application (6.78 spray) compared to IPM (3.63 spray) with judicious use of safer insecticides for pest management. Increased in natural enemies under IPM can be attributed to cultural practices such as border cropping with sorghum/bajra/maize and intercropping with cowpea which likely allowed these beneficial species to thrive upon.

Economics of IPM

IPM fields yielded significantly higher than conventional FP fields. IPM reported a mean yield of 15.05 quintals per hectare compared to 11.23 quintals per hectare in the FP fields (Table 2). On an average, IPM-managed cotton fields recorded a 25.38% increase in seed cotton yield. The net profit was increased by 56.18% in IPM over FP, mainly because of reduced pesticide use resulted in high benefit-cost ratio in IPM (2.92) as compared to FP fields (2.09).

A key outcome of this study was the successful involvement of farmers in the IPM process, leading to increased awareness and acceptance of sustainable pest management practices. Additionally, the participatory mode ensured that farmers were not passive recipients but active contributors to decision-making, thus improving their confidence and commitment to the IPM practices and trust in the technology. Such farmer-centric approaches are essential for sustainable pest management adoption, as they bridge the gap between research and real-world farming conditions. The study concluded that IPM strategy proved highly effective in reducing major cotton pests, ecologically safer by enhancing natural enemy population, and significantly lowering pesticide use across three seasons along with high benefit-cost ratio. Scaling this validated strategy through farmer field schools and improved access to pheromone-based tools can support wider adoption in future throughout the country.

Table 2. Economic analysis of pest management strategies in *Bt* cotton during 2022-24 at Khandwa, Madhya Pradesh.

Particulars	2022		2023		2024		Pooled Mean		% I/D
	IPM	FP	IPM	FP	IPM	FP	IPM	FP	
Insecticide Spray (Nos)	5.50	8.66	2.15	5.4	3.22	6.3	3.63	6.78	46.55
Seed cotton yield (q/ha)	9.25	5.80	11.36	7.37	18.74	15.1	15.05	11.23	25.38
Gross Income (Rs./ha)	55500	34800	76112	49379	168660	135900	122386	92639	24.30
Net Profit (Rs./ha)	9850	7560	35612	8579	126110	90150	80861	35429	56.18
Benefit Cost Ratio	1.92	1.27	1.88	1.21	3.96	2.97	2.92	2.09	-

*Average costs of seed cotton yield were ₹6000, 6700 and 9000/q during 2022, 2023 and 2024, respectively, IPM: Integrated pest management, FP: farmers practice; * % Increase(I) or % decrease (D) in IPM over FP

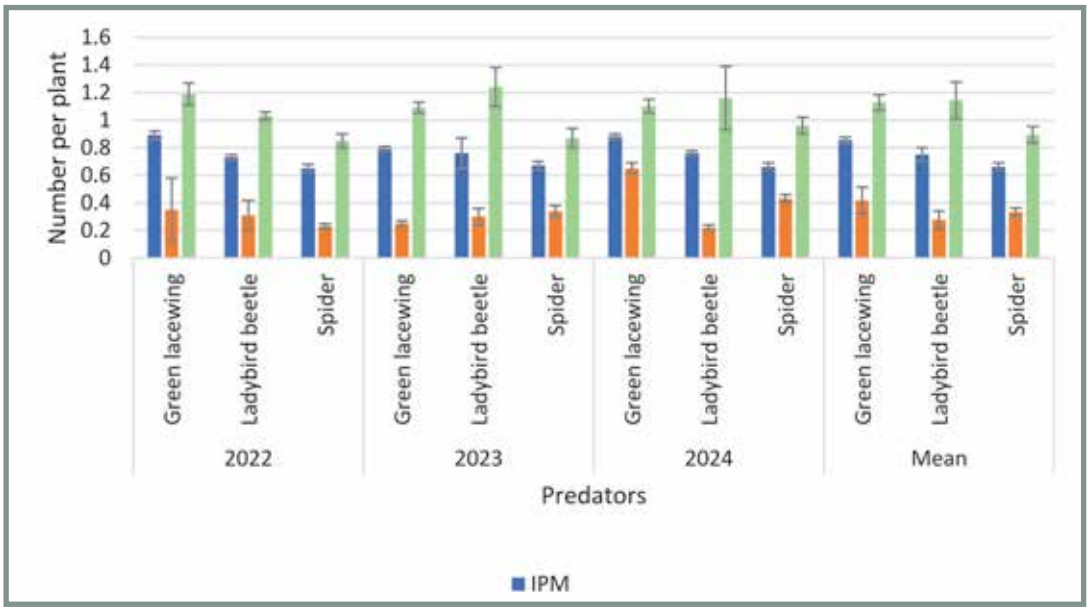


Fig. 1. Mean population of beneficials in Bt cotton fields during 2022–24 at Khandwa, MP



3. Integrated Pest Management for cotton at Rohtak, Haryana

Cotton cultivation in north-western India i.e. Punjab, Haryana, and Rajasthan is severely constrained by major insect pests and diseases, leading to excessive pesticide use, ecological imbalance, and resistance development. To address this challenge, ICAR -National Research Institute for Integrated Pest Management, New Delhi in collaboration with ICAR-Central Institute of Cotton Research, Regional Station, Sirsa, Haryana undertook a study to develop and validate an Integrated Pest Management (IPM) approach. The study was carried out during rainy (Kharif) season of 2022–2024 in Bhainichanderpal village (29°00'05.6" N, 76°18'32.4" E), Rohtak, Haryana. The trial initially covered 40 ha with 15 progressive farming families in 2022–23 and was expanded to 48 ha with 20 families in 2023–24. Population and incidence of major pests were compared with farmers' practices (FP) and untreated control plots (10 m × 10 m). In addition, the number of pesticides sprays and seed cotton yields were recorded. This strategy aims to manage key pests, particularly jassids, pink bollworm, and boll rot, while reducing chemical dependence and promoting ecological balance.

IPM strategy

- Timely sowing of crop up to 15th May with recommended hybrids (RCH 773, RCH 776, US-51)
- Seed treatment with Trichoderma asperellum (NCIPM/ T-9) @10 g/kg of seed
- Installation of yellow sticky traps (30 cm × 15 cm) @100/ha in June
- Installation of pheromone traps for *Helicoverpa armigera*, *Spodoptera litura* and *Earias vittella* @5 traps/ha each for monitoring purpose
- Use of bio-rational pesticides such as neem oil (Azadirachtin 1500 ppm) mixed with 0.5% laundry detergent emulsion, and
- Need based application of insect growth regulators (IGRs) i.e. Flonicamid 50 WG (200 g/ha) to manage jassid.
- Destructive sampling (20 bolls from a field) during the boll formation stage and need based spray of copper oxychloride 50 WP @25 g/10 L of water to manage boll rot.
- For management of pink boll worm, Specialized Pheromone and Lure Application Technology (SPLAT) based formulation [Gossyplure 4% RTU (CREMIT-PBW)] was used @125 g/acre/ application and was applied four times at monthly intervals (August–November). The ready-to-use formulation, available as paste was applied in the form of small dollops (peanut size) at the primary branch axil (below 3–4 inches from crop canopy) at 400–500 spots/acre 3 m apart in a zigzag pattern.
- In addition, for optimal nutrition 3–4 foliar applications of potassium nitrate fertilizer (NPK 13:0:45) @2% during flowering to boll formation stage at a weekly interval were also done.

Farmers' Field Schools (FFS) were held at fortnight intervals to educate farmers on pest and predator identification, economic threshold levels (ETL) of pests, safe and judicious use of pesticides,

balanced plant nutrition, awareness of pink bollworm vs. boll rot damage, and demonstration of SPLAT formulation. In the IPM fields, relatively safer chemical insecticides, mainly IGRs, were used, with pesticide applications limited to 3–4 sprays in both cropping seasons. In contrast, farmers in the FP fields applied 6–10 pesticide sprays, often using a mixture of 2–3 chemicals as a tank mix.

Impact of IPM on pest and beneficial scenario

In both years (*kharif* of 2022–2023 and 2023–2024), the IPM approach generally resulted in lower jassid incidences compared to the FP and control treatments. The jassid population was highest in the control plots, followed by the FP treatment, with the IPM treatment showing consistently lower infestations. Over the two seasons, the mean jassid population in the IPM treatment was 3.1 and 3.2 per three leaves in the two years, respectively, compared to 3.7 and 3.9 in the FP, and 4.5 and 5.4 in the control. In addition, the IPM approach helped delay the buildup of jassid populations compared to traditional farming practices (FP and Control). This delay in reaching the ETL under IPM suggests its effectiveness in managing pest populations, potentially reducing the need for early chemical interventions, and promoting more sustainable pest control strategies. Green boll damage due to pink bollworm was significantly higher in the control plots compared to both IPM and FP treatments. During both seasons, the green boll damage was lowest in the IPM. In the 2022–2023 season, the percentage of green boll damage was highest in the control treatment (37.2%), with the IPM plots exhibiting only 14.9% damage. Similarly, in the 2023–2024 season, the green boll damage remained consistently lower in IPM plots (11.5%) compared to FP plots (20.5%) and control plots (29.5%). The incidence of boll rot, was notably higher in the control plots across both seasons, with the disease incidence increasing significantly in the absence of management practices. In the 2022–2023 season, boll rot incidence was 37.2% in control plots, compared to 14.9% in IPM plots, and 27.2% in FP. In the 2023–2024 season, boll rot incidence continued to follow a similar pattern, with the control showing the highest incidence (29.5%), followed by FP (20.5%) and IPM (11.5%).

Populations of natural enemies (lacewings, ladybird beetles, and spiders) were highest in untreated control plots, followed by IPM and FP. Lacewing population was higher in control (0.94, 0.88 per plant) than IPM (0.50, 0.55) and FP (0.23, 0.19) during 2022–23 and 2023–24. Similarly, ladybird beetle populations were higher in control (0.48, 0.46) than IPM (0.18, 0.22) and FP (0.08, 0.08) in both years of study. Spider populations followed the same trend, with higher incidences in control (0.83, 0.77) and IPM (0.45, 0.49) compared to FP (0.15, 0.17) across both years.

Economic impact

During the 2022–23 cropping season, the IPM module reduced pesticide applications by 29.3% while improving seed cotton yield by 27.6% and benefit–cost ratio by 30.4% over farmers' practice (FP). Similarly, in 2023–24, IPM decreased pesticide use by 37.7% and increased seed cotton yield and benefit–cost ratio by 14.5% and 29.4%, respectively, compared to FP (Table 3).

In conclusion, the IPM approach successfully minimized pest damage, delayed pest buildup, and reduced pesticide applications, resulting in higher cotton yields and increased profitability, along with reduced pesticide costs. Moreover, the reduced chemical usage in IPM fields helped sustain populations of beneficial insects.

Table 3: Economic analysis of cotton under IPM and FP fields

Particulars	2022-2023			2023-2024		
	IPM	FP	I/D*	IPM	FP	I/D*
Pesticide spray (nos.)	4.1	5.8	29.3 (D)	3.8	6.1	37.7 (D)
Seed cotton yield (q/ha)	18.5	14.5	27.6(I)	19	16.6	14.5 (I)
Cost of cultivation (₹/ha)	56,250	57,300	1.9 (D)	57,100	63,400	9.9 (D)
Gross income (₹/ ha)	1,18,030	92,510	27.6(I)	1,25,780	1,09,892	14.5 (I)
Benefit cost ratio	2.1	1.61	30.4(I)	2.2	1.7	29.4 (I)

* % Increase(I) or % decrease (D) in IPM over FP, Market rate of cotton 2022-23- ₹6380/q, and 2023-24 - ₹6620 /q













Transforming Mustard Cultivation through IPM



MS Yadav, JC Gupta[1], SK Singh, Rekha Balodi, KV Raghvendra, AS Yadav[1], Jagender Singh[1], Pradyumn Singh[1] and Neelam Mehta

ICAR-National Research Institute for Integrated Pest Management, New Delhi
[1]Rajmata Vijayraje Scindia Krishi Vishva Vidyalaya- Zonal Agricultural Research Station and Krishi Vigyan Kendra, Morena-476001

Rapeseed–mustard is one of the major *rabi* oilseed crops of northern Madhya Pradesh, particularly in the Chambal and Gwalior divisions. The Grid region predominantly covers these two divisions. *Rajmata Vijayraje Scindia Krishi Vishwa Vidyalaya* (RVSKVV) – Zonal Agricultural Research Station (ZARS), Morena, caters to three districts of the Chambal division (Bhind, Morena, and Sheopur) and five districts of the Gwalior division (Gwalior, Datia, Shivpuri, Guna, and Ashoknagar).

The soils of the Morena region belong to the alluvial group, with textures ranging from sandy loam to clay, and are generally pale dark brown in colour. The climate is semi-arid, characterized by extreme temperatures—very hot during May–June (up to 50°C, minimum around 26°C) and very cold during January (maximum around 20°C and minimum 2–3°C). Despite these extremes, the region has strong potential for mustard cultivation, both under rainfed and irrigated conditions. The area and production of mustard have been steadily increasing and are expected to continue rising. In Madhya Pradesh, rapeseed–mustard crops are commonly affected by Sclerotinia rot, white rust, Alternaria blight, downy mildew, powdery mildew, and mustard aphid, all of which significantly reduce yield. Given the importance of this crop to the state's economy, an initial survey of the Morena and Bhind districts was conducted in February 2019 in collaboration with RVSKVV–ZARS, Morena. Madhya Pradesh ranks second after Rajasthan in terms of mustard area and production; however, the average productivity of 840 kg/ha during 2016–17 was much lower than the national average of 1,304 kg/ha. Therefore, there was a clear need to develop an Integrated Pest Management (IPM) package to enhance mustard productivity. A farmer-participatory IPM mustard programme was implemented in Morena and Bhind districts during the rabi seasons from 2019–20 to 2024–25. The primary objective was to develop, validate, promote, and implement a location-specific, prioritized, component-wise IPM technology package for mustard cultivation.

Initial surveys conducted in Morena and Bhind revealed a pressing need for a sustainable and location-specific IPM strategy. A multidisciplinary team developed a prioritized IPM package tailored to the unique agro-ecology of the Grid (Chambal–Gwalior) region characterized by semi-arid climate, extreme temperatures, and alluvial soils ranging from sandy loam to clay.

Development of location-specific prioritized component-wise IPM package

An IPM package for the management of mustard pests was essential to enhance crop productivity. In recent years, Sclerotinia rot (*Sclerotinia sclerotiorum*) and aphids? has emerged as a serious concern in mustard, largely due to the cultivation of a few susceptible hybrids. To address these biotic stresses effectively, an Integrated Pest Management (IPM) package was developed by an inter-institutional and interdisciplinary team, adopting a holistic approach to pest management.

Validation of location specific IPM package for major pest of *Grid* Zone (Chambal-Gwalior division) of Madhya Pradesh

Two IPM modules along with an untreated control were evaluated for the management of rapeseed–mustard pests. Field trials were conducted in a randomized block design (RBD) at ZARS, Morena (25°15’ N; 70°30’ E) under RVSKVV, Gwalior, Madhya Pradesh, during the rabi seasons of 2019–20, 2020–21, and 2021–22. Each trial consisted of 5 × 3 m plots sown with cv. Giriraj, with three treatments, during the second week of November each year.





IPM Modules

M1: Bio-Intensive IPM Module

- Soil application of *Trichoderma viride* (local strain; 2 × 10^6 cfu/g) @ 2.5 kg/ha pre-incubated with decomposed FYM
- Seed treatment (ST) with *T. viride* @ 10 g/kg
- Two foliar sprays of freshly prepared garlic bulb extract @ 2% (w/v)
- Need-based spray of Azadirachtin 300 PPM @ 0.5% (when aphid population crossed ETL)

M2: Chemical Pesticide–Based Module

- Seed treatment with metalaxyl-M 31.8% ES @ 0.35% (v/w)
- Seed treatment with imidacloprid 70% WS @ 0.7% (v/w)
- Two foliar sprays of metalaxyl 4% + mancozeb 64% @ 0.25% (w/v)
- Need-based spray of thiamethoxam 25 WG @ 0.04% (w/v) when aphids crossed ETL (25 aphids/10 cm central shoot)

The bio-intensive IPM module (M1) was found effective in reducing Sclerotinia stem rot and powdery mildew, and also recorded the highest seed yield (28.1 q/ha), outperforming both the chemical module M2 (26.5 q/ha) and the untreated control (21.9 q/ha) (Fig.1). Module M2, however, proved superior to M1 in managing white rust on leaves and inflorescence (staghead). Overall, M1 increased the population of natural enemies and pollinators and resulted in a 28.5% higher seed yield compared to the control. It effectively reduced the incidence of aphids (77.2%) and significantly curtailed Sclerotinia stem rot and powdery mildew. While chemical pesticides remain an important component of pest management, they often disrupt natural enemy populations and ecological balance, creating conditions for pest resurgence. In contrast, the bio-intensive IPM module offers more sustainable and eco-friendly pest suppression, making it a superior alternative to purely chemical approaches.

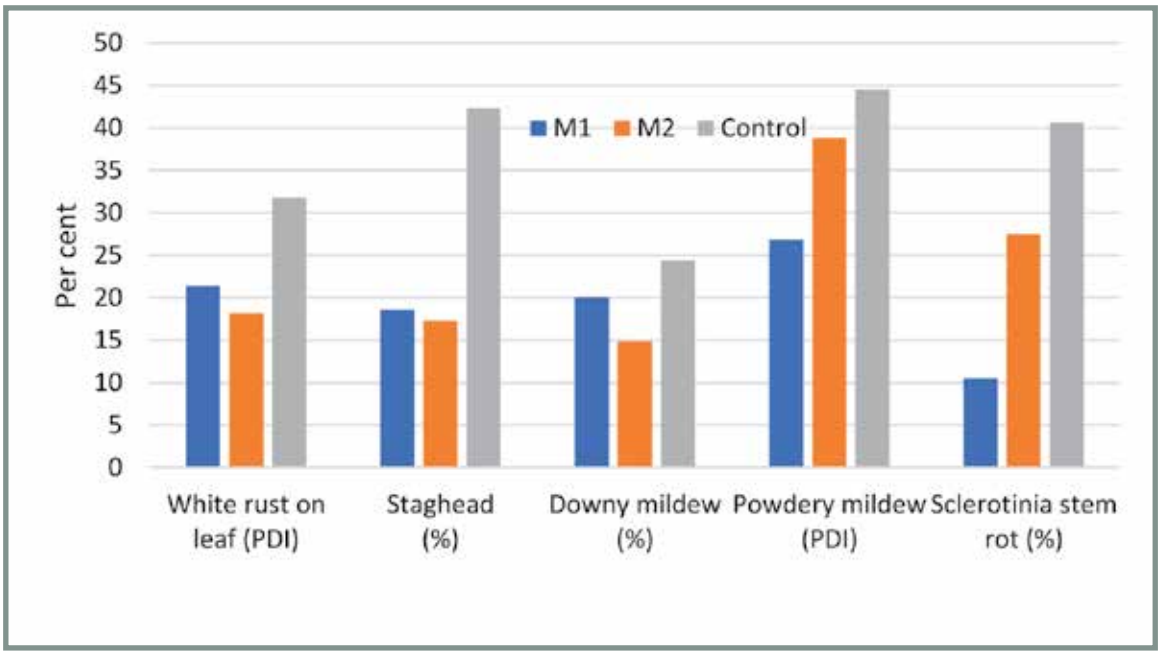


Fig.1 : Effect of IPM modules on diseases of mustard at Morena, MP

Promotion of IPM in mustard

Large-scale promotion of the IPM mustard package in a farmers' participatory mode was undertaken in the Bhind and Morena districts in collaboration with ZARS, Morena of RVSKVV, Gwalior, Madhya Pradesh. The project initially covered 70 ha across 30 villages, involving 175 progressive farmers. The IPM technology was successfully validated on farmers' fields for three consecutive years. Major IPM interventions were applied at different crop growth stages. At sowing, farmers received critical IPM inputs such as improved, healthy, disease-free seed of varieties Giriraj and RVM-3; fertilizers including potash and gypsum; and the bio-agent *Trichoderma viride* (local strain of M.P.). Need-based applications of thiamethoxam 25 WG (when aphid population exceeded the ETL of 25 aphids/10 cm central shoot) and metalaxyl-M 4% + mancozeb 64% (during severe white rust infection on inflorescence) were provided.

Severe incidences of staghead phase of white rust, Sclerotinia stem rot, and powdery mildew were effectively managed through these IPM interventions. IPM practices were compared with farmers'

Major IPM mustard interventions

- Pearl millet- mustard /Guar-Mustard crop rotation
- Removal of pest debris of previous crop; preparation of levelled and well drained field
- Soil augmentation with of *Trichoderma viride* (local strain; $2x10^6$cfu/g) @ 2.5 kg/ha pre-incubated in decomposed FYM
- Sowing window between October 01 -31
- Cultivation of recommended variety and seed rate
- Seed treatment with Imidacloprid 70 WS (7 ml/kg seeds) followed by seed treatment with *Trichoderma viride* (10 g/kg seeds)
- Judicious use of irrigation depending on soil type
- Regular monitoring of crop, hand picking of aphid-infested twigs during initial attack
- Rogueing of infected / infested plants
- Need-based spray of Thiamethoxam 25WG (0.01% a. i.) at above aphids ETL (25 aphids / 10 cm central shoot)
- Need-based spray of Metalaxyl 4% + Mancozeb 64% (0.25%) during severe infection of white rust on inflorescence

practices (FP), and significantly lower disease intensity and higher average seed yield were recorded under IPM. In Morena district, the average mustard seed yield under IPM was 26.2 q/ha, compared to 23.0 q/ha under FP. Over three years, IPM farmers in Morena earned a higher net return of ₹1,09,403.

The IPM approach consistently outperformed FP, with benefit–cost ratios ranging from 4.3 to 4.46 under IPM, compared to 4.0 to 4.13 under FP. Farmers achieved substantial economic returns with minimal additional input costs, resulting in a B:C ratio of 4.4. The validated IPM mustard package was discussed with the Director of Research Services, RVSKVV, Gwalior, and subsequently recommended for mustard cultivation in the Grid region of Madhya Pradesh.

Awareness about IPM technology was created among farmers through regular field visits, six Kisan Goshthis, three mustard field days, and on-field demonstrations for mass production of microbial biopesticides for disseminating IPM. Each programme witnessed participation from more than 100 farmers.

Based on these studies, it can be concluded that the IPM mustard technology is highly effective in managing major pests and enhancing seed yield. The approach is sustainable, economically viable, and cost-effective for mustard growers. Large-scale promotion of the IPM mustard package in a farmers' participatory mode was undertaken in the Bhind and Morena districts in collaboration with ZARS, Morena of RVSKVV, Gwalior, Madhya Pradesh.

The IPM mustard technology package was disseminated on a large scale in farmers' fields in collaboration with RVSKVV–Krishi Vigyan Kendra (KVK), Morena, Madhya Pradesh. The technology was further refined jointly with KVK, Morena, through a farmers' participatory approach. Additional farmers were subsequently included to ensure the horizontal spread of the IPM mustard technology, establishing model IPM mustard villages: Sirmor ka Pura in Ambah block (2022–23), Beerampura in Jaura block (2023–24), and Jawahargarh in Sabalgarh block (2024–25). Major IPM interventions were applied at different crop growth stages, and the performance of IPM practices was compared with farmers' practices (FP). Awareness about IPM technology was enhanced through four Kisan Sangoshthis, three mustard field days, and field demonstrations showcasing the superiority of IPM over FP.

With higher productivity and improved net returns, the programme attracted new farmers from adjoining villages. Consequently, the horizontal expansion of the IPM mustard programme covered 702 ha with 760 progressive farmers across the three model villages of Morena district. Overall, farmers achieved a 23.2% increase in productivity under the IPM approach.



During three years, IPM farmers recorded:

- 23.2% increase in productivity over farmers' practices
- Mustard seed yield of 26.2 q/ha (against 23.0 q/ha under FP)
- Higher net return of ₹1,09,403 per farmer in Morena
- B:C ratio of 4.3–4.46, compared to 4.0–4.13 under FP

The minimal additional input cost and substantial economic gain encouraged more farmers from adjoining villages to join the programme. This strong farmer response drove the horizontal

expansion of IPM mustard cultivation across the region.

The collaborative effort of ICAR–NRIIPM and RVSKVV–KVK Morena successfully demonstrated that an eco-friendly, scientifically validated IPM strategy can transform mustard cultivation in the semi-arid zones of Madhya Pradesh. The IPM mustard package has now been recommended by RVSKVV for widespread adoption in the Grid region, marking a significant step toward sustainable, profitable, and resilient mustard production.





IPM for Fruit fly in Cucurbitaceous Vegetable Crops



Devaramane Raghavendra and MN Bhat

ICAR-National Research Institute for Integrated Pest Management, New Delhi

India has the wide diversity for growing variety of vegetables right from down South to mid and high hills of Kashmir. This includes mainly the cucurbitaceous and solanaceous crops which are mainly the gourds such as bottle gourd, bitter gourd, sponge gourd, snake gourd, cucumber and melons such as watermelon and muskmelon. These vegetables are grown mainly in spring summer and rainy seasons across the country. Among several pests inflicting crop loss in these valuable crops, fruit fly, *Bactrocera* sp is one of the major pests, which alone cause > 50% if not properly attended. It is estimated that 30-40 per cent yield is lost due to pest attack in different horticultural crops which may be worth more than Rs 10000 crores. The management strategies for pests in vegetable/fruit crops, however, remain largely confined to pesticides only. In view of severe losses in vegetables caused due to insects, diseases, nematodes and weeds amounting to about 30%, pesticides are being used indiscriminately, especially in peri-urban areas so as to make vegetables the third largest consumer of pesticides i.e. about 14-15% while occupying about 5 per cent cultivable area. Thus, the pesticides consumption per unit area is more in vegetables than all other crops including rice. So far, there is no effective way of managing *Bactrocera* sp with farmers spraying indiscriminately at least once in a week without getting the desired result. The only effective way is to install lures and traps in large acreage in community approach. Cucurbitaceous, particularly cucumber, bitter gourd, sponge gourd and muskmelon are widely grown and are popular among the farmers of Karnal district, Haryana. ICAR-NRIIPM was involved in synthesis and validation of IPM in bitter gourd was successfully taken up at Padhana during 2014-19 and subsequently with the help of Dept. of Horticulture, Govt, of Haryana, wide area spread of fruit fly management in cucurbitaceous crops was successfully taken up during 2022-23 in > 1000 acres in Karnal district.

Seven villages *viz;* Samora, Padhana, Rambha, Ganger, Shamgarh, Takana and Sandheer have been identified and beneficiary farmers' growing cucurbitaceous crops *viz*; cucumber, muskmelon, bitter gourd, sponge gourd & bottle gourd have been selected. In Total an area of about 850-900 acre during 2019 & 2020 and 900-1000 acre during 2022 & 2023 under different cucurbitaceous crops has been taken for implementation of the Project.

IPM interventions

- Installation of used water bottle/plastic boxes cue lure traps baited with (as MAT) saturated wooden blocks (ethanol: cuelure: contact insecticide in a ratio 6:4:2) @ 25 traps/ha prior to flower initiation
- Soil raking to expose fruit fly pupae to sunlight
- Field sanitation - collect and destroy all damaged fruits
- Installation of delta and yellow sticky traps @25/ha
- Use Bait application technique (BAT) - Spray liquid of 0.1% insecticide and 10% jaggery or 10% ripe banana at 200 spots/ha (Homemade baits) –Both male and females will be trapped (MAT+BAT)
- Spray repellent (NSKE 5%) or Neem oil (1500 ppm) to enhance trapping and luring in bait spots
- Drench with *Metarhizium anisopliae*
- Apply need based label claim insecticides giving sufficient waiting period

Weekly data on fruit fly catches, no. of fruits infested with fruit fly, no. of chemical sprays used and total cost of cultivation incurred by farmers' practice were recorded. Farmers' meetings were organized to create awareness among farmers about fruit fly, its damage & management during pre-season, mid-season & post–season. The publications (leaf folder) regarding IPM in cucurbits was prepared and distributed among farmers.

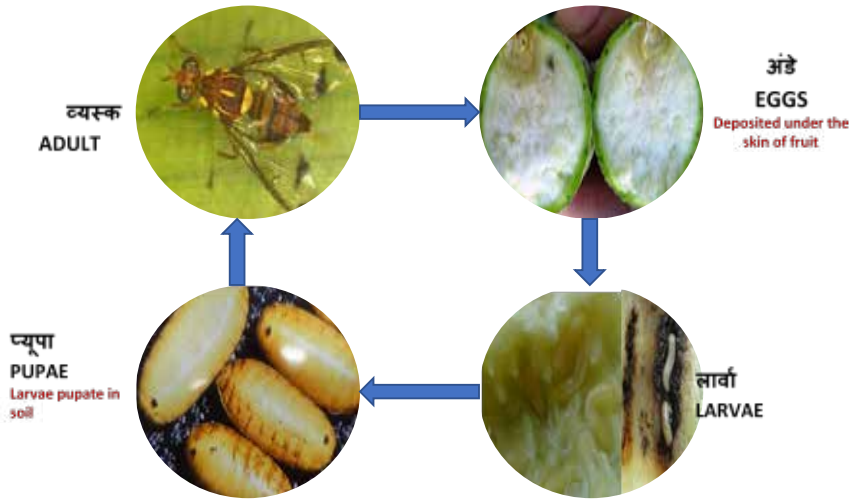
Damage symptoms of fruit fly

- Female fly punctures the skin of mature fruits with ovipositor and inserts white banana-shaped eggs (6–10/batch) in clusters into mesocarp.
- On hatching (after 1–2 days), the maggots tunnel into the fruit and feed on the pulp.
- The larvae pupate in soil (5–10 cm), and flies start emerging from April onwards with maximum population in July.





Life cycle



Impact of IPM

There was significant reduction of fruit fly infestation in IPM plots over farmers practice (FP) i.e., Bittergourd-50.29%, Bottlegourd-80.25%, Spongegourd-77%, Cucumber- 58.77% & Muskmelon-52.09% and per cent reduction of sprays was 28.44% (Bitter gourd), 39.43% (Bottle gourd), 33.77% (Sponge gourd), 34.14% (Cucumber) & 35.38% (Muskmelon) (Table 1.). Increase in yield was also observed in IPM compared to FP Bitter gourd-28.17%, Bottle gourd-16.36%, Sponge gourd-81.66%, Cucumber- 6.20% & Muskmelon- 13.88% besides registering highest BC ratio in IPM over FP (Table 1.).

Feedback from farmers of different villages was also collected. Majority of the farmers appraised our effort and impact of IPM and they were satisfied with the IPM activities in managing the fruit fly damage. Around 90 per cent of farmers accepted IPM interventions, its effect on reducing fruit fly damage and increased yield of the crop (Table 2).





Table 1. Average number of sprays and yield of IPM of fruit fly in Karnal

	% infested fruits	% reduction over FP	Number of sprays	% reduction over FP	Total amount spent on sprays (Rs)	Total yield (t/acre)	% increase over FP	Total Returns (Rs)	BC ratio
Bitter gourd (var. Vallabh)									
IPM	17.26%	50.29	4.68	28.44	3453	9.44	28.17	58240	2.05
FP	44.36%		6.54		5120	6.78		39220	1.38
Bottle gourd (var. Krishna)									
IPM	7.60%	80.25	3.84	39.43	2200	8.92	16.36	57400	2.14
FP	30.30%		6.34		4100	7.46		42620	1.72
Sponge gourd (var. Anokhi)									
IPM	14.24%	77	4.04	33.77	2300	4.20	81.66	89333	2.62
FP	41.40%		6.1		4200	0.77		68333	1.37
Cucumber (var. Tiranga)									
IPM	15.04%	58.77	5.40	34.14	4500	14.5	6.20	148100	3.73
FP	36.48%		8.20		8500	13.6		122400	2.70
Muskmelon (var. Madhu)									
IPM	22.23%	52.09	4.2	35.38	4200	3.6	13.88	45720	3.50
FP	46.40%		6.5		7200	3.1		39370	2.20

Table 2. Farmer's feedback for integrated management of fruit fly in cucurbits

Village	Crop	Awareness about (% of farmers)						Yield increase (%)		Reduced no. of sprays (%)		Remarks
		Fruit fly damage & life cycle	Traps Cue-lure	Raking of soil	Yellow sticky traps	Neem oil spray	Bait spray	Yes	No	Yes	No	
Samora	Cucumber	82	96	15	100	97	75	85	15	100	-	
Padhana	Bitter gourd	92	96	78	100	100	82	100	-	100	-	-do-
	Bottle gourd	95	95	85	98	96	80	100	-	100	-	-do-
Sandheer	Bottle gourd	80	98	80	95	95	75	100	-	100	-	-do-
	Bitter gourd	90	85	95	100	85	78	100	-	95	5	-do-
	Sponge gourd	95	92	88	100	90	80	100	-	100	-	-do-
Gangar	Bitter gourd	95	95	85	100	100	85	100	-	100	-	-do-
Rambha	Bitter gourd	90	90	85	98	90	75	100	-	94	6	-do-
	Cucumber	80	90	20	95	90	70	100	-	100	-	-do-
Shamgarh	Bitter gourd	80	80	70	95	80	60	100	-	100	-	-do-
Average of overall feedback		88	92	70	98	92	76	97	1.5	99	1.1	-do-

Overall impact of Fruit Fly Management:

- Focus on fruit fly management, including the balanced use of other inputs resulted in increased yields of cucurbits at farmers' fields.
- IPM with a focus on judicious use of inputs especially chemical pesticides resulted in overall reduction in use of pesticides.
- Large area adoption of Integrated Management of fruit flies made IPM more and more acceptable and adoptable to farmers thereby fast increasing the spread and percolation of IPM technologies in Haryana.
- Training of farmers entailed increased levels of knowledge base for the adopted farmers.
- Database development and publications would further enrich the knowledge resources of researchers, extension workers and decision makers for overall strengthening of IPM programmes on environment friendly vegetable production systems in future.
- Environment friendly technologies encouraged the healthy growth of fauna and flora and hence resulted in increased biodiversity in general and natural enemies and pollinators in particular.
- The cumulative effect of reduced pesticides and increased biodiversity increased environmental health.



Fruit fly infestation



Fruit fly trap

Pest Management Technologies in Rainy Season Cauliflower



SP Singh[1], MN Bhat[1], Satyendra Singh[1], Bharat Singh[2] and Anamika Sharma[2]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]ICAR-IARI KVK, Shikohpur, Gurugram (Haryana)

Cauliflower is an important cole crop vegetable grown extensively in almost every part of the country round the year. ThiscropSuch crop has great nutritional value and reported to have vitamin A and C, proteins, carbohydrates and minerals such as potassium, sodium, iron, phosphorous, calcium, and magnesium. Insect pests cause enormous yield and economic losses in *Brassica* crop production every year, and are a threat to global agriculture. Sometimes the yield loss by insects reaches as high as 60-70% and it is reported that Indian agriculture is currently suffering an annual loss of about ₹ 86.39 million due to insect pests. Major insect pests of cauliflower include aphids (*Myzus persicae* [Sulzer], *Lipaphis erysimi* [Kaltenbach]), painted bug (*Bagrada hilaris* [Burmeister]) cabbage head borer (*Hellula undalis* F.), diamondback moth (*Plutella xylostella* [L.]), cabbage webworm (*Crocidolomia binotalis* Zeller), tobacco catterpillar (*Spodoptera litura* [F.]) and mustard saw fly (*Athalia lugens proxima* [Klug]). Damping off (*Pythium aphanidermatum*), *Rhizoctonia* root rot, *Alternaria* leaf spot/blight (*Alternaria brassicicola*), black rot (*Xanthomonas campestris*), bacterial rot (*Erwinia* sp.) etc are major diseases of cauliflower crop. Several species of Root-knot nematode *i.e. Meloidogyne incognita*, *Rotylenchulus reniformis* and *Hoplolaimus indicus* were found infecting cauliflower in Varanasi region of India. It is reported that these pests cause damage to an extent of 80-100 % per cent in nurseries under favourable conditions and 10-25 per cent in field crops. Keeping all these facts in view, a very feasible, cost effective and environment friendly IPM strategies were devised validated in rainy season cauliflower crop which is prune to insect pests and disease attack as compare to winter season cauliflower.

A baseline survey was conducted in two villages *i.e.* Khanpur and Uncha Majra of district Gurugram (Haryana). Pests problem is a threat to rainy season cauliflower not to winter season. Total area under cauliflower is more than 2000 ha. Important pests infesting rainy season cauliflower in this area are following; Insect pests: tobacco caterpillar, *Spodoptera litura* is main defoliator insect and in some area Diamond back moth, *Plutella xylostella*. Diseases; Damping off, root rot, black rot and *Alternaria* leaf blight were major diseases. Very minor infestation by root knot nematode was observed**.** Farmer's knowledge about IPM, pests and natural enemies identification is almost nil. Blanket pesticide application whether relevant or not, is scheduled activity. In rainy season

cauliflower farmers normally spray 9-10 rounds of pesticides almost once in a week injudiciously at the behest of pesticide dealers and spend more than Rs. 25,000/- per ha. Hence development, validation and implementation of user and eco-friendly IPM strategies in the rainy season cauliflower was utmost necessity of the area. Therefore, a suitable pest management technology that can be adopted by the farmers with greater ease and is economically viable and can be implemented r in a compatible manner in farmer's participatory mode was validated and disseminated in rainy season cauliflower.

IPM Strategy

IPM components consisted of raised bed nursery about 15 cm above the ground level for good drainage and to avoid the diseases like damping off, root rot etc; uses of well rotten farm yard manure (FYM) @ 3 kg/m^2 treated with *Trichoderma viride* @ 150g and neem cake @ 50g/m^2 to avoid the soil borne diseases; seed treatment with *Trichoderma viride* 1.0% WP @ 4 g/kg and need based use of captan 75% WP @ 0.25% against soil borne diseases in nursery while in main field uses of well rotten farm yard manure (FYM) @ 20-25 t/ha treated with *Trichoderma viride* 1.0% WP @ 2.5 kg/ha; seedlings dip in *Trichoderma viride* 1.0% WP @ 10 g/litre of water for 30 minutes to avoid the soil borne diseases; managing the weeds through proper inter culture operations; installation of pheromone traps against *Spodoptera litura*; collection and destruction of eggs masses and larvae of *Spodoptera litura* and uses of need based application of label claim insecticides like Cyantraniliprole 10.26% OD @ 60 g a.i./ha and or Fenvalerate 20% EC @ 60-75 g a.i./ha against insect pests and use of fungicides like mancozeb 75% WP @ 3g per litre of water and or combination product *i.e.* Azoxystrobin 4.8% w/w + Chlorothalonil 40% w/w SC @ (0.144+1.2) kg a.i./ha (formulation dose 3 litre/ha) to manage the various diseases. Pesticide residue in cauliflower produce was also analyzed under IPM, FP and control.

Implementation of IPM

Location specific IPM technologies indicated as above were validated in rainy season cauliflower continuously for three years at the village Uncha Majra, district Gurugram of Haryana state during



2022-23 to 2024-25 in 10 acre area along with untreated control and disseminated during 2025-26 in the villages *i.e.* Uncha Majra, Narhera, Bhora Kalan, Bhora Khurd, Nurpur, Bas Padamka and Panch gaon of district Gurugram, Haryana (Hub of rainy season cauliflower production).

Impact on pest population

Data presented in table 1 indicated that a significantly low per cent of damping off and *Rhizoctonia* root rot was recorded in IPM over the farmer's practice (FP) and untreated control during 2022-23 to 2024-25. It was mainly due to raised bed nursery and application of *Trichoderma viridae* in IPM field. Black rot severity (PDI) caused by *Xanthomonas campestris* pv. *campestris* was significantly low in IPM over the FP and untreated control. It was first reported during last week of September and increased to significantly higher level during last week of October. Area Under Disease Progress Curve (AUDPC) was highest in control followed by FP and IPM. Significantly low severity of *Alternaria* blight was recorded in IPM as compare to FP and untreated control during all the three years of validation. It did not pose any serious threat. ADPUC was least in IPM followed by FP and untreated control. *Spodoptera litura* larvae incidence was noticed during mid August and reached on peak during mid September. Significantly low population of larvae per plant was recorded in IPM over the FP and untreated control. Maximum number of *S. litura* adult per trap were observed during 38th Std. week while it was declined to lowest level during 48th Std. week. Significantly higher spider population per m^2 was recorded in IPM and control over the FP. No plant parasitic nematodes were recorded except few saprophytic nematodes during entire period of study.



Table 1: Status of pests and natural enemies under different practices

Practices	Damping off (%)	*Rhizoctonia* root rot (%)	Black rot PDI (AUDPC)	*Alternatia* leaf blight PDI (AUDPC)	No. of *S. litura* larvae/plant	No. of spiders/M^2
2022-23						
IPM	4.3	3.6	13.8 (992)	9.3 (454)	0.06	2.76
FP	10.3	604	18.4 (1253)	14.8 (681)	1.28	0.64
Control	22.1	8.0	22.7 (1664)	16.0 (788)	3.12	3.04
CD @ 5%	1.90	1.31	1.77	1.10	0.05	0.13
SE(m)	0.81	0.40	0.53	0.33	0.01	0.04
2023-24						
IPM	3.6	4.0	18.6 (743)	10.6 (199)	0.1	3.2
FP	15.6	7.6	30.1 (1114)	15.2 (287)	2.3	0.5
Control	31.6	12.0	45.2 (1592)	25.2 (449)	4.3	3.5
CD @ 5%	1.14	1.95	2.40	1.40	0.13	0.12
SE(m)	0.31	0.59	0.73	0.42	0.04	0.04
2024-25						
IPM	5.1	3.2	25.6 (1071)	12.4 (251)	0.2	3.5
FP	20.3	8.4	40.8 (1412)	15.6 (346)	3.2	0.8
Control	34.4	16.0	51.6 (2121)	20.8 (434)	5.4	4.5
CD @ 5%	1.62	1.15	1.57	2.06	0.14	0.15
SE(m)	0.49	0.35	0.47	0.62	0.04	0.05

Table 2: Impact of IPM on per cent reduction of pests over the untreated control

Practices	% reduction of pests under IPM and FP over the control					% increase of spiders over FP
	Damping off (%)	Rhizoctonia root rot (%)	Black rot PDI (AUDPC)	*Alternatia* leaf blight PDI (AUDPC)	No. of *S. litura* larvae/ plant	
2022-23						
IPM	80.5	55.0	40.0	42.0	98.0	431.0
FP	53.4	20.0	20.0	7.5	59.0	-
Control	-	-	-	-	-	475
2023-24						
IPM	88.6	66.7	59.0	58.0	98.0	640
FP	50.6	36.7	50.0	40.0	47.0	-
Control	-	-			-	700
2024-25						
IPM	85.0	86.0	50.0	40.0	96.0	337.5
FP	41.0	47.5	21.0	25.0	41.0	-
Control	-	-	-	-	-	462.5

It is revealed from table 2 that significantly higher per cent reduction (80.5, 88.6, 85.0); (55.0, 66.7, 86.0); (40.0, 59, 50.0) and (42.0, 58.0, 40.0) in damping off, *Rhizoctonia* root rot, black rot and *Alternatia* leaf blight diseases respectively was recorded under IPM over the untreated control during 2022-23, 2023-24 and 2024-25. Similarly, significantly higher per cent reduction 98.0, 98.0 and 96.0 in *S. litura* population per plant was recorded under IPM over the untreated control during 2022-23, 2023-24 and 2024-25 respectively.



Economic impact of IPM

Significantly higher yield (q/ha) was recorded in IPM (225.55, 230.60, 210.6) over the FP (184.60, 195.50, 185.2) and control plots (130.5, 125.2, 102.5) during 2022-23, 2023-24 and 2024-25, respectively. Total expenditure on cauliflower production was quite low in IPM over the FP. Benefit: cost ratio was highest (5.4, 4.4, 4.7) in IPM over the FP (3.8, 3.1,3.2) and control (2.6,2.2,2.3) during 2022-23, 2023-24 and 2024-25 respectively (Table 3).

Increase in spider population in IPM was three to six times compared to FP, which was due to the reduction in pesticides application. The reduction of 70 to 75 per cent in pesticide spray was recorded in IPM over the FP during 2022-24. No pesticide residue was recorded in cauliflower produce under IPM and control while residue of pesticides i.e. Azoxystrobin, Difenoconazole, Fipronil, Thiamethoxam, Fenvalerate was recorded above permissible level under farmers practice.

Table 3: Yield and economic analysis of different practices

Practices	Yield (q/ha)	% increase in yield over the control	Total cost of production (Rs.)	Total return (Rs.)	Benefit-cost ratio	% reduction in pesticide spray over FP
2022-23						
IPM	225.55	73.0	1,08,530	5,86,430	5.4	70
FP	184.60	41.0	1,23,180	4,61,500	3.8	-
Control	130.50	-	1,00,200	2,61,000	2.6	-
CD @ 5% SE(m)	8.22 2.48	-	-	-	-	-
2023-24						
IPM	230.60	84.0	1,05,240	4,61,200	4.4	75
FP	195.50	56.0	1,20,320	3,71,450	3.1	-
Control	125.20	-	85,510	1,87,800	2.2	-
CD @ 5% SE(m)	10.85 3.26	-	-	-	-	-
2024-25						
IPM	210.6	105.0	98,500	5,86,430	4.7	70
FP	185.2	81.0	1,22,000	4,61,500	3.2	-
Control	102.5	-	80,400	2,61,000	2.3	-
CD @ 5% SE(m)	8.51 2.57	-	-	-	-	-

Knowledge up gradation and development of linkages

Farmer field schools and meetings were regularly organized in the village at different time intervals to upgrade the knowledge of farmers about the pests infesting rainy season cauliflower. Farmers

were also trained how to prepare raise bed nursery, usage of *Trichoderma* in nursery and main field crop. They were also trained to identify the beneficial natural enemies and how to conserve them efficiently. Cultural and mechanical methods of pest management were also advocated and demonstrated to the farmers time to time. Demonstration on seed treatment and seedling root dip treatment with *Trichoderma*, field sanitation and weed removal was also conducted before the farmers. They were also trained on need based application of label claim safe pesticides. The project was implemented in active collaboration with KVK Shikohpur, Gurugram (Haryana). Strong linkages were developed among the farmers, scientists and extension workers of state Government. Mobile numbers of the farmers, scientists/extension workers were shared among themselves through WhatsApp group.





Seedlings on raised bed under IPM Seed rate 750g/ha (25% reduction over FP) and healthy nursery



Seedlings on flat beds & damaged by ater logging (Seed rate 1000g/ha)

Integrated Pest Management in Chilli



Narayana Bhat M[1], Vinay Kumar MM[2], PS Ajjappalavar[3], Ravikumar B[3] and M Abdul Kareem[4]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]Horticulture Research & Extension Centre, Devihosur, Haveri, Karnataka
[3] College of Horticulture, Shirsi, Karnataka
[4] College of Horticulture, Bidar, Karnataka

Chili pepper (*Capsicum annuum* L.)) is indeed a highly important commercial crop cultivated globally in temperate, tropical, and subtropical regions, valued as both a spice and a vegetable due to its unique flavor, color, and rich nutritional content. With over 400 varieties globally, it is commonly referred to as hot pepper belong to the family *Solanaceae*, holds a significant position in global agriculture and cuisine. India is the largest producer, consumer, and exporter of chillies globally, with cultivation covering 844.3 thousand hectares with an annual production of 2278.50 thousand tonnes. Andhra Pradesh is the leading chilli-producing state, followed by Maharashtra, Karnataka, Odisha, and Madhya Pradesh. Approximately 80% of India's chilli production is consumed domestically, with only 15-20% allocated for export. Apart from culinary uses, chillies are utilized in various industries. Despite its importance, chilli cultivation faces numerous challenges, including pest infestations by thrips, whiteflies, mites, and fruit borers, as well as diseases leaf curl, wilt, fruit rot and leaf spots. Climatic changes have further impacted chilli cultivation in regions like Haveri, Karnataka, where a 37.31% annual reduction in cultivation area has been reported over the past decade. To meet the growing demand for chillies, there is a need to expand the cultivation area and enhance productivity per unit area. Adopting advanced techniques such as Integrated Pest Management (IPM) offers a sustainable solution. IPM minimizes pest damage while promoting ecological balance and ensuring higher yields and quality. This study examines the socio-economic impact of adopting IPM technology in chilli cultivation.

IPM strategy

This IPM implementation study was conducted in collaboration with Horticulture Research and Extension Centre (HRES), Devihosur, Haveri, for successive three years from 2020 to 2022. The study area focused on four selected villages *Viz*., Devihosur, Hosalli, Aladakatti, and Kabbur. The project aimed to provide knowledge and technical expertise on Integrated Pest Management (IPM) practices and supported by supplying IPM components such as selected label claim pesticides, traps and lures and vermicompost to farmers. Seven progressive farmers, each owning at least 2 acres of land, were selected. IPM module consisted of seed treatment with *Trichoderma asperellum* @

10g; raised nursery beds about 10 cm above ground level for good drainage; covering nursery bed with nylon net of 40-50 mesh to protect seedlings from sucking pests; destruction of previous crop residues, weeds etc. and levelling of main land avoiding water-stagnation; application of vermicompost @ 10 q / acre, neem cake @ 1 q/acre at the time of planting; application of *Trichoderma asperellum* @ 2 kg/acre enriched with well rotten FYM (1 t/acre); nipping of seedling tips five days before transplanting to reduce sucking pest, *murda* complex and increase side shoots; grow maize around chilli field as a barrier crop to avoid the entry of sucking pests and support natural enemies; planting marigold as trap crop after every 25 rows of chili crop; erect T-shaped bird perches @ 10/ acre to facilitate visits by predatory birds; install yellow sticky trap/ blue sticky traps @ 20 traps /acre for thrips, white fly and leaf hopper trapping; spray azadirachtin based neem oil 3000 ppm @ 0.5 % in the initial stages of crop growth during initiation of insect pests and spray of locally prepared *Beauveria bassiana* @ 10gm/l against black thrips during 2022; rogue out and bury murda infested plants in the early stages; erection of pheromone traps @ 5/ acre for *Helicoverpa armigera* for monitoring of adults; apply need based application of label claim pesticides against major pests and diseases.

Impact of IPM on insect-pests and diseases

During three years of validation, thrips population mean ranged from 0.8 to 2.35 in IPM while FP recorded 1.3 to 2.77/leaf. Mites mean population was <1.0 in IPM while FP recorded 0.7 to 1.0 /leaf. Whitefly population was < 1.0/leaf in both IPM and FP. *Helicoverpa* fruit borer incidence was low (0.57 to 0.79 %) during 2022 compared to 2020 and 2021 where IPM recorded mean incidence of 2.5 and 4.13 % respectively (Fig.1). During the same period, incidence in FP was 3.7 and 4.54 % respectively. Spider mean population was high (0.48 and 0.58/plant) in IPM compared to FP (0.34 and 0.35/plant) during 2021 and 2022. Similarly, coccinelids population mean was high (0.43 and 0.58/plant) compared to FP (0.28 and 0.31/plant). Powdery mildew, die back and *murda* complex severity was low in IPM compared to FP. In IPM, powdery mildew severity was < 20 % in both IPM and FP during 2021. While in 2020 and 2022 powdery mildew severity was 35.2% and 25.2 % respectively. In FP during 2020 and 2022 powdery mildew severity was 41.9 and 20.5 % respectively. Similarly, die back severity was maximum (24.5 %) in IPM during 2020 while its severity was maximum (30.9 %) in FP during the same year. Similarly *murda* complex severity was maximum (35.2 %) in IPM during 2020 during which FP recorded 40.2 % severity. During 2021 and 2022, murda severity ranged from 14.8 % in IPM to 31.5 % in FP. *Sclerotium* wilt was noticed only in 2022 during which its incidence was 4.6% in IPM while FP recorded 10.5 % (Fig.2).



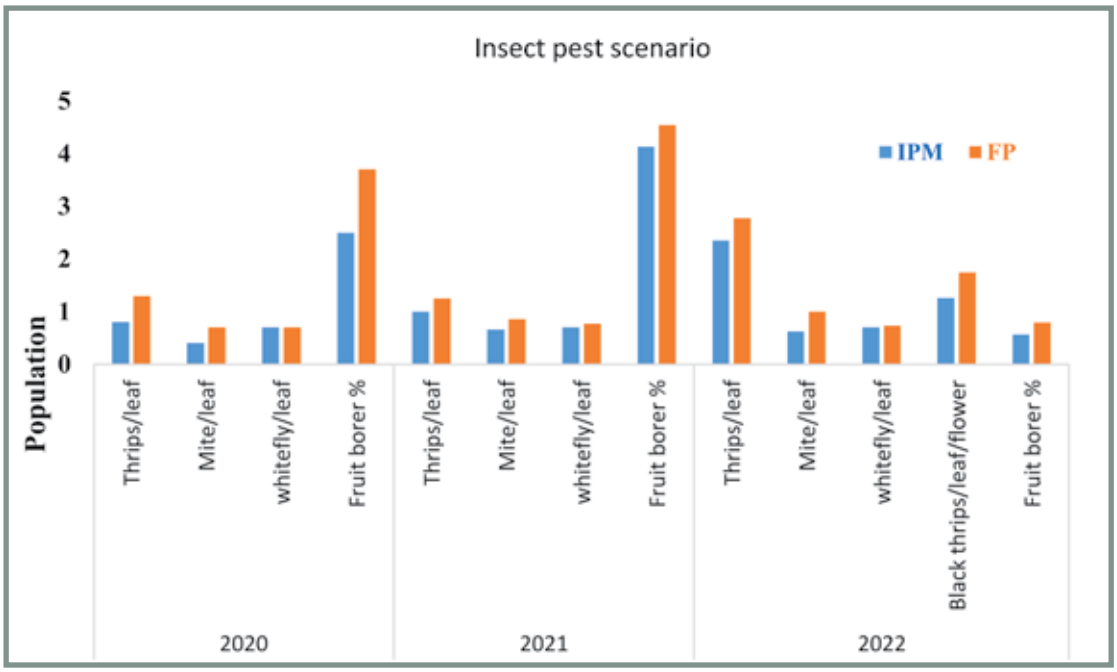


Fig.1 : Insect pest scenario in Chilli during 2020-22.

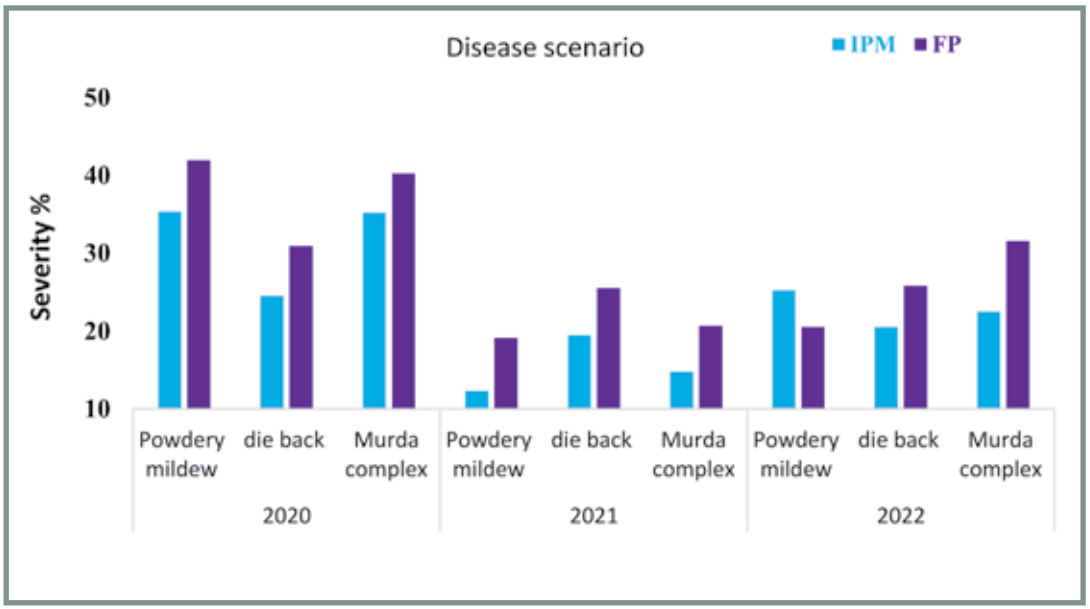


Fig.2 : Disease scenario in Chilli during 2020-22.

Economic impact of IPM

Further, number of pesticide spray reduction was maximum (42.8 %) recorded during 2020 which was followed by 2021 and 22 with 23.8 and 24.8 % reduction. Reduction in cost of production ranged from 3.7 to 14.6 % in IPM over FP during 2022 and 2021 respectively. Yield increase in IPM over FP was 4.3 and 6.1 % respectively during 2021 and 2022 respectively. The impact assessment was conducted in 2024, following the completion of the demonstration project. Using a purposive sampling technique, the same farmers involved in the initial project were surveyed between May and July 2024. The data from 25 farmers, who were trained and engaged during the project, were analyzed using descriptive statistical tools such as totals and percentages to interpret the findings.

The study highlighted that all the respondents (100%) possessed knowledge about Integrated Pest Management (IPM). A common agricultural practice among respondents was the use of raised seedbeds for cultivating seedlings. The frequency of farmers visiting *Krishi Vigyan Kendras* (KVKs) or related institutions was low with only 4% visiting regularly, 16% occasionally, and 80% rarely with many (>60 %) communicate through whatsApp. The limited visits may be due to factors like the distance of institutions from villages or inadequate transport facilities. Farmers acknowledged the effectiveness of discussions with experts in reducing the number of pesticide sprays. Regarding technical needs, all respondents prioritized pesticide information. Additionally, 100% of the farmers identified mites as a major cause of yield reduction, while 52 % highlighted the role of thrips 44 % fruit borers, and 20 % whiteflies. After three years of IPM demonstrations, 76 % of respondents confirmed a significant reduction in pest and disease infestations. However, only 12 % of the farmers were familiar with the concept of Economic Threshold Levels (ETL), while 60 % lacked this knowledge, indicating a need for further training. All respondents considered IPM a convenient, useful, and economical approach to sustainable plant protection. While 100% integrated chemical methods with botanicals and bioagents, only 36 % showed higher interest in using bio-agents, whereas, other farmers expressed a strong willingness to continue using IPM practices in the future.

The study revealed that 60 % of respondents were unaware of banned pesticides and the risks of overuse, highlighting the need for enhanced training programs. Nevertheless, all farmers were aware of the environmental and health hazards posed by pesticide contamination. While all respondents reported that, washing their hands after spraying, only 72 % covered their face and body during spraying. The remaining 28% failed to adopt these protective measures, underscoring the need for awareness campaigns. Innovativeness among the farmers was assessed, with 24% being highly innovative, 44 % exhibiting medium innovation, and 32 % classified as low innovative. In total, 68 % of respondents demonstrated some level of innovation. Majority (76 %) of the farmers gained 10,000 to 20,000 Rupees/acre by adopting IPM. The additional income through adoption of IPM helped 36 % farmers to buy critical inputs for next season.







This study highlights the positive impact of IPM on farming, showing that farmers benefit from lower production costs and more sustainable yields. IPM improves farm productivity while ensuring environmental safety. Economically, IPM reduces input costs and increases returns. Despite the initial cost of IPM inputs, long-term savings on pesticides and higher yields make it a financially viable option. However, many farmers still lack adequate knowledge about IPM, which limits its adoption. To bridge this gap, investments in training, demonstrations, and extension services are crucial. These efforts will promote IPM's environmental and economic benefits, enabling farmers to adopt sustainable methodologies for sustainable economic growth and social responsibility.

Sustainable Management of Striped Flea Beetle in Radish



Kerur Vishwanath Raghavendra, Rekha Balodi and Subhash Chander
ICAR-National Research Institute for Integrated Pest Management, New Delhi

Vegetables play a crucial role in Indian agriculture by ensuring food and nutritional security and improving farmers' incomes. Among vegetablesthem, cruciferous (*Brassicaceae*) crops such as cabbage, cauliflower, radish, turnip, mustard, knol-khol, kale, broccoli, and collard greens occupy an important place due to their nutritional, medicinal, agro-industrial, biocontrol, and crop rotation benefits. However, recent changes in cropping patterns, ecosystems, climate, and the widespread cultivation of high-input varieties have altered pest infestation scenario, leading to increased losses in cruciferous crops. Insect pests now pose a major threat, causing substantial yield and economic damage annually. Notably, flea beetles (*Phyllotreta* spp.), once considered minor pests, have emerged as highly destructive. Flea beetles are significant coleopteran pests of cruciferous vegetables, well adapted to diverse environments. The striped flea beetle, *Phyllotreta striolata* (Fabricius), is a serious pest of brassica crops and is distributed across North America, Europe, and Asia. Recently, severe infestations of *P. striolata* were recorded on radish (*Raphanus sativus* L.) and mustard in several villages of Haryana and Delhi NCR, causing 63.02% leaf and 53.96% root damage. Adult beetles create shot-hole symptoms on leaves, while larvae feed on roots, forming grooves that reduce plant growth. Due to the furrowed grooves owing to larval feeding found on radish roots (edible part), the marketability of the produce is hampered and these infested radish roots (edible part) fetched no value in the market.

Compounding the problem, flea beetles have developed resistance to insecticides in various countries, and *P. striolata* lacks effective natural enemies or parasitoids. In India, only Malathion 50 EC is recommended for radish, prompting farmers to resort to indiscriminate pesticide use. Such practices result in pesticide residues, environmental pollution, pest resistance, resurgence, new pest outbreaks, destruction of natural enemies and pollinators, and higher production costs. This situation highlights the urgent need for a shift toward sustainable pest management. To address these challenges, it became essential to develop and validate an Integrated Pest Management (IPM) strategy combining cultural, mechanical, biological, botanical, and chemical methods for sustainable management of flea beetle in radish. Therefore, a IPM module was developed, validated and disseminated during Rabi 2020 and 2021 under a Farmer Participatory Approach (FPA) for managing the striped flea beetle in radish at Samora village of Karnal District, Haryana (29° 49' 16.8"N 77° 00' 41.4"E).





Samora village is considered to be the leading producer of good quality radish for local markets and the menace of striped flea beetle, *P. striolata* was found to be very serious in this village. In the baseline survey it became evident that. 55-60 per cent farmers take up radish cultivation during *Rabi* season (first week of October – mid December) in this village. Also, since Rabi 2018-19, there incurred a huge economic loss in radish cultivation due to very serious infestation of flea beetles wherein they could not obtain even half of their expected yield and also opined that the radish which were infested by the flea beetle grubs fetched very less market value because of the deterioration of the radish quality due to grooving. Farmers used six to eight rounds of synthetic insecticides as first line of defense and frequently resorted to indiscriminate and non-judicious use of insecticides for management of flea beetles in radish and other cruciferous crops. Yet, farmers could not fetch a satisfactory result in flea beetle management. Accordingly, Samora village of the Nilokheri block, Karnal District, Haryana, was chosen for the seasonal incidence study and validation trials, following which the developed technology was disseminated over 173 hectares in Samora and adjoining villages.

IPM module

IPM module comprising of deep summer ploughing to expose overwintering stages of *P. striolata* (adult stage) to intense sunlight and natural enemies; application of well decomposed enriched farmyard manure @ 2.50 t/ha, enriched with *Metarhizium anisopliae* Sorokin (Con. = 1×10^8 cfu/g) @2 kg/t; soil application of 0.50 – 0.62 t of neem cake per ha to the main filed before sowing; growing 5–6 rows of sorghum/ maize all around radish field at least two months before sowing of radish seeds as a barrier crop; intercropping a bold seeded variety of mustard as a trap crop @10:1 ratio; installation of yellow sticky traps @ 12 traps per ha, 12–15 cm above the plant canopy; timely intercultural operations for maintaining weed free fields; drenching the root zone with entomopathogenic fungi, *Metarhizium anisopliae* (Con. = 1×10^8 cfu/ml or g) @8–10 ml or g/L; spraying of Neem oil 0.50% @5 ml/L or 5% Neem Seed Kernel Extract @ 500 gm of kernels/10 L or commercial formulation (Azadirachtin 0.03% WSP 300 PPM) @05 ml/L; need based dusting of malathion 5% D @25 kg per ha or spraying of malathion 50 EC @1.5 ml/L.



(a) Healthy radish leaves in T_1 - IPM fields



(b) Infested radish leaves in T_2 - FP fields



(c) Healthy radish in T_1 - IPM fields

(d) Infested radish in T_2 - FP fields

Validation of IPM Module

The IPM strategy evaluated against *P. striolata* in radish was effective with less leaf (10.99%) and root (12.93%) damage due to *P. striolata* compared to Farmers practice with 20.47% leaf and 39.43% root damage and also recorded 14.95 t/ha yield with cost: benefit ratio of 1:3.83 compared to Farmers practice (10.00t/ha yield and 1:1.60 C: B ratio). IPM strategy also reduced average number of insecticide sprays from 6.11 to 3.57 sprays (41.51% reduction), which clearly evince that the IPM strategy so validated can be adopted by the farmers as an economically viable option for management of *P. striolata* in radish. IPM strategy recorded the maximum Cost: Benefit ratio of 1:3.83 with 28.71 percent reduction in cost of cultivation as compared to Farmers practice (cost: benefit ratio - 1:1.60) indicating that IPM strategy effectively reduced the pest incidence in the radish crop and contributed to higher yield and enhanced farmers' income by reducing the cost of cultivation and increasing the yield per unit area as compared to Farmers practice (FP).

Impact of IPM on Radish cultivation

During field survey it was found that flea beetle**,** *P. striolata* infested various cruciferous crops like radish (*Raphanus sativus* L.), cabbage (*Brassica oleracea* L. *var. capitata*), cauliflower (*Brassica oleracea* L. *var. botrytis*), mustard (*Brassica juncea* L.) and knol-khol (*Brassica oleracea* L. *var. gongylodes*) where the infestation was found to be more that their economic thresholds. All the cruciferous crops surveyed were infested by *P. striolata* and the reason behind it is that the striped flea beetle, *P. striolata* and crucifer flea beetle, P. *cruciferae* belonging to the family Chrysomelidae are attracted to and stimulated to feed on cruciferous plants due to the presence of glucosinolates in the plants. It was found that, the *P. striolata* once noticed infesting the radish crop remained

active throughout its growing season up to the final harvesting of the crop (*i.e.,* from 42nd SMW - third week of October) to 50th SMW - third week of December). Further, important weather parameter affecting the radish infestation was temperature. Both maximum and minimum temperature showed a significant negative relationship with leaf infestation due to adults and root infestation due to grubs of *P. striolata*.

The IPM strategy adopted against *P. striolata* in radish was highly effective in terms of reducing pest infestation, higher economic yield, reduced insecticide consumption and reduced cost of cultivation in comparison to the FP which envisage to adopt IPM strategy for effective management of *P. striolata* in radish. The radish crop produced from IPM fields fetched higher price in the market as compared to FP proving IPM is a socially acceptable and economically feasible approach for pest management. However, there was scanty information available/awareness regarding IPM strategies against *P. striolata* management in radish. Thus, farmers started relying upon chemical insecticides, which failed to attain the satisfactory results. In this circumstances, the IPM strategy comprising of deep summer ploughing, application of well decomposed farm yard manure enriched with *M. anisopliae*, soil application of neem cake, growing sorghum/ maize as a barrier crop, intercropping mustard as a trap crop, installation of yellow sticky traps, drenching the root zone with biological control agent *M. anisopliae*, spraying of neem oil and need based dusting or spraying of malathion was validated and found that the strategy collectively resulted in making IPM effective and economical in dealing the menace of *P. striolata* in radish. Every single intervention of IPM mentioned above had their significant role in providing the satisfactory results.

To conclude, the IPM strategy thus validated against *P. striolata* in radish performed significantly effective in tackling the insect pest menace in comparison to the Farmers practice. Farmers got benefitted in terms of reduction in pest incidence, avoidance of unwarranted insecticidal sprays, obtaining higher yield and higher prices in the market for the produce by following IPM interventions in radish in Nilokheri Block of Karnal District Haryana.



ICAR Certification of the Technology

Integrated Pest Management module for striped flea beetle, *Phyllotreta striolata* infesting radish (*Raphanus sativus* L.)-ICAR-CS-NCIPM Technology-2024-031.

IPM for Transforming Tomato Cultivation



Kerur Vishwanath Raghavendra[1#], Rekha Balodi[1*], Ramakrishnappa Manjunatha[2], Maddireddy Papireddy[3], Peeru Saheb Y[4], K Manjula[4], Srinivasulu A[4], GS Panduranga[4], Reshu Singh[5], Subhash Chander[1] Mukesh Sehgal[1], Ajanta Birah[1] and Raman Thangavelu[1]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]College of Sericulture, University of Agricultural Sciences, Bengaluru, Karnataka
[3]Krishi Vigyan Kendra, Chintamani, Chikkaballapura, Karnataka
[4]Krishi Vigyan Kendra -Kalikiri, Annamayya District, A.P.
[5]Krishi Vigyan Kendra - Bulandshahr District, U.P.
[1#]Current Address: ICAR-Indian Institute of Rice Research, Hyderabad, Telangana

Tomato, a cornerstone of Indian cuisine and agriculture, faced an escalating crisis. Across the farming heartlands of Karnataka and Haryana, fields were under siege. The invasive South American tomato pinworm, *Phthorimaea* (*Tuta*) *absoluta* and the relentless fruit borer (*Helicoverpa armigera*) were causing devastating losses. Farmers, trapped in a cycle of pest panic, were spraying a cocktail of chemical pesticides 25 to 30 times per season, with costs soaring and risks multiplying. This chemical dependence was more than a financial burden; it was eroding ecosystem health, harming beneficial insects, contaminating soil and water, and jeopardizing farmer and consumer safety. The need for a paradigm shift was urgent.

In response, the ICAR-National Research Institute for Integrated Pest Management launched a mission-oriented project: to design, validate, and mainstream a sustainable alternative. Rejecting the one-size-fits-all approach, the vision was to create location-specific, ecological, and farmer-centric IPM strategies. The goal was not just pest management, but system resilience - aligning with the global 'One Health' principle that recognizes the interconnected health of plants, animals, humans, and the environment. The project, conducted from 2020 to 2024, was anchored in two distinct agro-ecologies: the tomato-growing regions of Chikkaballapura, Karnataka (Representing southern plateau conditions), and Karnal, Haryana (Representing northern Indo-Gangetic plains conditions) (Fig. 1).

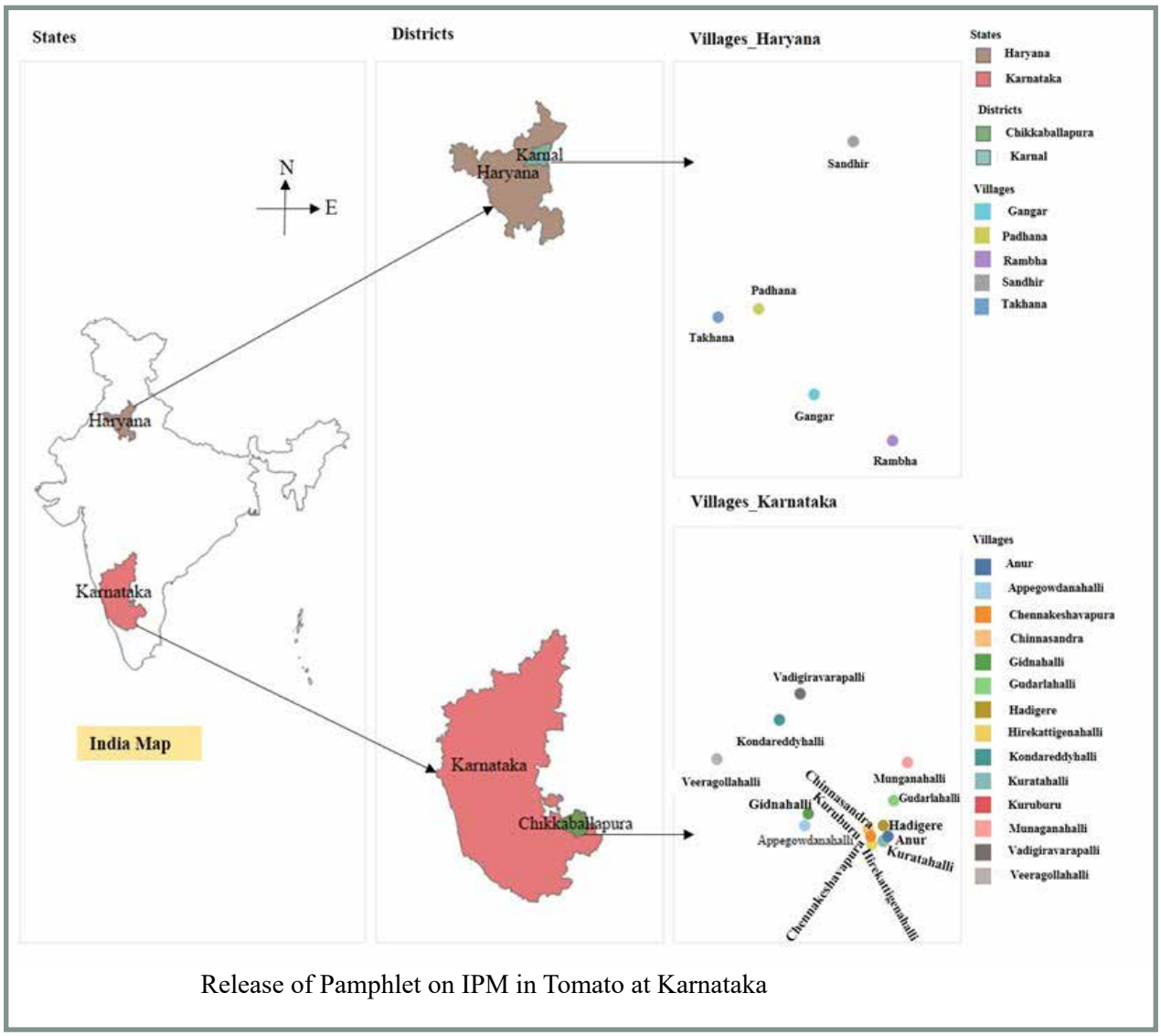


Fig. 1 India Map depicting locations of validation and promotion of IPM in tomato

IPM Strategy

The validated IPM module (Fig. 2) was a meticulously designed with integration of science-backed methods, moving away from calendar-based spraying of chemical pesticidesto need-based, intelligent management:

- Pre-emptive Fortification: It began at the nursery itself with insect-proof nets and seedling treatment with beneficial microbes like *Trichoderma*. Soil was fortified with neem cake to suppress nematodes and soil-borne diseases.
- Ecological Engineering: Fields were surrounded by tall border crops (maize, sorghum) to act as windbreaks and physical barriers. Marigold trap crops were planted to lure and concentrate pests away from the main tomato crop.
- Monitoring & Precision Trapping: Yellow and blue sticky traps monitored sucking pests, while pheromone traps specifically targeted male moths of *Tuta absoluta* and *Helicoverpa*, disrupting their breeding cycles.

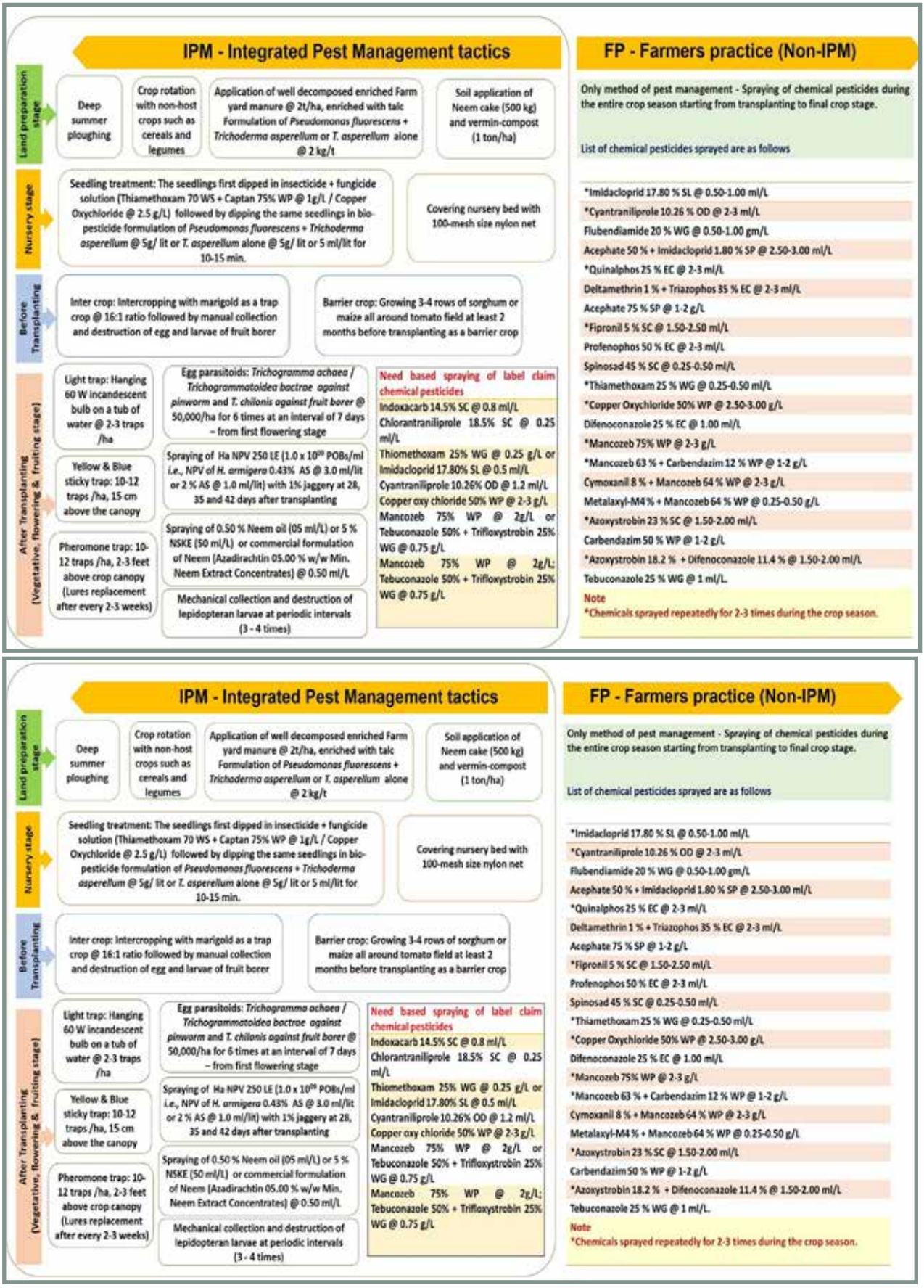


Fig. 2 IPM - Integrated Pest Management strategy *vis-à-vis* FP- Farmers' Practice (Non-IPM) for pest management in tomato crop.

- Biological Warfare: Trichocards (carrying eggs of the parasitic wasp *Trichogramma*) were released to destroy pest eggs. For the voracious fruit borer larvae, *Ha*NPV (a virus specific to *Helicoverpa*) was applied.

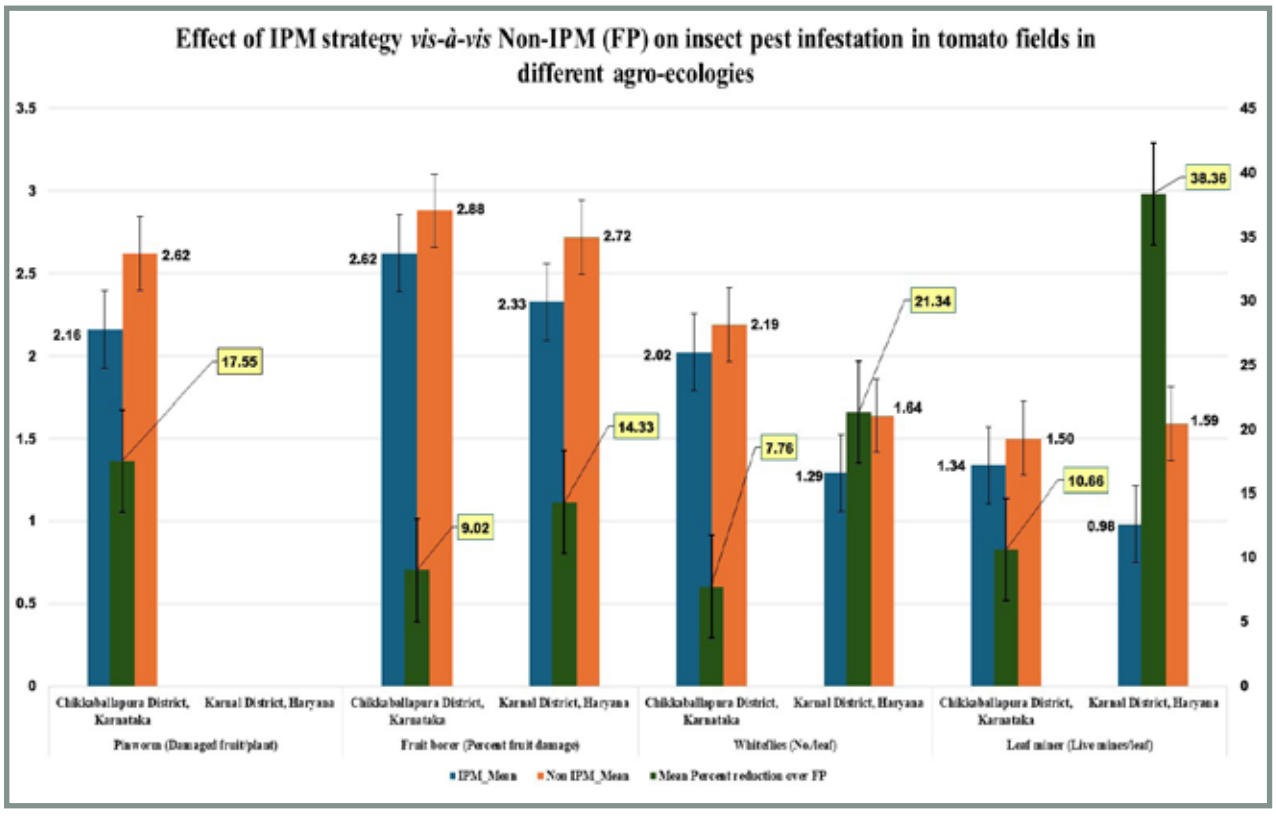
- Botanical Intervention: Neem-based bio-pesticides served as a broad-spectrum yet biodegradable deterrent, affecting pests' growth and feeding without toxic residues.

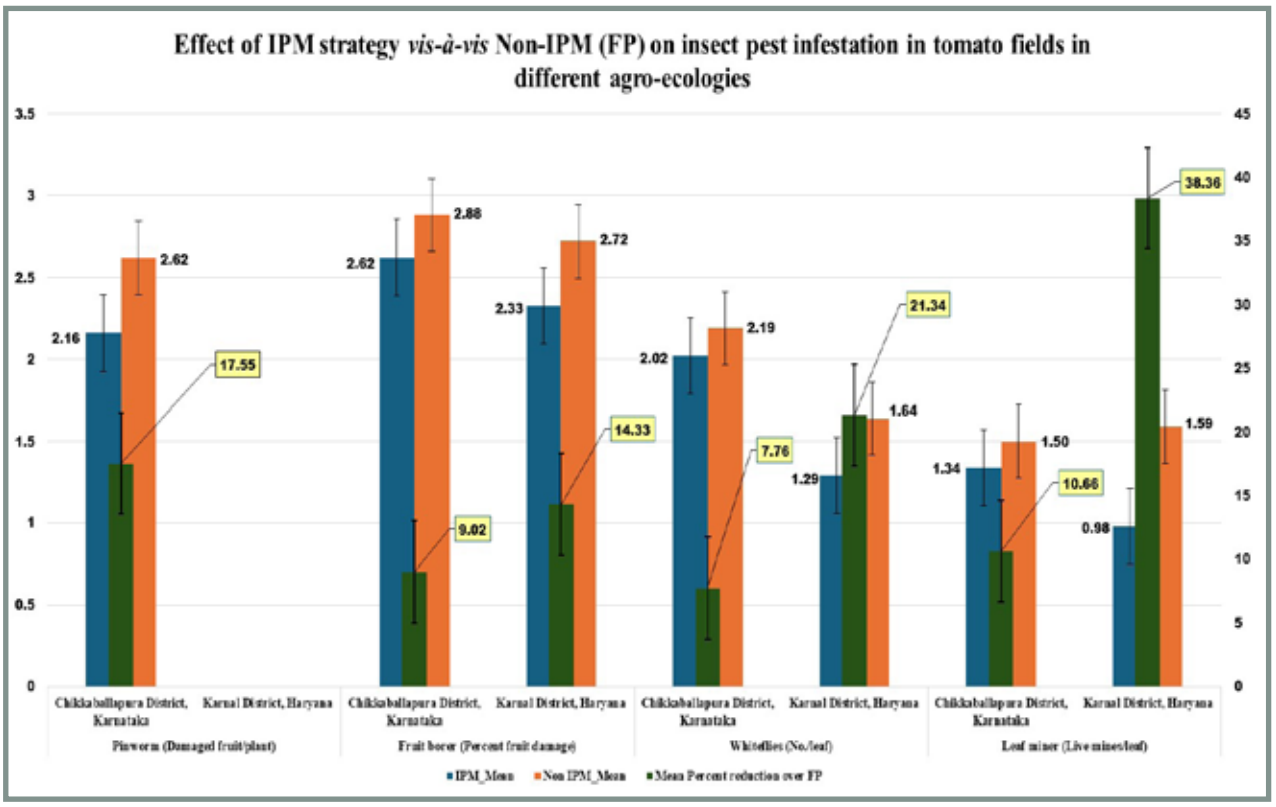
- Judicious Chemical Use: Synthetic chemicals were used only as a last resort, and that too selectively (e.g., Cyantraniliprole), minimizing ecosystem impact.

Quantifiable Impact: A Story Told in Data

The results, drawn from rigorous comparison between IPM and conventional Farmer Practice (FP) plots over two seasons, were transformative:

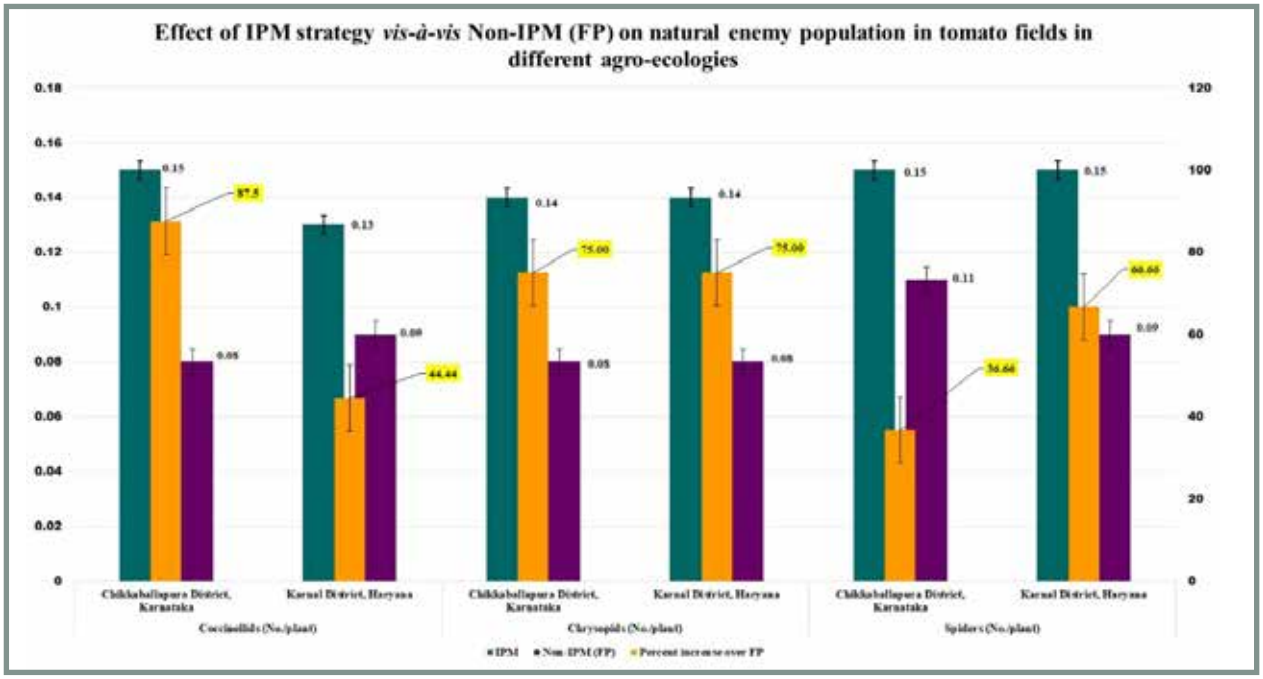
A. Pest Suppression: IPM fields recorded 17.55% reduction in *Tuta absoluta* damage in Karnataka and 9.02% () and 14.33% reduction in fruit borer damage in Karnataka and Haryana respectively. Whitefly and leaf miner populations dropped by 7.76 - 38.36%.

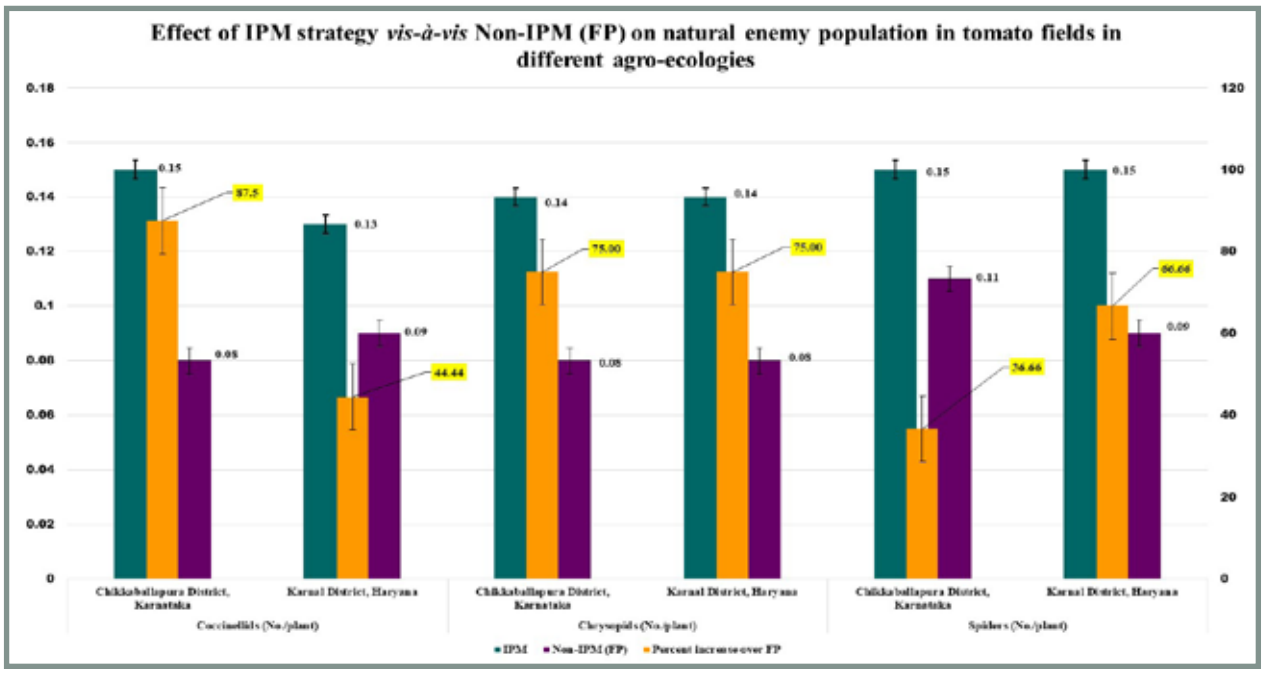




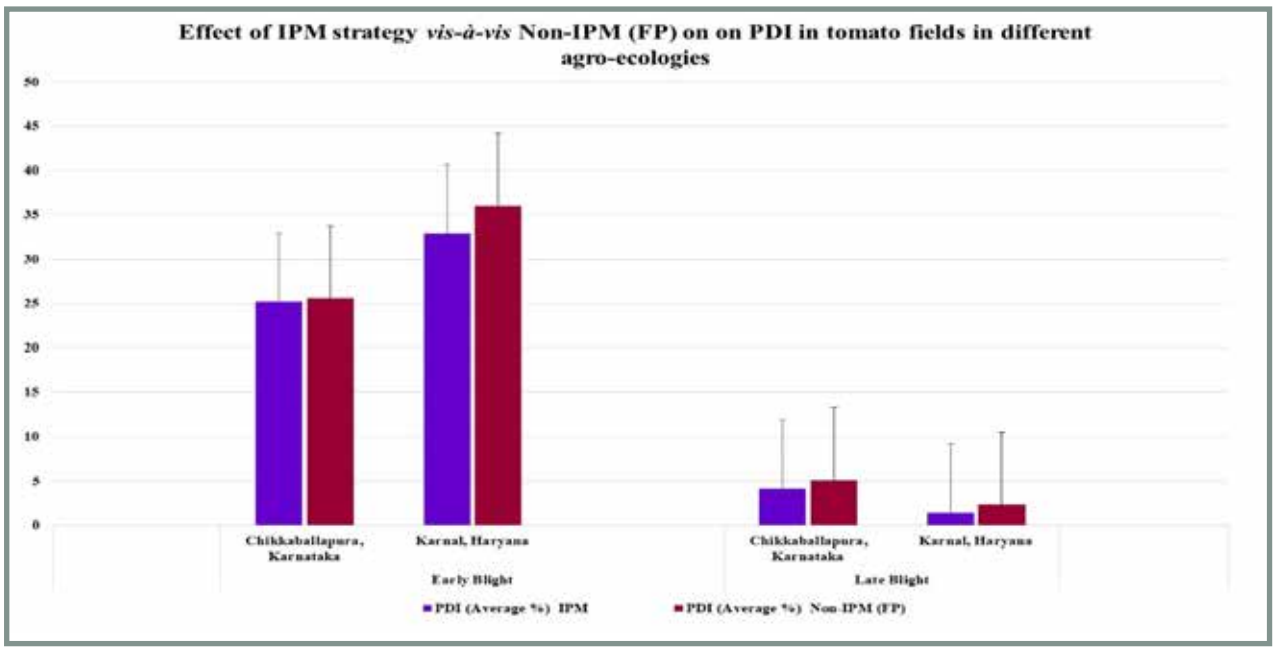
Predator Prosperity: The true indicator of ecological health soared. Populations of beneficial predators increased drastically:

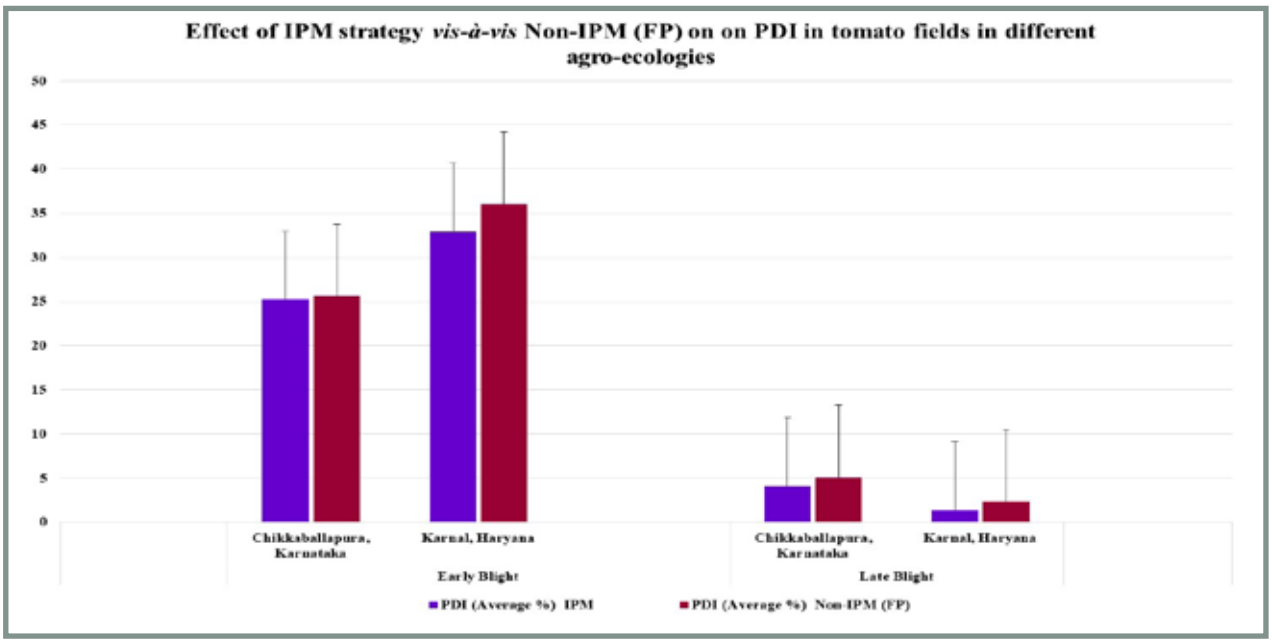
- Coccinellids: increased by 87.5% (Karnataka) and 44.4% (Haryana).
- Chrysopid: increased by 75% at both locations.
- Predatory spiders: by 36.66% (Karnataka) and 66.66% (Haryana).





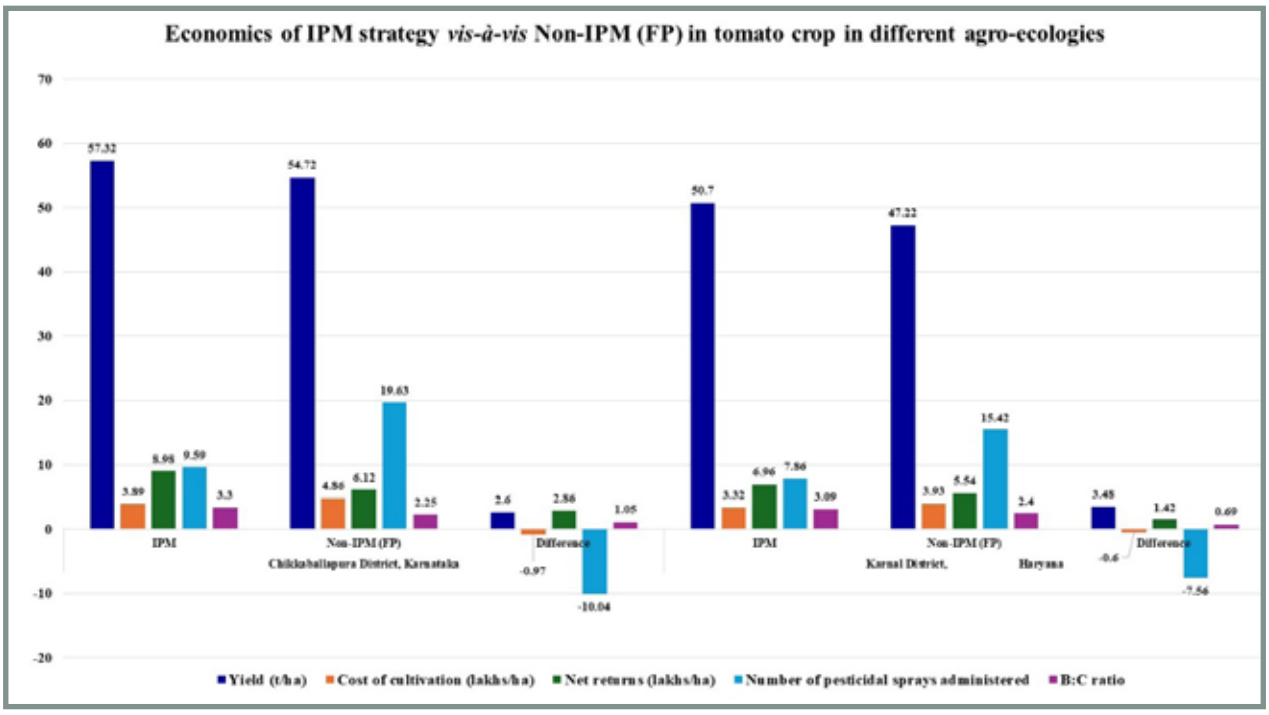
Disease Management: The implementation of IPM resulted in a measurable reduction in epidemic development for both Early Blight (EB) and Late Blight (LB). Key epidemiological parameters were lower in IPM plots viz. EB AUDPC decreased in Karnataka (3139.29 vs. 3200.96) and Haryana (3644.43 vs. 3996.79). For LB, IPM achieved a lower average PDI (1.42% vs. 2.34%) and a substantially reduced AUDPC (141.23 vs. 240.69) in Haryana, confirming enhanced disease suppression, preserving more healthy foliage.

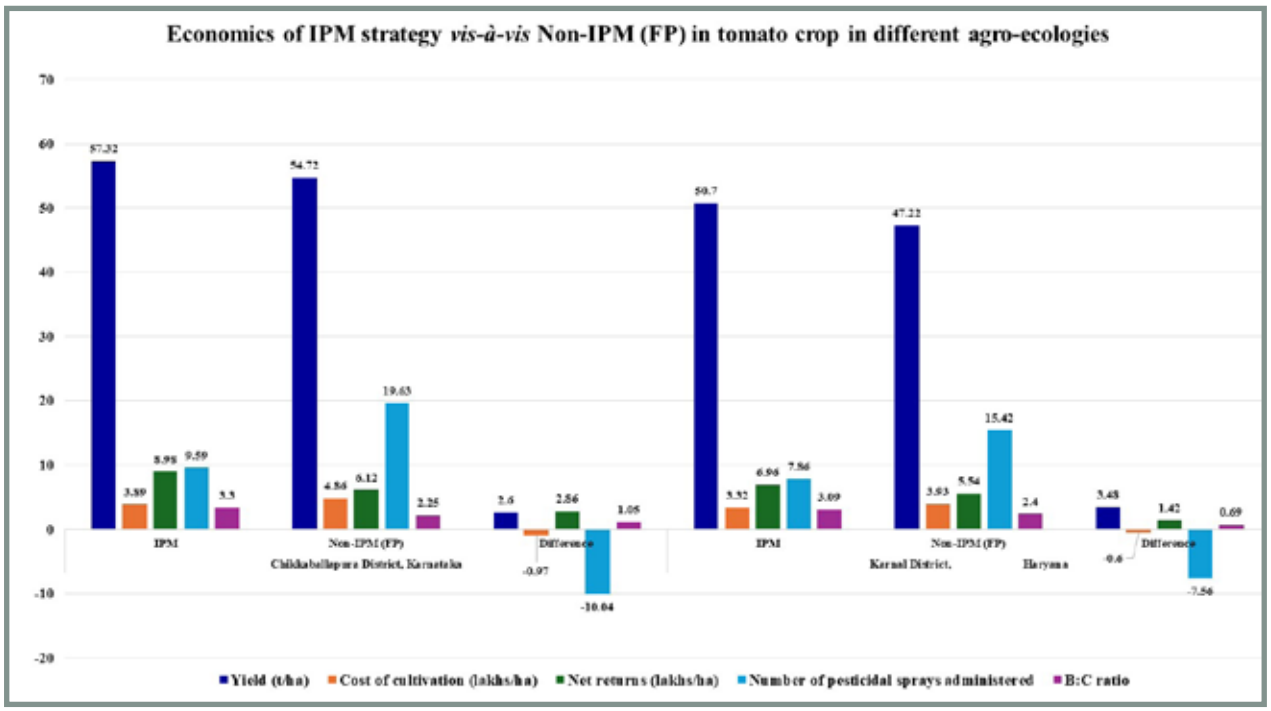




Yield Boost: Despite using far fewer chemicals, IPM fields produced higher yields - an increase of 4.75% in Karnataka (57.32 t/ha) and 7.36% in Haryana (50.70 t/ha). A staggering ~50% reduction in pesticide sprays (from ~19 sprays to ~9) led to a 15.52–19.95% reduction in overall cost of cultivation.

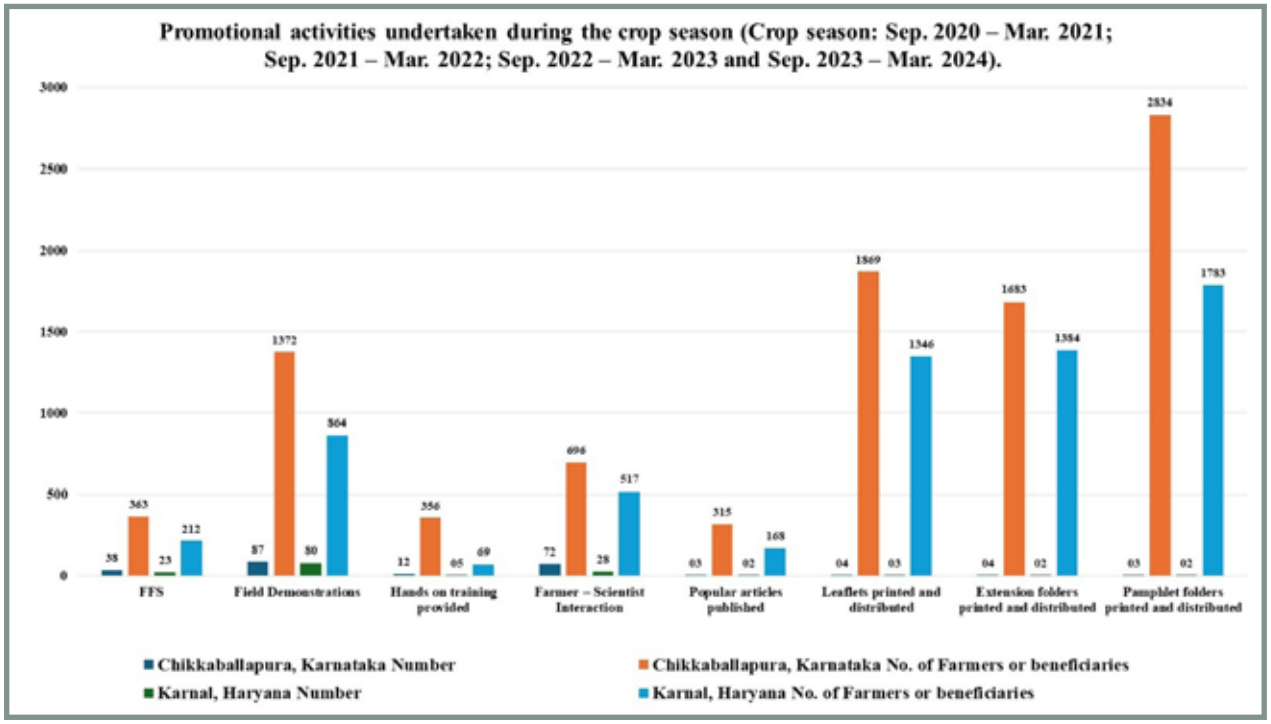
Enhanced Profitability: The Benefit-Cost (B:C) ratio told the ultimate success story. IPM farmers achieved a B:C of 3.30:1 in Karnataka and 3.09:1 in Haryana, compared to 2.25:1 and 2.40:1 in FP fields in these locations. This meant ₹1.05 and ₹0.69 more profit per rupee invested than their conventional counterparts.

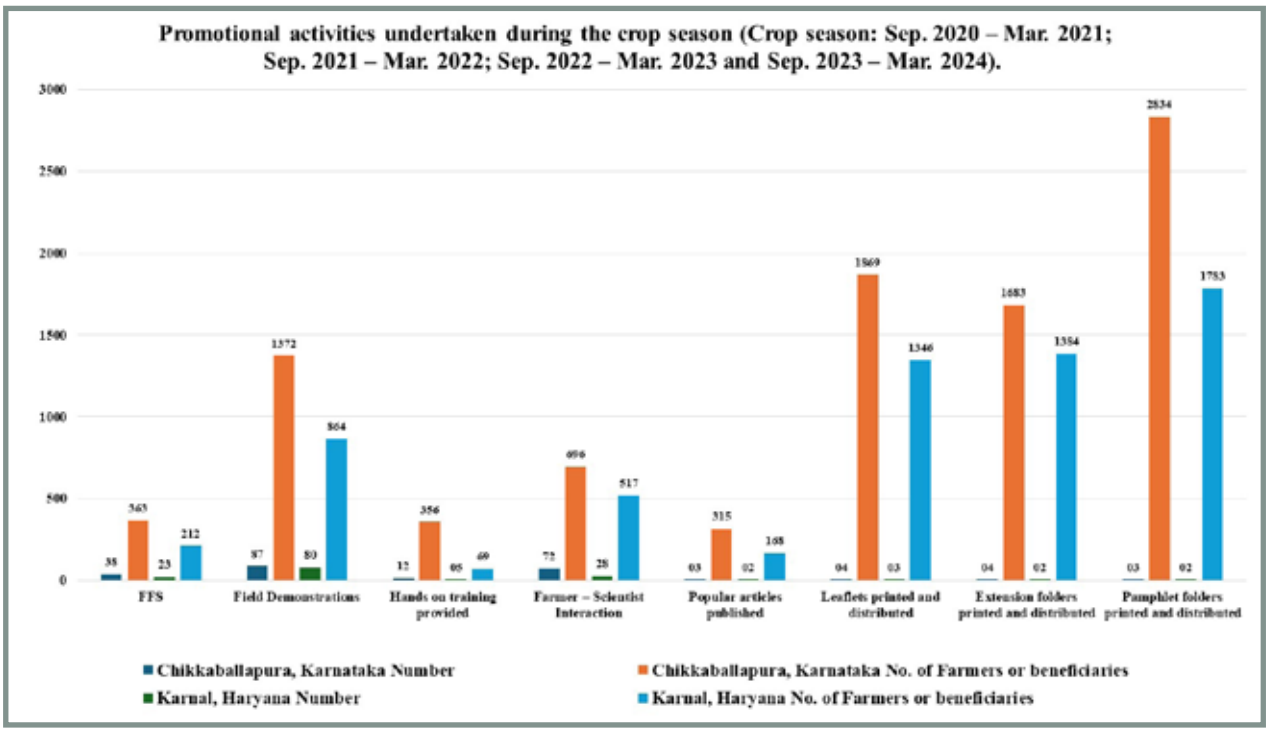




The success transcended Tomato cultivation. ICAR-NRIIPM built a grassroots movement for change:

- **Farmer as Innovator:** Through 61 Farmers' Field Schools (FFS), 167 field demonstrations, and >25 training sessions, over 2,200 farmers became confident IPM practitioners.
- **Knowledge as Input:** Over 1,800 mobile advisories, 2,500 pamphlets, and direct Farmer -Scientist interactions ensured continuous support.
- **Scalable Adoption:** The model was successfully adopted across 300+ hectares, proving its scalability and adaptability.





The Ripple Effect: Towards 'One Health'

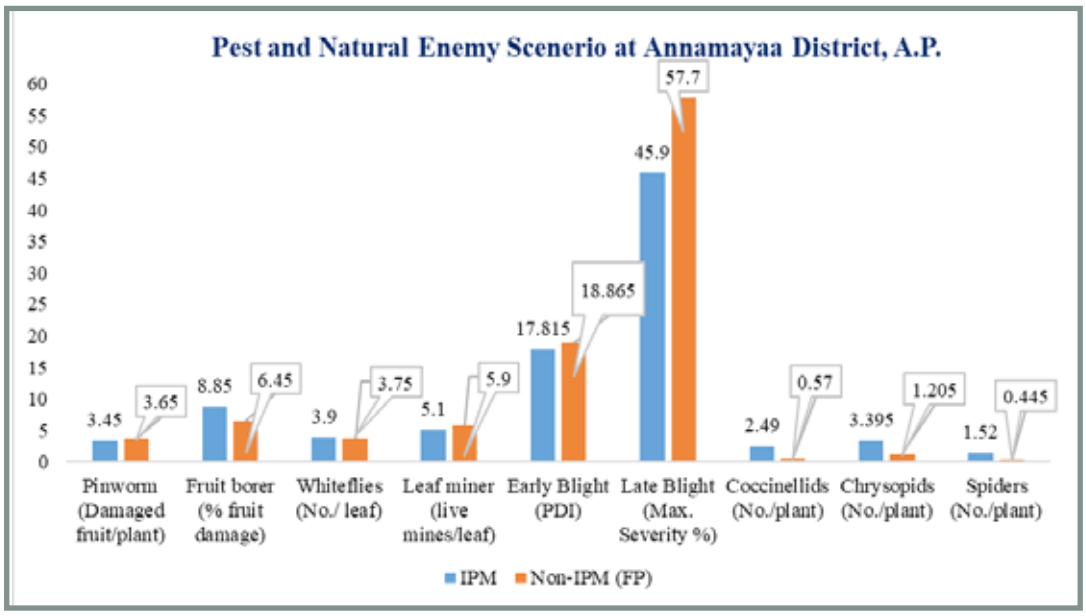
This IPM initiative is a living model of the 'One Health' approach. By drastically cutting chemical pesticides, it:

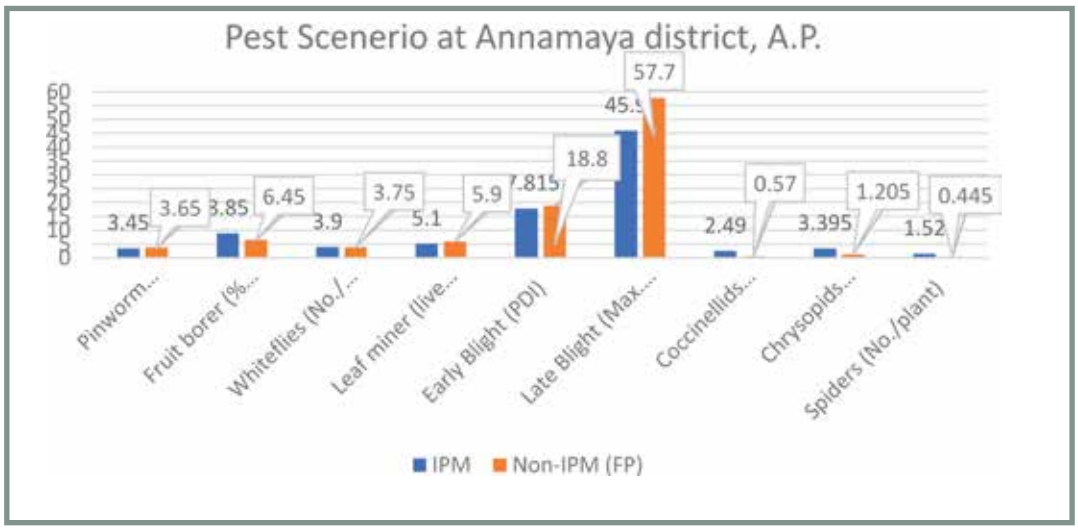
- Protects Consumer Health by reducing residues in food.
- Safeguards Farmer Health by minimizing exposure to toxic chemicals.
- Revitalizes Environmental Health by conserving soil, water, and biodiversity.
- Promotes Animal Health by protecting pollinators and other non-target organisms.

The IPM modules developed and validated at Karnataka was further Validated under Farmer Participatory approach at Annamayya District, A.P. in collaboration with KVK, Kalikiri, ANGRAU and location specific module validated at Karnal, Haryana was disseminated under wide area approach at Bulandshahr District, Uttar Pradesh in collaboration with KVK Bulandshahr, U.P. during 2023-24 and 2024-25.

Pest scenario at Annamaya District, AP in comparison to farmers' practice following the IPM intervention:

It was observed that pest pressure reduced and yield of IPM fields improved. Further, IPM fields were ecologically rich and population of beneficial insects was more in IPM fields. During these field trials, series of farmers training and outreach activities were conducted at KVK Annamayya District, A.P. in collaboration with KVK, Kalikiri, ANGRAU.





***Pooled data of two years trials**

At Bulandshahr District, U.P., wide area promotion of IPM technology in tomato was carried out in 20 ha at Jahidpur Kalan, Firozpur and Ramgarhi villages under Farmer Participatory Approach. Critical IPM inputs were distributed to selected IPM farmers during Farmers Field Schools held during the crop season. Nine Farmer Field Schools were conducted to create awareness regarding IPM interventions to be followed during the crop season to the tomato farmers. Further, series of demonstration for on farm mass multiplication of *Trichoderma*, installation of IPM inputs like sticky traps, pheromone traps, Chrysopa cards etc. conducted with active collaboration of KVK, Bulandshahr. With the help of Whats' App group, regular advisories were sent to the tomato farmers regarding crop stage wise IPM interventions. Critical IPM inputs like talc formulation of *Trichoderma asperellum* (NRIIPM-T44), sticky and pheromone traps and neem oil were provided to the selected IPM farmers for wide area promotion of IPM in Tomato. Pesticide residue analysis of tomato samples collected from IPM, FP and untreated control fields of Bulandshahr was carried out at ICAR-AINP (Pesticide residue), New Delhi. Results revealed that, samples collected from IPM and untreated control fields had below detectable limits levels (BDL) of pesticides while tomatoes grown under FP contained residues of azoxystrobin (0.061 - 0.121 mg/kg), difenconazole (0.027 - 0.063 mg/kg), diafenthiuron (0.032 - 0.069 mg/kg) and dimethomorph (0.047 - 0.139 mg/kg).

The “Tomato IPM Success Story” from Karnataka and Haryana is more than a local achievement; it’s a blueprint for sustainable horticulture. It demonstrates that productivity and ecological health are not opposing goals but can be synergistically achieved through science, participation, and commitment.

ICAR-NRIIPM is now poised to replicate this holistic model (Fig. 2) across other crops and geographies, championing a future where Indian agriculture is not only productive and profitable but also regenerative, safe, and resilient - a testament to the power of integrated, intelligent pest management.

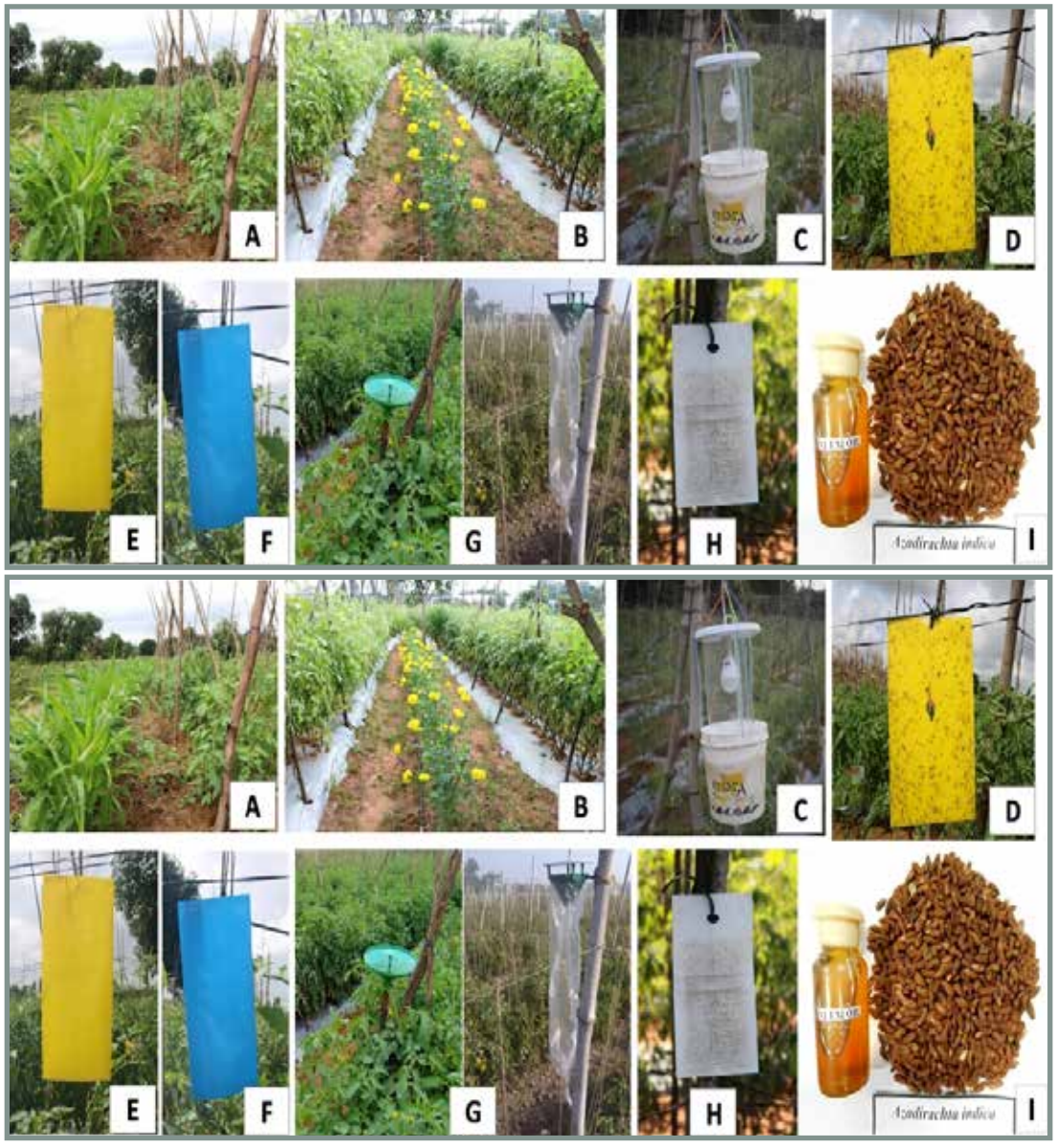


Fig. 3 Non-chemical IPM interventions for pest management in tomato: (A) Maize as border crop; (B) Marigold as trap crop; (C) Indigenous Light trap; (D) Sticky trap with pheromone lure; (E) Yellow sticky trap; (F) Blue sticky trap; (G) Pheromone traps; (H) Tricho card; (I) Neem oil








ICAR - KRISHI VIGYAN KENDRA, CHINTAMANI






NCIPM/T-44
(Trichoderma asperellum)






GPS Map Camera
Jahidpur Kalan, Uttar Pradesh, India
5qq4+qxf, Mdr 70w, Jahidpur Kalan, Uttar Pradesh 203132, India
Lat 28.189521° Long 77.756983°
31/07/2025 02:00 PM GMT +05:30
Google

IPM Techniques for Management of Major Pests of Mango



Devaramane Raghavendra and PN Meena

ICAR-National Research Institute for Integrated Pest Management, New Delhi

Mango (*Mangifera indica* L.) is very important commercial fruit crop in the world and choicest fruit of sub-continent and considered as king of all fruits. India contributes major share with 50% of worlds mango production (22 MT) with covering an area of 2.5M ha (NHB, 2023-24). The major mango growing states in India are Andhra Pradesh, West Bengal, Karnataka, Kerala, Bihar, Uttar Pradesh, UttarakhandUttarkhand, Maharashtra, Punjab and Haryana. Production of mango is enormously handicapped by various insect pests and diseases from seedling to maturity stage. The mango crop is attacked by about 492 species of insect pests and 285 pathogens, 17 species of mites and 26 species of nematodes in the world level. Of these, 188 species have been reported from India. Important and most destructive pests include, mango hopper, fruitfly, stone weevil, stem borer, thrips, leaf webber etc and among diseases powdery mildew, anthracnose, dieback, sooty mould etc. are of great economic importance and cause huge loss in mango production.

A survey was conducted before initiating the project at two different geographical regions of the country (Chikkaballapura, Karnataka and Meerut, Uttar Pradesh) in collaboration with KVK & College of Sericulture UAS, Bengaluru and SVPUAT, Meerut during October, 2020. The baseline information consists of name of village, area of mango cultivation, variety grown, total population and major constraints in mango crop etc. Mango hopper, fruitfly, leaf webber, stone weevil, stem borer, thrips, powdery mildew, anthracnose, dieback, sooty mould were important pests observed. Apart from insect pests and diseases, we also come across natural enemies *viz*., coccinellids, chyrsoperla, spiders and reduvid bug which play major role in checking the pest population. Also baseline information on varieties cultivated (Mallika, Totapuri-Chintamani, Dasheri, Gulab jamun, Chausa-Meerut), type of pesticides applied for management of major pests of mango, rate of application, cocktail pesticides if any, economics involved in the management of pests of mango was collected.

IPM module

An IPM module was synthesized for validation and further disseminated in wide area as per below details:

S. No.	Interventions	Against pests
1	Pruning of overcrowded branches, pruning of malformed flowers & paste with Bordeaux mixture, mechanical removal of leaf webber nests and burning, raking soil around tree trunk & ploughing operations, flooding orchard & alkathene stem banding	Leaf hoppers, Anthracnose, Leaf webbers, Fruit fly & Mealy bug
2	Installation of yellow sticky traps (5/acre)	Leaf hoppers
3	Use of Arka borer control & Installation of Light traps (Black bulb) or 250 wt bulb)	Stem borer
4	Installation of fruit fly traps (methyl eugenol) @ 20 traps/ha & bait splash on tree trunk	Fruit fly
5	Neem oil (5ml/lit) & azadirachtin 1% (3 ml/lit)	Thrips and leaf hoppers
6	Need based spray with sulphur 80% WP (2g/lit) or hexaconazole 5% EC (1 ml/lit) or azoxystrobin 23 % SC (1ml/lit) and	Powdery mildew, anthracnose
7	Need based Spray with lambda cyhalothrin 05% EC (0.5-1 ml/lit) or buprofezin 25% SC(1-2 ml/lit) and tolfenpyrad 15% EC (0.5 ml/lit)	leaf hoppers and Thrips

IPM module for major pests of mango at Chintamani, Karnataka

The experiment was implemented and validated in farmers participatory mode in 5 villages at Chintamani, Karnataka covering 16 ha. Different Integrated Pest Management (IPM) strategies were validated against important pests of mango *viz*; leaf hopper, thrips, leaf webber, stem borer, powdery mildew, anthracnose and sooty mould. Two orchards of IPM and two farmer practice from every village were selected for recording weekly pests' observations. Besides, control plants were also maintained in orchard for comparison with IPM and farmer practice at each location.

The population dynamics of leaf hopper was recorded for three consecutive years. The pooled mean of three years data revealed that, mean population of hoppers was lowest in IPM (2.99/ panicle) followed by farmers' practice (FP) (6.69/panicle) and highest in untreated control (10.57/ panicle). Reduction of hopper population in IPM over untreated control and FP was 71.71% & 55.3%, respectively. According to meteorological data, hoppers appeared throughout the year but peak population of hoppers was observed during 44-52th SMW. The population of hopper was below the economic threshold level in IPM whereas it crossed ETL in both untreated control and FP. Similarly, thrips also appeared from 40-52 &1-18 SMW of three consecutive years (2021-2023).

Highest population of thrips was observed in untreated control (3.54/tap) followed by FP (2.14/tap) whereas, IPM plot recorded lowest population (1.02) which is below ETL. There was 71.18 & 52.33% reduction was observed in IPM against untreated control and FP, respectively. Peak population of thrips was observed during 1-12 SMW. Leaf webber population started appearing during April and symptoms of web started appearing during July-August. IPM recorded lowest no. of webs per direction (2.27 webs/direction) followed by FP (5.21 webs/direction) and highest in untreated control (8.70 webs/direction). Reduction of 73.90 & 56.42 % was noticed in IPM compared to untreated control and FP respectively. Fruit fly population was also recorded using methyl eugenol traps from 1-22 SMW i.e., from beginning of flower to till harvest of the crop. An average of 40.12/flies/trap/week was observed from 2021 to 2023.

Population dynamics of coccinellid population was highest in untreated control (2.51/ m^2) followed by IPM plots (1.75/ m^2) and lowest was in FP (1.17/ m^2). Other natural enemies like, chrysoperla and spider has highest population in untreated control followed by IPM and lowest in FP. Among the diseases, powdery mildew severity (%) was highest in untreated control (19.13%) followed by FP (14.41%) whereas, lowest severity was observed in IPM (3.44%) during 2021-23. There was a reduction of 82.01 & 76.12% observed in IPM against untreated control and FP, respectively. Similarly, for sooty mould disease, highest pooled mean severity was observed in untreated control (15.19%) followed by FP (5.59%) and lowest in IPM (1.77%).

Socio-economic impact of IPM strategies

Economics of mango (var. Totapuri) were calculated considering various yield and other parameters. The average number of chemical sprays was 4.23 in IPM compared to 8.60 in farmer practice while no chemical spray was taken up in untreated control. There was 50.81% chemical sprays were reduced in IPM over FP for control of various pests. There was reduction of 9.81% total cost of cultivation in IPM compared to farmer practice. Highest average yield was recorded in IPM plots with 24.58 tons/ha, followed by FP with 20.46 tons/ha and lowest yield was in untreated control 13.31 tons/ha. The elevated yield of 16.76% & 45.85% in IPM over FP and untreated control respectively. Highest benefit cost ratio was also highest in IPM (2.72) compared to farmer practice (1.61) and control (0.99) respectively. Highest yield and other economic parameters were highest in IPM due to effective IPM techniques intervention at right time against key pests of mango crop.

IPM module for major pests of mango at Meerut, Uttar Pradesh

The experiment was implemented and validated in farmers participatory mode in 5 villages at Meerut, Uttar Pradesh covering 16 ha. The mean of three years data revealed that, population of hoppers was lowest in IPM (5.14/panicle) followed by farmer practice (10.27/panicle) and highest was in untreated control (11.25/panicle). There was reduction of 54.31 & 49.95% in IPM against untreated control and FP, respectively. The population of hopper was below or near the economic threshold level in IPM whereas it crossed ETL in both untreated control and FP. the highest population of thrips was observed in untreated control (11.91/tap) followed by FP (7.27/tap) whereas, IPM plot recorded lowest population (1.12/tap) which is below ETL. Per cent reduction of 90.59 & 84.59% was observed in IPM plots over untreated control and FP, respectively. Peak population of thrips was observed during 1-12 SMW. Leaf webber population started appearing during April and symptoms of web started appearing during July-August. The pooled mean population was

also highest in untreated control>FP>IPM. Fruit fly population was also recorded using methyl eugenol traps from 1-22 SMW i.e., from beginning of flower to till harvest of the crop. An average of 194.44/flies/trap/week was observed from 2021 to 2023.

Among coccinellids, highest no. of population/ m^2 was recorded in untreated control (3.50/ m^2) followed by IPM plots (1.94/m^2). Lowest was in (1.47/ m^2). Other natural enemies like, chrysoperla and spider has highest population in untreated control followed by IPM and lowest in FP. Among the diseases, powdery mildew severity (%) was highest in untreated control (20.34%) followed by FP (16.11%) whereas lowest severity was observed in IPM (4.20%) during 2021-23. Reduction of powdery mildew disease 79.35 & 73.92% over untreated control and FP, respectively. Similarly, for sooty mould disease, highest pooled mean severity was observed in untreated control (16.78%) followed by FP (5.55%) and lowest in IPM (2.51%).

Socio-economic impact of IPM strategies

Yield parameters and economics of mango (var. Dasheri) showed that, the average number of chemical sprays were 4.26 in IPM compared to 9.43 in (FP) while no chemical spray was taken up in untreated control. Reduction of 54.82% chemical sprays was observed in IPM over FP. Reduced cost of 7.81% was observed in IPM compared to FP. Highest average yield was recorded in IPM plots (9.79 tons/ha), followed by FP with 8.03 tons/ha and lowest yield was in untreated control 6.18 tons/ha. An increased yield of 17.97 & 36.87% was noticed in IPM over FP and untreated control, respectively. Benefit cost ratio was also highest in IPM (2.93) compared to FP (1.66) and least in untreated control (1.78), respectively. Timely intervention of IPM strategies are responsible for highyield and other economic parameters in IPM against key pests of mango crop.

Socioeconomic studies of IPM technologies in mango crop was carried out in five selected villages covering 16 farmers each at two locations (Chintamani, Karnataka & Meerut, UP). Various parameters were used to know the IPM impact on mango farmers. It was found that cent percent farmers have knowledge on IPM, minimizing the numbers of sprays, all technical information related to IPM, usefulness and economics of IPM, different components of IPM like, use of pheromone traps, yellow, blue sticky traps, neem oil, *Trichoderma*, *Pseudomonas*, *Bacillus*, awareness on environmental pollution, contamination of air, water, soil by pesticides and their adverse effect on beneficial insects, pesticides spraying methods, safety issues and intercropping. Likewise, 80% farmer know about economic threshold limit of pests and 80.58% farmers have identification ability of natural enemies. However, 23.5% farmers still depend on local pesticide dealer advisories. The income of mango farmers increased by 10-20% after adoption of IPM technology.

Dissemination of IPM technology

The IPM module developed, refined and validated in farmers field were disseminated in large area covering around 65 ha in each location (Chintamani, Karnataka & Meerut UP area). Which includes various villages covering more than 100 mango growing farmers. The awareness on IPM was created among farmers, which includes use of cultural, mechanical

and biological control agents for sustainable pest management, conducting various trainings, FFS, field days and distribution of IPM related literature.









Integrated Pest Management in Kinnow Mandarin



PN Meena and Devaramane Raghavendra

ICAR-National Research Institute for Integrated Pest Management, New Delhi

Citrus is one of the most relevant fruit crops cultivated in sub-tropical, tropical, and temperate regions across the globe. It is second most produced fruit worldwide with cultivated area of more than 10.2 million hectares with the production of 161.8 million tonnes. Citrus play a vital role in the fruit economy of the country, next to mango and banana. India is the home of many citrus fruits, and their cultivated area is spread over more than 109.6 million hectares with a production of 14.25 million tonnes. India ranks fourth among the top citrus-producing countries in the world. In India, citrus is primarily grown in Assam, Andhra Pradesh, Maharashtra, Punjab, Haryana, Karnataka, UttarakhandUttaranchal, Bihar, Orissa and Gujarat states. Among the citrus fruits, mandarin also known as Kinnow is the most valuable fruit crop that is mostly grown in Haryana, Punjab, and Rajasthan states. The cultivated area under citrus fruits in Haryana is 25.17 thousand hectares with a production of 359.08 thousand million tonnes in which Kinnow mandarin occupied 90% in both area and production. Kinnow mandarin has superseded the other oranges in terms of its high yield, good quality fruits, prolific bearing, high juice content, and more sweetness. The productivity and fruit quality of citrus fruits are adversely influenced by multiple factors, among which pest incidence plays a major role. More than 250 insect pests arereportedarre reported to attack citrus in India. Asian citrus psyllid, (*Diaphorina citri* (Kuwayama)),), whitefly, *Dialoeurodes citri* (Ashmead), Leaf miner (*Phyllocnistis citrella*), Thrips (*Scirtothrips citri*), dieback, *Colletotrichum gloeosporioides*, Gummosis (*Phytophthora nicotianae*) and sooty mould, *Capnodium citri*, are major threats to Kinnow mandarin which cause economic losses from nursery to harvesting. Baseline surveys of Kinnow growing areas by ICAR-National Research Institute for Integrated Pest Management, New Delhi revealed injudicious use of chemical pesticides and fertilizers by farmers that aggravated the pest menace, residue problems in fruits, soil & water contamination, reduction in population of natural enemies & beneficial soil microorganism, and lack of awareness of identification of major pests and their natural enemies. In this context, an interdisciplinary team from ICAR-NRIIPM with the collaboration of KVK, Sadalpur, CCSHAU, Haryana, developed IPM practices to address these problems holistically. IPM strategies were validated and disseminated in Kinnow mandarin areas at village level in Hisar, Haryana.

Validation of IPM module

IPM validation trial was initiated in Kisangarh village in farmer's participatory mode in 10 ha area covering 10 farmers in 2021. The selection of village was based on pests load in Kinnow orchards, excessive use of chemical pesticides (carbendazim, imidacloprid, ethion, beta-Cyfluthrin + imidacloprid) to an extant of 8-12 sprays for reduction of pests, lack of awareness about IPM practices and identification of pests and their natural enemies. The area was extended upto 25 ha in village Daroli covering 25 farmers in 2022 and then 65 ha areas in Sadalpur, Chuli and Khara barwala villages covering 45 farmers in 2023, respectively. Different Integrated Pest Management (IPM) strategies *viz*; deep summer ploughing; pruning the excess branches and bottom leaves of the tree for proper ventilation; destruction of rotten and dropped infected fruits; regular monitoring of orchard to assess the damage and severity of pests; Installation of yellow sticky traps @ 20/ha followed by a need-based spray of neem seed kernel extract (NSKE) @ 5% on young leaves and if pest population exceeded above ETL then applied need-based spray of label claim imidacloprid 17.8SL @ 200ml in 500 litres of water or thiamethoxam 25% WG in 50g/500 litres water to manage psylla and whitefly; spray of 1% starch against sooty mould disease during August, September and October months and dipping sooty mould infected fruits in a bleaching solution @ 0.1%; pruning and destruction of dieback infected dead twigs in the month of March and July followed by spray of copper oxychloride 50 WP @ 3 g/l were validated in IPM fields. In farmers' practice (FP), farmers used only FYM (100kg) and urea (700g/plant) and not practiced IPM techniques. Injudiciously they used 8-12 sprays of pesticides such as copper oxychloride 50 WP @ 3g/l (dieback); cymoxanil 8% + mancozeb 64% WP @ 1.5g/l (sooty mould); carbendazim 50 WP @ 2g/l (dieback); imidacloprid 17.8SL @ 2ml/l (whitefly); ethion 50 EC @ 1ml/l (whitefly); beta-Cyfluthrin + imidacloprid 300 OD (8.49 + 19.81 % w/w) @ 1ml/l (psylla and whitefly); lambda cyhalothrin 2.5% EC @ 1.5ml/l (psylla); chlorpyrifos 20 % EC @ 2ml/l (psylla); diafenthiuron 50% WP @ 1g/l; quinalphos 25% EC@ 2ml/l and chlorantraniliprole 18.5% w/w@ 1.5ml/l (psylla and whitefly); farmers mostly depend on local pesticide dealer for advice and used higher than the recommended dose of pesticides.

During validation of IPM approaches, farmers were advised to use farm yard manure (FYM) (80 kg), urea (500g/plant), single super phosphate (2 kg/plant) and muriate of potash (1.75kg/plant) minerals like manganese, copper, sulphur, boron, zinc as per age and phenological? stage of plant. To improve fruit size and increase yield in Kinnow mandarin, farmers were also made aware to apply three foliar sprays of 1.0% potassium nitrate (10 g/litre) at the end of May, June and July. The drip irrigation method along with intercropping with sunflower, marigold, chickpea, garlic and onion were also suggested to enhance the population of natural enemies.

Effect of IPM on major pests and their natural enemies

The populations of psylla in IPM, FP, and control treatment was recorded from 11th -52nd standard metrological weeks (SMW) and lowest population of psylla (6.11±0.63, 4.14±0·28 and 4·21±0·29 nymphs and adults/10cm shoot) occurred in IPM compared to FP (9.35±0·77, 5.29±0·30 and 5·37±0·32 nymphs and adults/10cm shoot) and control (10.86±0·88, 6.10±0·30 and 6·19±0·31 nymphs and adults/10 cm shoot) during 2021, 2022 and 2023, respectively· Highest reduction in psylla population over the control was also observed in IPM (37·49%) compared to FP (13.48%). The psylla appeared during 11th SMW in IPM (2.33±0.63/shoot) FP (3.55±1.10/shoot) and control (5.03±1.77/shoot) and reached peak in 17th SMW (9.43±1.43, 12.97±1.55 and 14.50±2.12/

shoot), thereafter its population declined. Similarly, the lowest population of whitefly (3.81±0.36, 2.22±0.25 and 2.36±0.21 nymphs and adults/leaf) was noticed in IPM compared to FP (5.24±0.33, 3.17±0.27 and 3.26±0.20 nymphs and adults/leaf) and control (6.57±0.38, 3.98±0.29 and 4.12±0.21 nymphs and adults/leaf), respectively. The highest reduction of the whitefly population (42.86%) was observed in IPM followed by farmer practice (20.61%). The highest disease severity of sooty mould was recorded in control (12.41±0.53, 11.04±0.37 and 10.39±0.30%) followed by FP (9.60±0.31, 9.35±0.37 and 8.96±0.35%) and in IPM (7.62±0.33, 7.42±0.31and 7.20±0.28%). Likewise, the highest reduction in sooty mould severity was also recorded in IPM (34.30%) in comparison to farmer practice (17.46%). As well, highest reduction of sooty mould incidence over control was also seen in IPM (62.06%) compared to FP (18.12%). Highest disease severity of sooty mould was reached at peak in 43rd SMW (10.38±1.03, 12.45±1.27 and 12.78±1.16%). In case of dieback, minimum disease severity was recorded in IPM (10.94±0.45, 9.72±0.39 and 9.39±0.37%) while higher severity was observed in FP (13.14±0.40, 11.75±0.41 and 11.44±0.37%) and control (15.21±0.52, 13.44±0.44 and 13.08±0.40%) plots. In similar way, the highest reduction of dieback severity over control was recorded in IPM (28.03%) compared to farmer practice (12.94%). The dieback severity appeared in 11th SMW (4.60±0.53, 6.17±0.66 and 6.70±0.83%) in IPM, FP and control; Thereafter, it increased and reached peak during the 19th SMW (12.75 ± 1.27%, 16.25 ± 1.69%, and 18.70 ± 1.86%) and again during the 41st SMW (13.29 ± 1.33%, 14.85 ± 1.41%, and 16.25 ± 1.69%), before declining steadily until the 52nd SMW.

The populations of natural enemies were higher in IPM compared to farmer practice. The average highest populations of coccinellid (1.57/m^2), *Chrysoperla* (1.21m^2) and spider (2.19 m^2) were recorded in control followed by (1.02, 0.80 and 1.60/m^2) in IPM and (0.47, 0.36 and 0.91/m^2) in farmer practice. The first appearance of coccinellid populations dynamics was noticed in the month of March (11th SMW) and it persisted until 52nd SMW in the range of 0.69 to 2.67/m^2 in control, 0.67 to 1.52/m^2 in IPM and 0.08 to 0.90/m^2 in farmer practice. Likewise, *Chrysoperla* was observed in the range of 0.82 to 1.63/m^2 in control, 0.40 to 1.27/m^2 in IPM and 0.00 to 0.70/m^2 in farmer practice. Population dynamics of the spider were also recorded from 11th SMW to 52nd SMW in the range of 0.92 to 3.90/m^2 in control, followed by 0.67 to 2.89/m^2 in IPM and 0.29 to 1.65/m^2 in farmer practice, respectively.

Impact of IPM on economic parameters

Economics of Kinnow mandarin in IPM, farmer practice and control from 2021-2023 were computed considering various relevant parameters. The average number of chemical sprays was reduced to 4.7 in IPM compared to 11 in farmer practice. The total cost of plant protection alone in IPM was less (Rs.19555/ha) compared to farmer practice (Rs. 30909/ha). Similarly, the average total cost of cultivation in IPM was lower (Rs.135708/ha) compared to farmer practice (Rs.148125/ha) and control (Rs.128250/ha), respectively. The highest fruit drop was noticed in control (88.56%) followed by farmer practice (75.57%) compared to IPM (69.07%) Highest average no. of fruits/tree, average fruit weight (g) and average fruit yield (kg/tree), respectively were also recorded in IPM (357, 230 & 82) compared to farmer practice (336.67, 204.33 & 68.67) and control (194.33, 139.67 & 27). Lower average fruit yield (7.42 tons/ha) was recorded in control and farmer practice (18.88 tons/ha) compared to IPM (22.46 tons/ha). The highest fruit yield loss caused by psylla, whitefly, sooty mould and dieback was recorded in control (66.96%) compared to farmer practice (15.94). Similarly, the maximum increase in fruit yield (ton/ha) over control and increase

in fruit yield (ton/ha) over farmer practice, respectively (15.04% & 31.19%) was also found in IPM. Similarly, the highest average net income was also noticed in IPM (Rs.518436/ha) compared to farmer practice (Rs.387366/ha) and control (Rs. 94450/ha). Additional net profit due to increase in fruit yield over control, additional net profit due to increase in fruit yield over farmer practice, and additional profit due to reducing no. of spray were also higher (Rs.423986/ha, Rs.131070/ha & Rs.11354/ha) in IPM compared to control. Overall, the IPM increased the net profit of Rs. 529790/ha compared to farmer practice and control. IPM implementation significantly reduced the number of pesticide sprays (57.27%) and increased the average kinnow yield (15.93%) against the farmer's practice (FP). The number of natural enemies' population was more in IPM compared to FP orchards due to the adoption of ecological engineering. No pesticide residue was detected in IPM orchard fruits, while acephate, imidacloprid and tebuconazole were detected in farmer practice. In terms of benefit-cost ratio, the highest benefit-cost ratio was recorded in IPM (4.34) compared to farmer practice (3.16) and control (1.73), respectively. The IPM technology was well adopted by the farmers, which resulted in the wide area dissemination among the farmers in cluster villages covering >100 ha in 2024-25. Besides, Farmer's field school (FFS), *Kisan ghosti*, Kinnow day and awareness programmes were organised at 15–30 days interval in adopted villages during each crop season for the dissemination of integrated pest management strategies. FFS included the training on identification of insect pests, diseases and beneficial, Economic Threshold Level (ETL) concept, use of bio pesticides and bio agents and management tactics including safer pesticides. About 45 farmers were trained through FFS, trainings, scientist-farmers interaction and 150 farmers were made aware about the IPM technology through Kinnow field days.

Socio-economic studies and impact analysis

Socio-economic studies and impact analysis of IPM technologies used in kinnow was carried out in five selected villages covering 17 farmers at Hisar, Haryana. Various impact analysis parameters were used to determine the IPM impact on kinnow farmers. It was found that cent percent farmers know IPM, minimizing the number of sprays, all technical information related to IPM, usefulness and economics of IPM, different components of IPM, use of pheromone traps, yellow, blue sticky traps, neem oil, *Trichoderma*, *Pseudomonas*, *Bacillus*, awareness of contamination of air, water, soil by pesticides and their adverse effect on beneficial insects, pesticides spraying methods, safety issues and intercropping. Likewise, 76.47% farmers know about the economic threshold limit of pests, and 70.58% farmers have identification ability to identify the natural enemies. However, 23.5% farmers still depend on the advice of local dealers. The income of kinnow mandarin farmers increased by 15-20% after the adoption of IPM technology. 11.76% farmers use increased income for repayment of loan, while 76.47% for crop insurance. Similarly, 82.35% farmers used the income for the purchase of spade, kurpi, cultivator, and sprayer. It was also observed that 66.67% farmers purchased buffalo, whereas 29.41% farmers made farm shed for their animals.











Microbial Biogels: Tool for Pest Management in Pulse Crops



Jitendra Singh[1], Ritu Mishra[2], Anoop Kumar[1] and Raman Thangavelu[1]

[1]ICAR-National Research Institute for Integrated Pest Management, New Delhi
[2]Department of Zoology, University of Allahabad, Prayagraj (UP)

The Biogel formulation was developed to overcome the limitations of existing microbial bio-agent formulations. The primary objective of this novel formulation was to enable easy application of beneficial bacteria and fungi for biocontrol and plant growth promoting (PGP) activities along with their easy and efficient mass multiplication for use over large crop areas at minimal input cost. A series of systematic experiments were conducted to optimize formulation, preservation and enhancement of shelf life of promising microbial bio-agents. As a result, a standardized process and protocol were successfully developed for formulating diverse microbial products in gel form, thus, collectively named Biogel.

This preservative-based, readily water-soluble formulation induces a dormant state inof microbial bio-agents, thereby ensuring their extended shelf life. To the best of our knowledge such formulation with these characteristics has neither been reported earlier nor is it currently available in the market. These biogels are concentrated preparations with



Figure 1: Demonstration on process of mass multiplication of microbial bio-agent on Institute foundation day

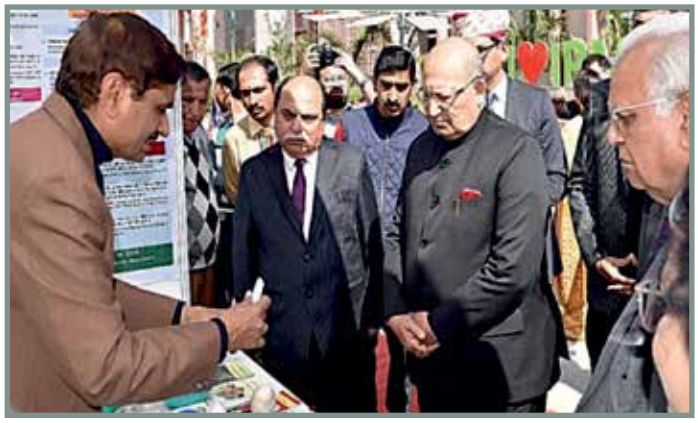


Figure 2: Showcasing of different Biogel and mass multiplication protocols

exceptionally high microbial loads (approximately 10^{18}–10^{20} CFU for bacteria and 10^{12}–10^{15} CFU for fungi). These formulations can be diluted as per requirement for seed treatment, soil application and foliar spray. Further, these can also be effectively utilized for on-farm mass multiplication of bio-agents. The technology is highly user-friendly and adaptable. Due to the extremely high CFU levels, biogels can be diluted up to 10,000 times and still remain superior to conventional liquid and talc-based formulations in terms of viable microbial count. The biogels require minimal storage space and can be conveniently stored under cold storage as well as ambient conditions. Comparative evaluations demonstrated that biogel based microbial formulations exhibited higher efficacy against target crop pests and significantly enhanced PGP activities.

Unlike talc-based formulations, where microbial cells are subjected to stress due to desiccation,and physical disturbance during storage and transportation, microbes in biogels remain embedded in a protective matrix with minimal friction and movement. Consequently, microbial viability and efficacy are maintained for longer durations. Because of their longer shelf life, high CFU content, ease of application, reduced storage requirements and superior performance, biogel-based microbial formulations possess strong commercial potential. Overall, Biogel technology represents a promising and sustainable tool for plant protection and crop productivity enhancement across diverse cropping systems.

Shelf life assay of Biogels

The shelf life of microbial bio-agents was determined based on the survival of colony-forming units (CFUs) per unit volume of the formulation. The formulations were prepared separately following the newly developed protocol. Biogel formulations of *Bacillus thuringiensis* and *Trichoderma asperellum* were stored under ambient conditions in plastic collapsible tubes (50 g capacity). The viable CFU counts of all microbial formulations were recorded at monthly intervals. Shelf-life evaluation was conducted using the direct plate count method from March 2019 to Oct. 2020 (20 months) for *Trichoderma asperellum* and *Bacillus thuringiensis*.

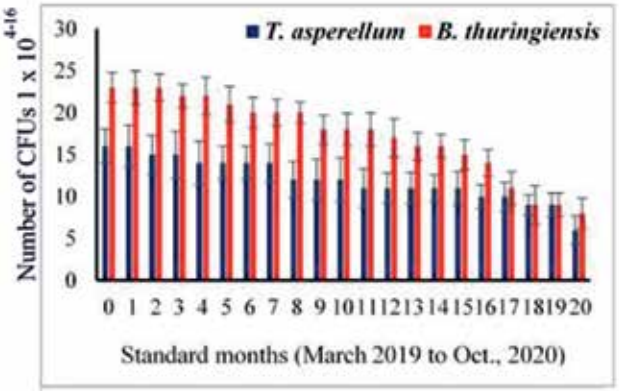
During the first month (March 2019), the initial CFU counts of bacteria (*Bacillus thuringiensis*) in gel formulation were recorded as 1×10^{20} CFUs/g (Fig. 4). The CFU levels in bacterial biogels remained stable for the first three months. A gradual decline in CFU counts was observed from the 4^{th} month onwards. However, the populations stabilized within the range of 10^{15} to 10^{18} CFU g^{-1} up to 9^{th} month. During the 17^{th} to 20^{th} month of storage, the CFU counts in bacterial biogel ranged between 1×10^{8} to 1×10^{10} CFU g^{-1} .

In contrast, the CFU counts of fungal biogel remained constant during the first three months (March–May 2019), recording approximately 1×10^{15}, in *Trichoderma asperellum*. During the 4^{th} month, a slight reduction in CFU counts was observed which declined to approximately 1×10^{14} CFUs g^{-1}. and a similar trend continued up to the 7^{th} month of storage. Subsequently, stable CFUs of *T. asperellum* were remained up to 10^{th} month *viz*., 1×10^{12} g^{-1} Overall, a gradual decline in CFU counts was recorded over the storage period. Based on these observations, it was concluded that the shelf life of *T. asperellum* in biogel formulations could be extended up to 20 months (Fig. 4).

Validation of efficacy of Biogel



Trichogel filled collapsible plastic



Shelf-life of *T. asperellum* reduction in CFUs/g

The validation of gel based products of *T. asperellum* and *B. thuringiensis* under the IPM programme was conducted in the Bundelkhand region (U.P.) in chickpea during rabi 2018-19 to 2020-21. Selected villages were Ragauli, Rura addu and Kukargaon under KVK Jalaun (BUAT) and Chokari, Tejpura and Bilati with KVK Jhansi, for the implementation of IPM strategies. During the 2018–19 cropping season, the IPM programme was validated over an area of 135 ha which was subsequently expanded to 710 ha for large-scale promotion and dissemination of IPM strategies.



Application of Trichogel as seed treatment of chickpea

The disease complexes in chickpea mainly includes collar rot (*Sclerotium rolfsii*), *Fusarium* wilt (*Fusarium oxysporum*), and dry root rot (*Rhizoctonia bataticola*/ *Macrophomina phaseolina*) can cause yield losses of up to 100%. Whereas, pod borer (*Helicoverpa armigera*) was the major insect pest that may reduce yields by up to 24.8%. Chickpea growers in the region had limited awareness of scientific pest management practices and mainly depended on chemical pesticides. Therefore, the programme was aimed to disseminate biological pest management strategies among farmers in the Jalaun and Jhansi districts with the collaboration of KVK Jalaun and KVK Jhansi under Banda University of Agriculture and Technology, Banda (Uttar Pradesh). Emphasizing on biological control initiatives, 1300 tubes Tricho-gel and 1700 tubes of Btgel were distributed among farmers for seed treatment (@) and foliar application (@) against soil borne disease and pod borer management in chickpea crop.

The formulation of T. *asperellum* (Tricho-gel, CFUs ~10^{15}/g) was applied as seed treatments (0.5g/ kg seed) in chickpea for soil borne disease management in a total 52 villages covering a large area under IPM programmes for three consecutive years. Farmer field days (173) were conducted for training and demonstrations of the seed treatment with Tricho-gel for wilt complex and foliar spray of *Bt*-gel for pod borer management in chickpea. Results indicated reduction in incidence of wilt complex, which is a major challenging constraint in chickpea production that may deteriorate crop yield up to 70%. The adopted farmers could achieve successful disease management in chickpea.

Table 1: Insect pest and disease management in chickpea using Tricho-gel and Bt-gel in Bundelkhand region

Year	Wilt Disease complex (%)			Pod damage (%)			B:C ratio	
	IPM	FP	% reduction over FP	IPM	FP	% reduction over FP	IPM	FP
2018-19	7.7±2.5	27.7±4.6	72.2	10.7±3.3	23.0±4.4	53.5	4.45	2.96
2019-20	9.3±2.3	25.0±5.6	62.8	12.7±2.6	22.0±3.6	42.3	4.33	3.23
2020-21	6.7±1.8	22.0±4.3	69.5	8.7±3.0	24.7±4.3	64.8	4.26	3.18
Pooled	7.9±1.3	24.9±2.9	68.2	10.7±2.0	23.2±1.4	53.5	4.35	3.12

Impact on Pest reduction and Economics

Pooled data revealed that IPM recorded 68.2 % reduction in wilt disease complex and 53.5 % reduction pod damage due to *H. armigera* over FP. On an average 7.9% disease incidence of wilt complex was found in IPM fields in chickpea. Whereas, it was 24.9% in FP fields at both the KVKs during 2018-19. The pod damage was 10.7% in IPM and 23.2 % in FP fields.



Tricho-gel showed strong efficacy against wilt complex and Bt-gel against pod borer in chickpea, with high BC ratios (4.35 in IPM, 3.12 in FP). Their inclusion in IPM strategies can cut chemical pesticide use by nearly 80% in adopted fields.

A successful pest management could be achieved using the bio-agents in the form of gel formulation. Farmers could get a handsome return with the minimum input cost. Since then we have delivered several trainings and demonstrations for on-farm mass production.

Innovative IPM Tools



Surender Kumar Singh

ICAR-National Research Institute for Integrated Pest Management, New Delhi

Integrated pest management (IPM) emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. The traditional pest control philosophy has undergone a radical change in the light of the limitations of chemical pesticides, their environmental hazards and other devastating side effects. Indiscriminate application of chemical pesticides has several side effects which may lead to pollution of air, water, soil, food and feed and mortality of fauna. The implementation of location-specific eco-friendly Integrated Pest Management (IPM) technology can minimize this problem. While implementing IPM prog. in different ecological zones, the farmers face the problem of shortage of IPM inputs. The IPM inputs producing firms/industries/entrepreneurs also feel bottle-necks in mass-production of IPM inputs due to inheritance problems of manufacturing, lack of precision, limited automation, mass-multiplication of predators, parasitoids in desired number/quantity, its handling, storage, transport, high cost, etc. The automation process and low-cost IPM inputs are the key requirement of the time as insect-pests of various kinds are taking a heavy toll of crops. To meet these requirements, conceptualization, designing, development, fabrication, standardization and validation of new and innovative IPM tools, traps and techniques has been done at ICAR-NRIIPM, New Delhi; the details provided below:

Light trap safer to beneficial insect

Light traps are the most widely used visual traps for the agricultural insect pests, and have been particularly important in surveillance programme and monitoring of the seasonal appearance of many species of moths, hoppers, beetles, etc. A light trap basically consists of a light source above a funnel and a container below to collect the catch. The present light trap safer to beneficial insects is for monitoring and mass trapping of insects in the crop fields. The porous insect collection container provided in the system helps in separating the beneficial (parasitoids) and micro sized non-targeted insect fauna from the harmful insect pests. The harmful insects can be easily removed from the light trap unit. Mass trapping of adults of both sexes of insect pests by light trap will help in minimizing their infestation in the crop fields. The key insect pests of cereal crops (rice, maize,

sorghum), pulse crops (chickpea, pigeonpea), vegetable crops (cauliflower, cabbage, tomato, brinjal), horticultural crops can be mass trapped by using this light trap. The newly invented trap is an important tool of eco-friendly integrated pest management technologies. The technology had been demonstrated in several states viz, Maharashtra, Haryana, U.P., M.P., A.P., Gujarat, Rajasthan, Chhatishgarh and Bihar covering more than 10 villages and a total of 5.5 lakh units were utilized in different agro-ecosystem.

The precise advantages of this light trap are:

(i) It can be used to monitor or mass trap the population of phototrophic insects in the crop fields. The mass trapping of both the sexes may reduce the insect pest population in the fields.

(ii) The micro sized beneficial/non-targeted insects will come out from the trapping system of the light trap through the porous means provided in the insect collecting chamber.

(iii) The application of chemical pesticides may be minimized by the use of this trap.

(iv) It is durable and may be used year after year.

(v) The individual or a group of farmers can use this trap to save the beneficial insects.

(vi) Expenditure on pesticides and their application will decrease. Biodiversity will increase.

(ix) Decrease in the pressure of pesticides on other natural enemies will allow them to play an additive part in suppressing the insect pests.

(x) It will control the menace of the insect pests at a very low cost and it would be boon to the poor farmers as an alternative cost-effective method of pest control.

(xi) During rains most of the insecticides are washed away with the hopes of poor farmers. The light trap on the other hand continues catching harmful insect pests.



Light trap safer to beneficial insects

(1) Aerial Insect Trap

It was developed for sampling air born insects i.e., aphids. It is zero energy trap which moves with the help of air thrust. Also, the population of parasites and predators can also be known with this Aerial-Insect Trap. Furthermore, the natural enemies caught are alive can be released back to the field. The Aerial Insect Trap (AIT) comprises of broad barrel shaped structure made of cotton cloth supported by a wire frame. Inside of this barrel, this cone section acts as a trap. The barrel is held horizontally over a pole fixed on the ball bearing. The ball bearing provides the free movement of the barrel. The air thrust keeps the trap always opposite the direction of the wind. The height of the trap can be adjusted by the provision for adjustment made in its stand. The flying insects enter in the trap by their flight and also with the gush of the wind. The trap is kept just above the height of the crop throughout the season. The insects are periodically collected and examined. The insects are not attracted by any kind of lure or suction force. The aerial insect trap was installed in the mustard (KVK, Sonepat, Haryana) and chickpea crop (village Shikohpur, U.P and village Korai, Distt. Fatehpur, U.P.) during the Rabi season of 2001-2002 and onwards and has been found effective in monitoring air borne insects.



Aerial Insect Trap

(2) Egg cleaning device

The insect *Corcyra* is reared in the insectaries all over the country. It is needed for the mass multiplication of several biocontrol agents *viz.,* egg parasitoids- *Trichogramma* spp.; egg-larval parasitoid- *Chelonus blackburni*; larval parasitoids- *Bracon* spp., *Goniozus nephantidis, Apanteles* spp.; insect predators *Chrysoperla carnea, Mallada boniensis* and *Cyrtorhynus lividipennis.* Besides, some entomopathogenic nematodes such as *Steinernema feltiae (Neoaplectana carpocapsea)* is also reared on the larvae of *C. cephalonica*.

Eggs are obtained in billions by rearing *Corcyra*. The egg laying is accompanied by shedding of mounds of scales, which are health hazardous. They cause pulmonary problems (Tuberculosis and Asthma). To collect and clean the eggs, the said device is very efficient. Clean eggs are segregated from the scales with great ease without harming the workers and the hazardous scales are safely disposed. This mechanical device was developed to separate Corcyra eggs from dust, insect scales,

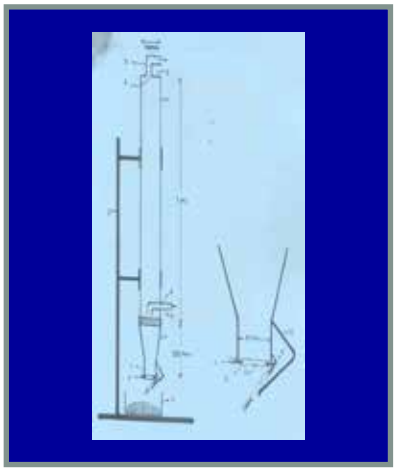
insect body parts (antennae, legs, wings etc.) in the biocontrol laboratories. This device works with the help of vacuum cleaner.

Trichogramma is produced in several:

- ❖ Sugar mills (There are more than 250 sugar mills in Maharashtra, U.P. and other states)
- ❖ Agricultural Universities (30 Agricultural Universities)
- ❖ Agriculture Colleges

Private companies producing Bio-control agents (There are >130 Pvt. Companies) and NGO's

This device can be used in their biocontrol lab.





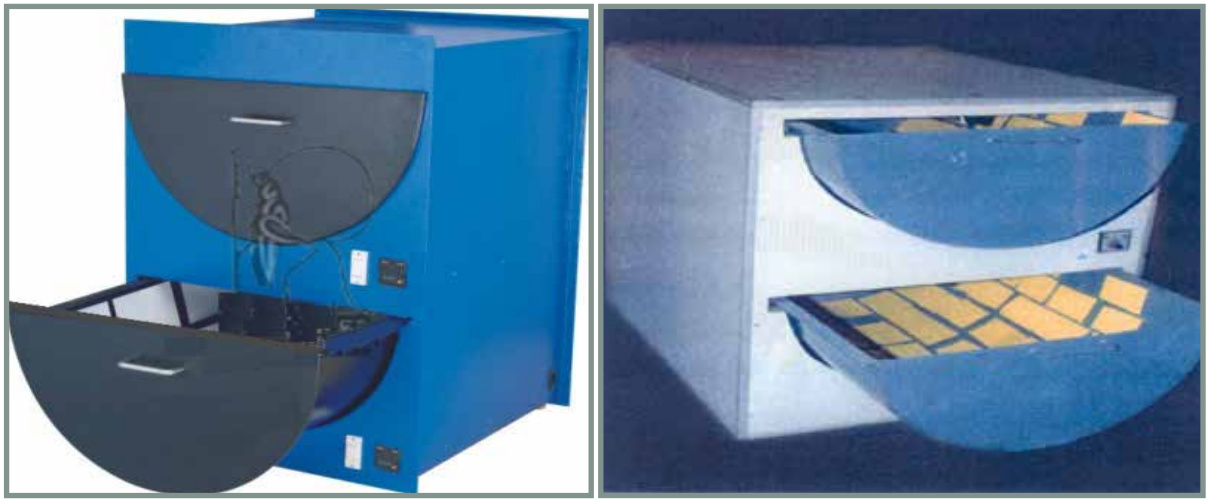
Egg cleaning device

(3) UV Sterilization chamber for *Corcyra eggs*

For the mass production of *Trichogramma*, the *Corcyra* eggs are to be sterilized before use. For quick and uniform sterilization of *Corcyra* eggs a new type of sterilization chamber has been developed. The said sterilization chamber comprised of a cuboid box, 105 cm long, 88 cm broad and 105 cm high. It is closed on all the sides except from the front. The chamber is divided into two equal parts by a horizontal partition. Each partition is provided with a drawer which has a semicircular base of radius 35 cm. The cross section of this drawer is semicircular. The length of the drawer is 100 cm. In the inner surface of the semicircular base the drawer is provided with longitudinal flanges of 2 mm thick and 9 cm apart. These flanges prevent the egg bearing cards to glide one over the other from the curve surface. 75 post card size cards bearing eggs on its upper surface (Trichocard) can be arranged in one drawer. There are two such drawers, which can be pulled out and pushed back in place easily in the manner as table drawers are operated. The ceiling of each drawer is provided with a 30 W UV tube light. Each tube light is connected with a 30 minutes timer thus there are two timers. The time of the timer can be set for a desired time with a least count of one minute.

Features:

- ❖ 75 cards can be exposed to UV at a time in each drawer.
- ❖ Since the source of light is at the center of the curve exposure by UV rays is uniform on the surface of the cards.
- ❖ Since there are two drawers, the time required to arrange the cards in one drawer is sufficient to sterilize the cards in another drawer. Thus, one can sterilize 75 cards per 10 minutes using these drawers alternately.
- ❖ The timers ensure to prevent over exposure or under exposure of the cards.
- ❖ Since the cards are exposed to UV radiation in a closed box, the undesired exposure to UV radiation is ruled out in the structure.



UV chamber for *Corcyra* eggs sterilization

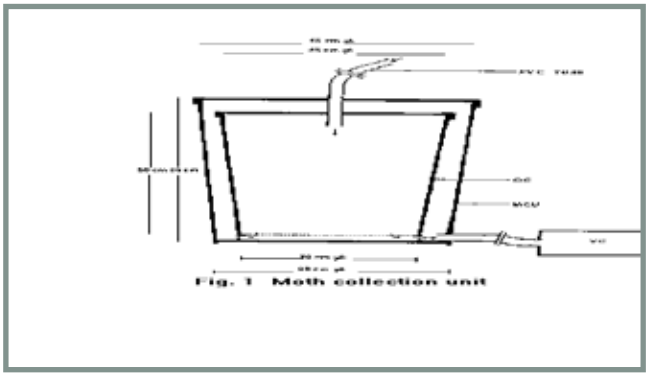
(4) Cage for rearing *Corcyra cephalonica*

It was developed at ICAR-NRIIPM and found very successful in working *i.e.,* to stop the attack of larval parasitoid – *Bracon hebetor* on the *Corcyra* culture.

(5) Corcyra moth collection unit

It was made for the collection of *C. cephalonica* in insect biocontrol laboratories. The unit works with the help of vacuum cleaner.

***Corcyra* moth collection unit**



The Patents were granted to ICAR-NRIIPM, New Delhi for the various innovative IPM tools developed and invented, the details are provided as below:

S. N.	Patents title
National Patents	
1.	Egg cleaning device (Indian Patent No. 213744)
2.	Aerial Insect Trap (Indian Patent No. 226238)
3.	An insect rearing device for multiplication of insect larval parasitoids (Indian Patent No. 274901)
4.	Non-sticky Insect Trap (Indian Patent No.278215)
5.	Insect rearing and collection apparatus (Indian Patent No. 280435)
6.	Light trap for managing insects (Indian Patent No. 293621)
7.	Insect oviposition and egg collection apparatus' (Indian Patent No. 294933)
8.	Light Trap Safer to beneficial insects (Indian Patent No.479233)
International Patents	
1.	Light trap for managing insects (Australia) (Australian Patent No. 2012208304)
2.	Light trap for managing insects (Indonesia) (Indonesian Patent No. IDP000043686)
3.	Light trap for managing insects (Vietnam) (Vietnam Patent No. 22361)

*These inventions are patented by ICAR-NRIIPM, New Delhi. The license(s) of these technologies can be obtained through M/s Agrinnovate India Ltd., New Delhi.

Strengthening Integrated Pest Management through Eco-Friendly Technologies



Sumitra Arora

ICAR-National Research Institute for Integrated Pest Management, New Delhi

Integrated Pest Management (IPM) has emerged as a critical approach for ensuring sustainable crop protection while minimizing environmental and health risks associated with indiscriminate pesticide use. Increasing concerns over pesticide residues, resistance development, ecological toxicity, and regulatory restrictions have created an urgent need for validated bio-based alternatives, safer pesticide selection tools, and scientifically tested low-risk pest management strategies. At the same time, large volumes of Indigenous Technical Knowledge (ITKs) and natural resources remain underutilized due to lack of scientific validation and standardization. Addressing these gaps requires translational research that combines traditional knowledge systems, toxicological science, bioassay validation, and field-scale testing to develop practical, scalable IPM solutions.

The research contributions have been developed under the broader mandate of IPM with the objective of reducing chemical risk, validating bio-based alternatives, improving pesticide safety decisions, and developing scalable eco-compatible technologies for crop and post-harvest protection. The work integrates indigenous knowledge (ITK) validation, pesticide risk assessment, toxicological modelling, post-harvest pest control, and natural product innovation, leading to patents and commercialization.

1. ITK in plant protection

A major milestone was the scientific validation of Indigenous Technical Knowledge (ITKs) through the development and standardization of a cow urine based formulation (CBF) within the IPM framework. The formulation was evaluated under laboratory and it could effectively inhibit *Rhizoctonia bataticola*, *Sclerotinia sclerotiorum* and *Pythium aphanidermatum* compared to untreated control. It was tested on tomato crop under field studies for two consecutive years, and two sprays of this formulation @ 3% at nursery stage and four sprays @ 10% at flowering, fruiting and maturing stage, gave promising results in controlling tomato fruit borer, leaf miner, mites and whitefly giving good yield of the produce. The observed yield in CBF treated tomato fields with zero inputs (no fertilizers or any other inputs used in the soil) was 36 t/ha as compared to 15 t/ha in check plots and 17 t/ha in organically treated plots during 2006-08. Detailed compositional

analysis of the CBF revealed the presence of essential macro and micronutrients at levels adequate to support crop growth, indicating that the formulation could contribute to plant nutrition without requiring additional nutrient supplementation under tested conditions. The CBF demonstrated dual functionality as a plant growth regulator and pest management input.

Its consistent performance as a bio-based IPM tool resulted in granting a patent *Biopesticide formulation for controlling insect pests and fungal pathogens and process for preparation there of*" from Indian Patent House in 2018 followed by its commercialization through three Indian companies, enabling farmer-level adoption of a validated traditional technology. The CBF has been registered under the trade name "Coneem" as a plant growth regulator, and the trademark was granted in 2019 under Application No. 3896650 in accordance with the Trade Marks Act, 1999, Government of India. This innovation was highlighted in ICAR news in 2018 under the title, '*An indigenous biopesticide enhances tomato yield*'. In continuation of ITK-based bioresource validation under the IPM framework, systematic studies were conducted on plant-derived compounds through solvent extraction and chromatographic fractionation. One such investigation involving *Ailanthus longifolia* led to the isolation of an active column fraction that demonstrated highly promising insecticidal activity at very low concentrations (as low as 10 ppm). The fraction showed significant efficacy against both sucking and chewing pests, including mustard aphid (*Lipaphis erysimi*) and the lepidopteran pest *Helicoverpa armigera*. This work highlighted the strong potential of plant-based bioactive fractions as low-dose, eco-compatible pest management tools and reinforced the scientific value of Indigenous Technical Knowledge–based plant resources within modern IPM strategies.



Effective visibility of the indigenous formulation with Zero inputs

2. Pesticides with reduced risk to environment

To promote safer pesticide use within IPM programs, the Environmental Impact Quotient (EIQ) model was applied to pesticide usage patterns in the rice cropping system of Sitapur district, Uttar Pradesh. Rice is among the highest pesticide-consuming crops in India, and indiscriminate pesticide application remains a major constraint to sustainable agricultural development. Field surveys indicated widespread non-IPM pesticide use practices among farmers, leading to elevated environmental risk and avoidable input costs.

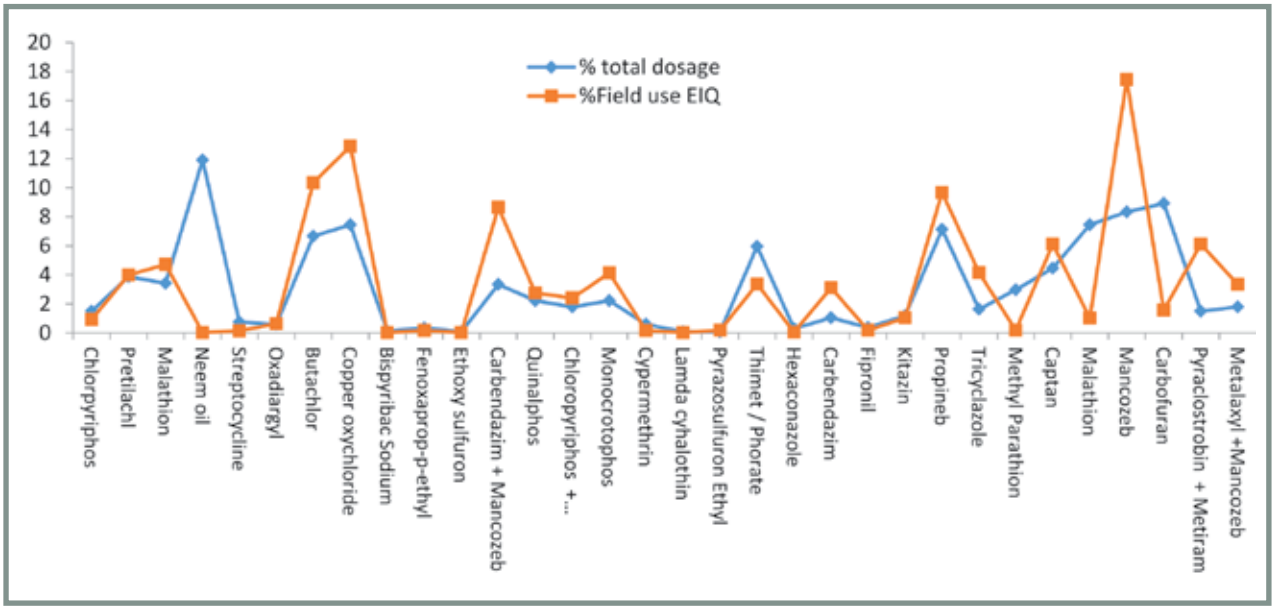


Fig. 1. EIQ Product Profile ranked by % formulated dose

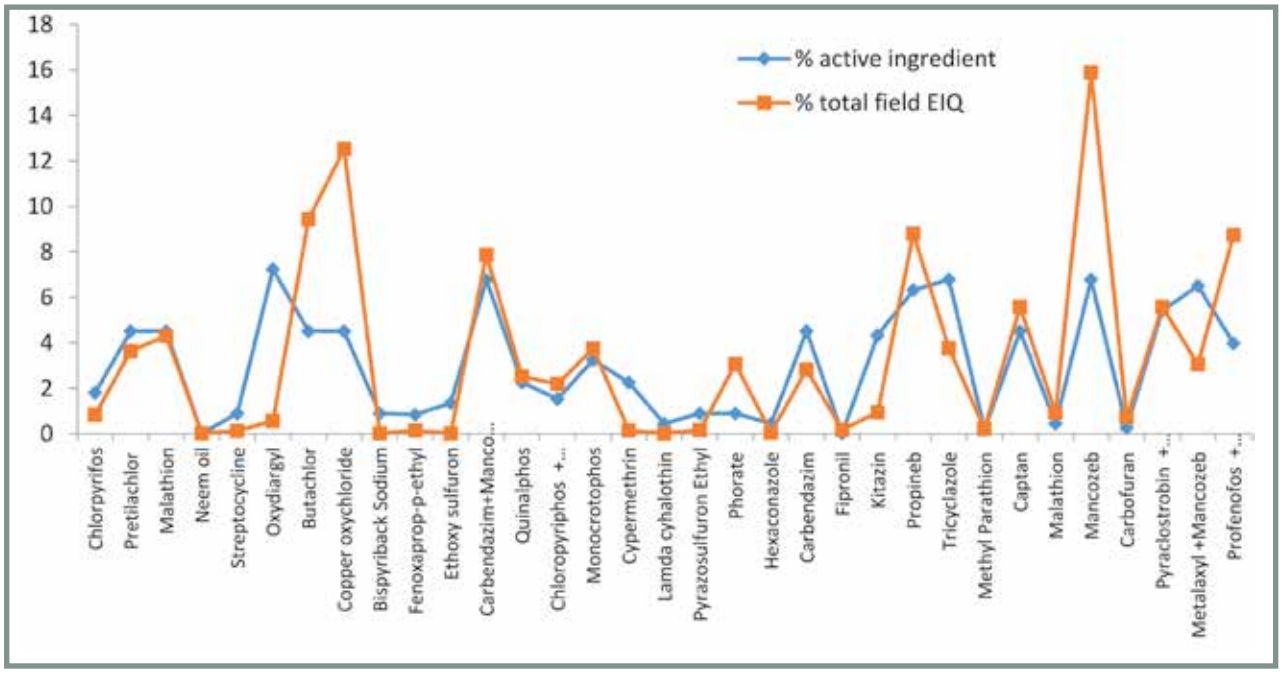


Fig. 2. EIQ Product Profile ranked by % active ingredient

The EIQ, a science-based decision-support tool developed for evaluating the inherent toxicity and environmental impact potential of pesticide molecules, was adapted and applied under local field conditions to guide safer pesticide selection. Soil samples were analyzed for impacts on soil flora

and fauna, including both beneficial and harmful organisms. Comparative analysis of percentage dosage, percentage of active ingredient applied, and percentage contribution to total field EIQ revealed that certain fungicides (mancozeb and copper oxychloride) and the herbicide butachlor contributed disproportionately to environmental risk and were identified as high-risk inputs (Fig 1 & 2).

In contrast, some insecticides categorized under WHO Class I hazard category, such as carbofuran and phorate, contributed relatively small proportions to the total field EIQ (1.6% and 3%, respectively), demonstrating that hazard classification alone may not reflect field-level environmental impact. Mixture effects further highlighted the importance of EIQ-based evaluation: cypermethrin alone showed limited impact, but when combined with profenofos, it emerged as a major contributor to total field EIQ, indicating synergistic risk behavior. Conversely, mancozeb alone showed the highest contribution to total field EIQ, whereas its combination with metalaxyl resulted in substantially lower impact, indicating antagonistic interaction. This analytical approach enabled identification of pesticide products and combinations that contributed disproportionately to environmental risk relative to their application rate, thereby supporting their avoidance or substitution within IPM programs.

Field comparisons of management strategies showed that IPM modules had the least ecological impact, with 30–40% increase in natural enemy populations and weed levels were maintained below 10%. In contrast, prevailing farmer practice resulted in approximately 20% reduction in crop yield, 50% reduction in biodiversity and nearly 150% increase in weed population relative to untreated control fields. Total field EIQ values further indicated that farmer practice posed about 56% greater environmental risk compared to IPM-based management (EIQ rating was 141 under farmer practice and was 62 under IPM conditions). These findings demonstrate that the EIQ model is a practical and effective tool for pesticide risk assessment and can be readily adopted by pesticide managers and IPM planners to support environmentally responsible pest management decisions.

3. Toxicity assessment of pesticides for IPM strategies

A technology platform was also developed for assessing pesticide toxicity in binary mixtures relevant to real-world IPM spray practices and environmental exposure scenarios. Since pesticides frequently occur in the environment as mixtures through agricultural runoff and effluent discharge, their combined risk cannot be reliably predicted from individual compound assessments alone. The developed approach utilized dose responsive modelling to characterize mixture effects and determine whether interactions were additive, antagonistic or synergistic across pesticides with similar or different modes of action, particularly in aquatic ecosystems containing living organisms.

The methodology combined biochemical and organism level indicators to strengthen environmental risk assessment. *In-vitro* enzyme inhibition studies were conducted using a scaled-down assay based on purified acetylcholinesterase (AChE) from housefly head enzyme systems as a sensitive bioindicator. A total of nine commonly co-occurring pesticides, including organophosphates, carbamates, and synthetic pyrethroids, along with their binary combinations, were evaluated. *In-vivo* biomarker studies were conducted using fingerlings of *Bidyanus bidyanus* fish as aquatic bioindicator organisms to capture sub-lethal and behavioral toxicity responses that are not detected through residue analysis alone.

The approach demonstrated very high analytical sensitivity, detecting enzyme inhibition and toxic effects at environmentally safer concentrations (IC_{10}), with sensitivity levels 50–100 times greater than conventional toxicity endpoints. Results showed that several pesticide mixtures, even at low concentrations that did not produce immediate lethal effects, caused significant impairment in fish behavior and physiological activity. Importantly, findings indicated that pesticide residues present at or below maximum residue limits (MRLs) may still pose substantial ecological risk when present in mixtures.

Mixture dose calculations at IC_{10} levels, generally considered environmentally safe, frequently produced toxicity comparable to or greater than the recommended doses of individual pesticides, demonstrating strong synergistic behavior. In several cases, combining pesticides at as little as 1/50th of their standard application rates resulted in toxicity levels many times higher than those observed for single compounds. The technology proved capable of detecting pesticide effects at parts-per-trillion (ppt) levels and effectively capturing synergistic amplification in combined exposures.

This mixture-toxicity assessment framework provides a highly sensitive and practical tool for screening environmental samples and strengthening pesticide risk analysis by integrating chemical residue measurement with biomarker-based early warning indicators. The approach supports improved ecological risk evaluation and safer pesticide use strategies within IPM programs by emphasizing mixture effects rather than single-compound toxicity alone.

4. Post-harvest pest management

Effective post-harvest pest management is essential for safeguarding the quantity, quality, and market value of agricultural produce across commodities such as food grains, pulses, dry fruits, spices, and perishable fruits, vegetables, and flowers. Significant losses occur after harvest due to insect infestation, contamination, and quality deterioration during storage, transport, and marketing. These losses not only reduce food availability and farmer returns but also affect seed viability, nutritional quality, trade standards, and export potential.

In the post-harvest IPM, multi-locational laboratory and field trials were undertaken to evaluate phosphine (PH_3) fumigation against stored-grain insects under quarantine and pre-shipment (QPS) as well as long-term storage conditions. Methyl bromide (MBr), widely used for QPS treatments and grain storage pest control, is being phased out globally under the Montreal Protocol due to its ozone-depleting potential. In addition, international trade restrictions on MBr-treated consignments have created economic and regulatory challenges, highlighting the urgent need for an effective and compliant alternative.

Phosphine, that is already registered for domestic use and is internationally accepted, was systematically evaluated across diverse agro-ecological regions to standardize dosage and exposure protocols for reliable insect control in cereals and pulses. This work gained particular importance during periods of surplus pulse production, when safe and effective long-term storage solutions were urgently required. A phosphine-based fumigation protocol was developed and validated based on extensive field trials for QPS and bulk storage applications using 1.5 g/m^3 phosphine delivered through 56% aluminium phosphide tablets and 77.5% granule formulations. The standardized treatment achieved effective control of major storage insect pests within a 7-day exposure period,

with no insect emergence recorded up to 60 days after treatment. The terminal concentrations of PH_3 gas for different dosages, under field trials, were observed in the range of 250-800 ppm. The residues of PH_3 in all fumigated food grains, from different locations, were observed below MRL. The observations based recommendations were submitted to DAC, ministry of agriculture for implementation for trading of food grains treated with phosphine. *This developed protocol has been certified by ICAR under certificate number ICAR-CS-NRIIPM-Process-2025-030.*

The fumigation approach was successfully extended and validated for use on a wide range of perishable commodities, including fruits, vegetables, and cut flowers, thereby substantially broadening the scope of IPM-based post-harvest protection strategies. Phosphine fumigation demonstrated high efficacy in managing economically important insect pests across multiple commodities, such as aphids (*Macrosiphoniella sanbornii*) in chrysanthemum flowers, thrips (*Rhipiphorothrips cruentatus*) in rose flowers, thrips (*Scirtothrips dorsalis*) in chilli fruits, fruit fly larvae (*Bactrocera dorsalis*) in mango, and fruit fly (*Bactrocera cucurbitae*) in bitter gourd during storage. Effective control was achieved under varying exposure periods ranging from 4 to 15 hours, depending on the commodity and pest load (Table 1). Detailed post-treatment evaluation of treated produce included assessment of physical as well as biochemical quality parameters, which confirmed that commodity quality and nutritional attributes were not adversely affected by phosphine treatment. In addition, systematic analysis of phosphine residues and sorption behavior showed only trace-level residues in all treated commodities, consistently remaining below the MRLs prescribed by the Codex Alimentarius Commission (CAC), thereby establishing both the safety and practical applicability of the protocol for perishable produce systems.

This validated phosphine fumigation technology supports regulatory compliance, reduces dependence on methyl bromide, minimizes trade-related losses, and provides a practical, scalable solution for researchers, storage managers and policymakers involved in post-harvest pest management.

Phosphine is currently the only single-molecule fumigant registered with Central Insecticides Board and Registration Committee (CIBRC) for stored-product protection, and resistance to phosphine has been widely reported in several major storage insect pests. Following the phase-out of MBr, there is an urgent need to identify and register additional fumigant molecules for effective storage pest management. Under post-harvest pest management programs, newer fumigants, namely e-fume (a mixture of 83.3% CO_2 and 16.7% ethyl formate) for stored insects of food grains and dry fruits and EDN (ethanedinitrile) for timber insects, were evaluated under laboratory and multi-location field conditions to generate data required for CIBRC registration in India. The study was supported by Draslovka Services India (DSI) Pvt Ltd.

Field trials were conducted in fumigation cocoons at multiple locations including Jaipur, Kandla (Gujarat), and Mumbai/Pune to assess the efficacy of e-fume fumigant at three dosage levels (340, 420, and 525 g/m³) with a 24-hour exposure period. Target pests included major stored-grain insects, *Trogoderma granarium* (khapra beetle larvae), *Tribolium castaneum* (red flour beetle adults and larvae), *Sitophilus oryzae* (rice weevil adults), and *Rhyzopertha dominica* (lesser grain borer adults), as well as dry fruit pests *Ephestia cautella* (almond moth) and *Lasioderma serricorne* (cigarette beetle). EDN was separately evaluated against timber insects at Bengaluru, Mumbai, and CAFRI, Jhansi. The experiments were laid out with five treatments comprising three dosages of e-fume, one positive control (MBr @ 32 g/m³), and one untreated control, each with four replicates.

Laboratory-reared target insects were placed in perforated plastic containers and distributed at different positions within the commodity stacks inside the cocoons. Gas concentration levels were monitored at multiple time intervals viz. 30 minutes, 1 hour, 6 hours, 12 hours and 24 hours for each treatment replicate. Observations recorded after fumigation showed that e-fume and EDN achieved 95–100% mortality of stored-product and timber insects across treatments. The reports based on laboratory and field have been submitted along with application for registration of these molecules have been submitted to CIBRC by DSI.



stored food grain insect management using e-fume (83.3% CO_2 + 16.7% ethyl formate) by fumigating wheat grain stacks at Jaipur.



Timber insect management using EDN (ethane dinitrile) by fumigating stacks of wooden logs at Jhansi.

Table 1. Impact on quality of phosphine treated perishable commodities

Commodity	Name of commodity	Exposure period	Effective concentration	Quality parameters		Residues (ppm)	Remarks
				Physical	Biochemical		
Vegetables	Bitter gourd	4	1400	Moisture Content, Colour, Texture	Chlorophyll content,	0.1	No significant difference was observed in any quality parameter of treated and untreated control samples
		6	1200		Ascorbic Acid (AA), and Total Soluble Solids (TSS)	0.09	
		8	1100			0.1	
		10	800			0.1	
		15	600			0.07	
	Chillies	4	60	Moisture Content, colour and Texture	Chlorophyll content, Ascorbic Acid, TSS, and Antioxidants	0.01	
		6	50			0.01	
		8	40			0.015	
		10	30			0.02	
Fruits	Mango	4	1500	Texture, and Physiological loss in weight (PLW)	Titratable Acidity (TA), Carotenoids	0.03	-do-
		6	1200			0.019	
		8	1000			0.03	
		10	800			0.024	
	Pomegranate	10	0, 500, 1000, and 2000	PLW, Juice Yield, and Juice pH	TSS, AA, phenols, TA, Antioxidants, Anthocyanins		-do- Infested samples could not be arranged
		24	0, 500, 1000, and 2000	PLW, Juice Yield, and Juice pH,	-do-		
Flowers	Chrysanthemum	4	2400	Water uptake, vase life, Initial & final Dry weight	Anthocyanins content	0.24	No significant difference was observed in quality parameter of treated and control samples
		6	2200			0.21	
		8	1400			0.21	
		10	1200			0.17	
	Roses	4	65	-do-	-do-	0.02	-do-
		6	55			0.003	
		8	50			0.004	
		10	40			0.008	

ICT-Based Pest Surveillance & Advisory System: A Path Breaking Initiative



Niranjan Singh, OM Bambawale, S Vennila, DB Ahuja, HR Sardana, P Jeyakumar, Manoj Choudhary, Mukesh Khokhar, Meenakshi Malik, Anoop Kumar, Rakesh Kumar, PN Meena, D Raghvendra, Ajanta Birah and SK Singh

ICAR-National Research Institute for Integrated Pest Management, New Delhi

"Pest surveillance is the cornerstone for pest management through which epidemic situations can be avoided by detecting damage prior to establishment at a higher population."

Correct pest identification and regular wide-area pest surveillance/monitoring are the vital aspects of process of decision-making in pest management. Early pest identification and timely availability of pest surveillance-based management advice to the farmers are of paramount importance in terms of productivity and reduction of the usage of pesticides. Through regular pest surveillance, epidemic situations can be avoided by detecting damage prior to establish at a higher pest population. The basic purpose of pest surveillance is to determine whether and which pests are present in the field and their level of incidence to initiate pest management action, and if required to initiate action, what is the appropriate management option. For effective pest management, farmers require timely support in pest identification and appropriate control measures. Due to limited knowledge and expertise, many farmers rely heavily on pesticide dealers, often leading to excessive and indiscriminate use of chemicals. Timely assistance in pest identification and surveillance-based advisories can help farmers either save crops worth several crores of rupees or avoid unnecessary pesticide applications, thereby reducing costs and protecting the environment.

Recognizing the vast potential of Information and Communication Technology (ICT) in plant protection, with its ability to enable both centralized and decentralized services, ICAR–National Research Institute for Integrated Pest Management (NRIIPM) designed and developed an ICT-based pest surveillance and advisory system. This system has been continuously upgraded using modern ICT tools and has now been integrated into various programmes implemented across the country.

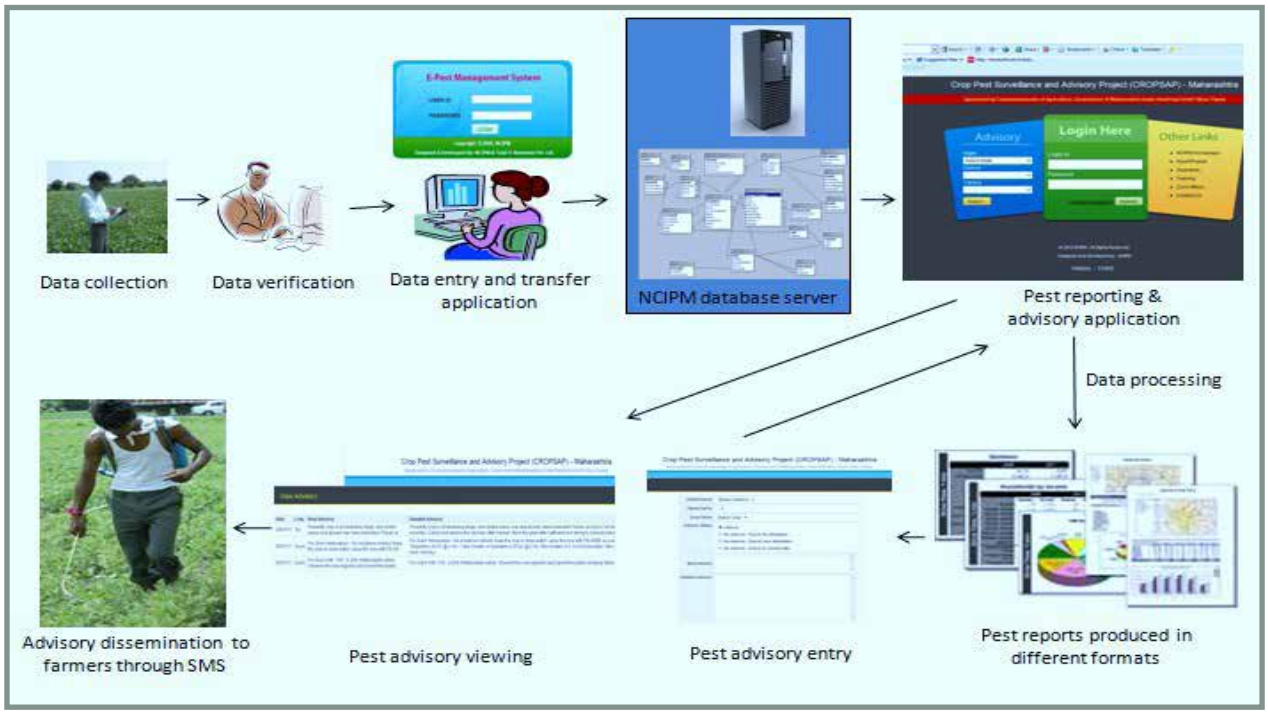
Why ICT for pest surveillance?

Information and Communication Technology acts as an accelerating force for increasing agricultural productivity. ICT has become very convenient technology for timely delivery of pest management

information and services to the farmers. This has the potential for improving effectiveness and efficiency of pest management programmes being carried out across the country. Its ability to allow quick transfer of information and its ready access as well as the knowledge base assist the plant protection workers in advising farmers appropriately so as to save the crop from pest damage and economic losses by judicious use of timely intervention and relevant pest management inputs. The goal of using ICT for pest surveillance is to capture the pest information from farmer's field, transferring it to a centralized database, compilation, reporting and dissemination of data to different stakeholders. Use of ICTs not only automates but also speeds up the process of providing support for pest identification. This also facilitates in quick reporting of pest situations of different locations and thus helps the experts in making appropriate pest management decisions and quick dissemination of these decisions to the farmers as advice.

Structure of ICT based pest surveillance and advisory System

The system comprises three major components: Mobile app for data capture; a centralized database; web-based application for pest reporting and advisory. System has been enhanced and upgraded regularly, using modern ICTs such as technologies Artificial Intelligence, Hybrid mobile app development packages. Latest version of the system was developed using React Native, Angular, .net core with C# and SQL 2019 technologies.



ICT-based pest surveillance programmes

ICT-based pest surveillance and advisory system has been successfully implemented in the following programmes in various states of the country, since 2009.

- Crop Pest Surveillance and Advisory Project (CROPSAP)
- Horticulture Pest Surveillance and Advisory Project (HORTSAP)
- Pest Surveillance in Rice, Odisha
- Increasing Chickpea and Pigeonpea Production through Intensive Application of IPM (A3P, NFSM)
- Implementation of ICT based Pest Surveillance in Malawi under TAP Africa
- ICT based Pest Surveillance and Management through Advisory System for Boro Rice in Tripura
- ICT based Surveillance and Advisory Services for Selected Horticultural Crops in Haryana
- National Pest Surveillance System (NPSS)

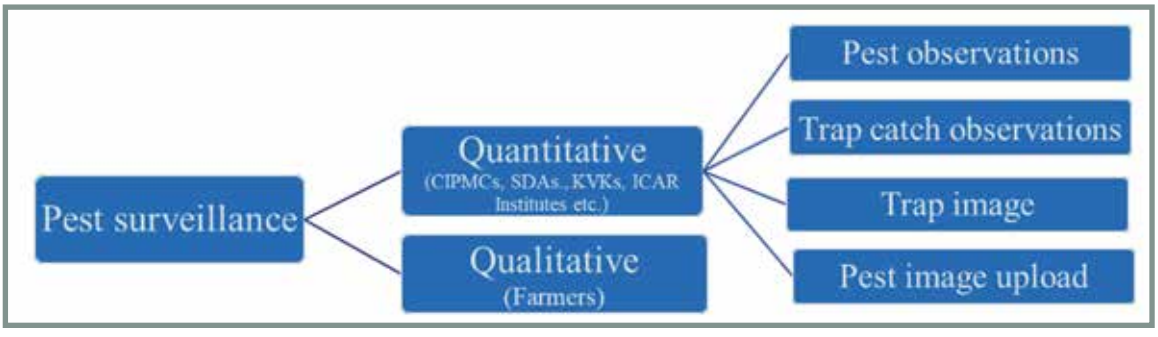
National Pest Surveillance System (NPSS) at a glance

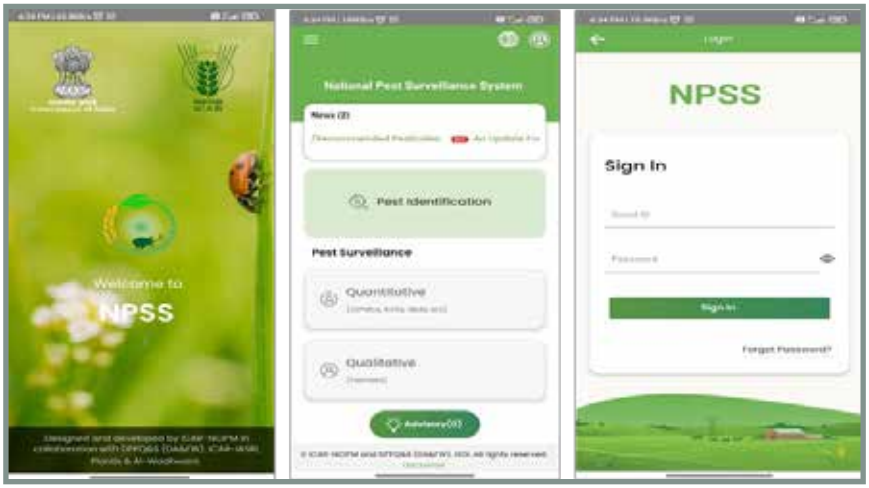
Regular enhancement of the ICT-based pest surveillance system resulted in National Pest Surveillance System (NPSS), a comprehensive technology enabled system for identification, Surveillance and Management of pests. NPSS was developed by leveraging modern ICTs such as Machine Learning (ML), reverse geo coding and hybrid mobile app package, to enhance the pest management across the country, launched by Honorable Minister of Agriculture and Farmers' Welfare on 15th Aug, 2024. The system provides real-time data collection, analysis, expert advisories, and decision-making tools for all stakeholders including farmers, field scouts, agricultural officers, and extension workers. NPSS comprises mobile app, web portal and database. Mobile app has capability of AI-based pest identification for 65 crops and surveillance of key pests of 31 crops to provide pest management advice to the farmers. Web portal comprises admin panel, dashboard & pest reporting. The system is available in four languages viz. English, Hindi, Punjabi & Marathi.

NPSS mobile app

Following are the important features of the NPSS mobile app:

- AI-based pest identification
- Pest surveillance
- Pest surveillance-based management advice

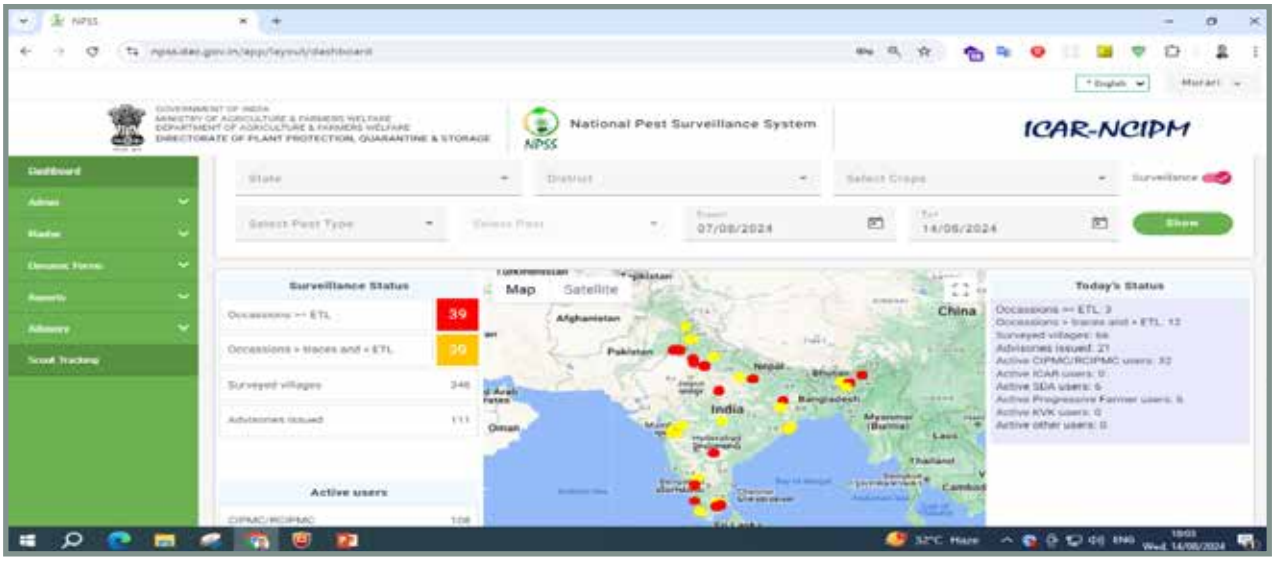




NPSS Web portal

Important features of the web portal:

- System administration
- Dashboard
- Pest reporting
- Submission of pest advisory



Area of operation, under ICT-based pest surveillance programmes

ICT-based pest surveillance and advisory system has been successfully implemented in the following programmes in various states of the country, since 2009.

- Crop Pest Surveillance and Advisory Project (CROPSAP)
- Horticulture Pest Surveillance and Advisory Project (HORTSAP)

- Pest Surveillance in Rice, Odisha
- Increasing Chickpea and Pigeonpea Production through Intensive Application of IPM (A3P, NFSM)
- Implementation of ICT based Pest Surveillance in Malawi under TAP Africa
- ICT based Pest Surveillance and Management through Advisory System for Boro Rice in Tripura
- ICT based Surveillance and Advisory Services for Selected Horticultural Crops in Haryana
- National Pest Surveillance System (NPSS)

Programme	Crops	State/region	Districts	Sub districts /Blocks
Crop Pest Surveillance and Advisory Project (CROPSAP)	Soybean, Cotton, Rice, Pigeaonpea, Chickpea, Sorghum, Maize, Sugarcane	Maharashtra	28	271
Horticulture Pest Surveillance and Advisory Project (HORTSAP)	Mango, Sapota, Sweet Orange, Santra, Pomegranate, Banana, Tomato, Okra	Maharashtra	32	241
Pest Surveillance in Rice, Odisha	Rice	Odisha	13	126
Increasing chickpea and pigeonpea production through Intensive Application of IPM (A3P, NFSM)	Pigeon pea Chickpea	Maharashtra, Uttar Pradesh, Andhra Pradesh, Madhya Pradesh & Karnataka	10	37
Implementation of ICT based Pest Surveillance in Malawi under TAP Africa	Cotton	Southern region	2	4
E-pest surveillance and advisory services for Boro Rice in Tripura	Boro Rice	Tripura	7	54
ICT based pest surveillance & advisory services for horticultural Crops in Haryana	Kinnow, Tomato, cabbage, cauliflower, cucurbits	Haryana	9	14
National Pest Surveillance System (NPSS)	Apple, Banana, Brinjal, Chilli, Cotton, Grapes, Maize, Mango, Pigeonpea, Pomegranate, Rice, Soybean, Sugarcane, Tomato, Urad bean, Wheat	All India	583	2075

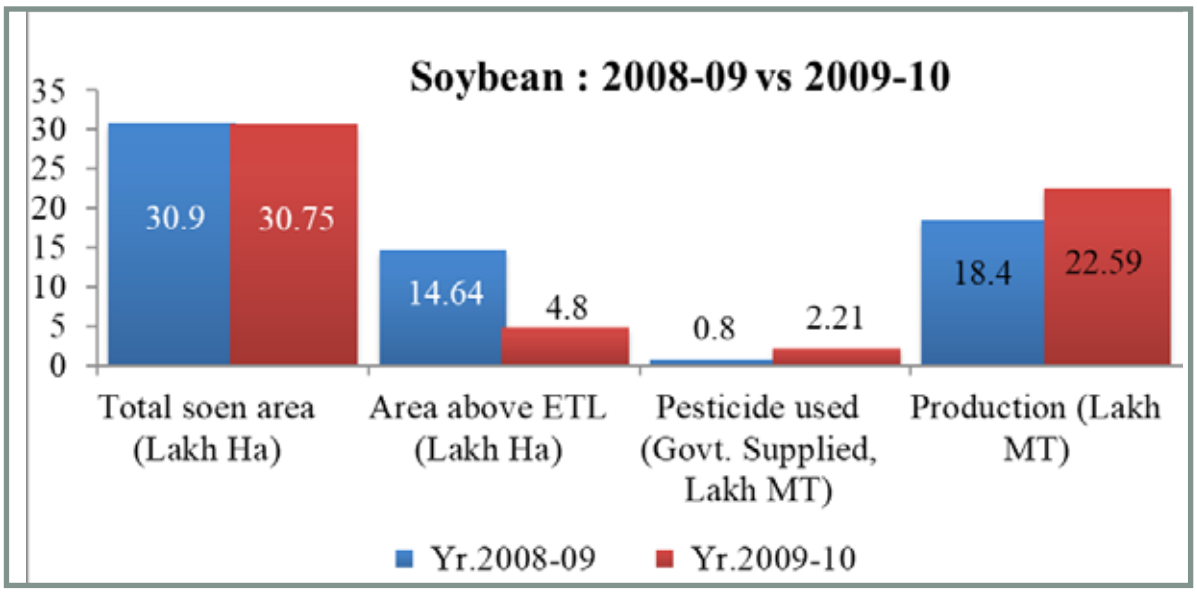


Tangible benefits of the system

- ✓ ICT infrastructure established: Robust ICT infra created at ICAR-NRIIPM, SAUs and SDAs involved for regular and effective pest surveillance.
- ✓ Scientific methods of recording pest observations: quantitative pest observations recorded according to pest specific scientific methods.
- ✓ Delivery of timely and correct pest management advisories to the farmers of the state.
- ✓ Avoidance of pest epidemic: Regular pest surveillance resulted in avoidance of pest epidemic.
- ✓ Awareness among the farmers on pest identification and their management.
- ✓ Increased socio-economic benefits: Dissemination of timely and pest management. advisories resulted in saving the crop and environment.
- ✓ Enhanced interaction among farmers and the scientific community.

Impact of ICT-based Pest Surveillance System: a glimpse

Maharashtra



Constant and timely watch over pest scenario of the crops with the help of ICT based pest surveillance system aided in identifying the pest hot spots in the states where it was implemented. Staff of state agriculture departments were geared up to manage epidemic situations through awareness creation and supply of critical pest management inputs. The pest affected areas across the crops under pest surveillance viz., soybean, cotton, rice, pulses, vegetables and fruits get scientific pest management practices implemented over wider areas which in turn aids in increased productivity of the crops per se in that region. Pilot study was done to assess the impact of the system for soybean crop during 2010, results are as shown in the following graph.

Year	Farmers registered (in lakhs)	Advisories issued	SMSs sent (in lakhs)
2013-14	3.90	85098	265.80
2014-15	15.00	57365	550.27
2015-16	48.66	36593	199.01
2016-17	50.76	5072	366.95
2017-18	46.85	13055	599.81
2018-19	50.76	-----	304.07

Prime Minister's Award for Excellence in Public Administration 2012-13

Crop Pest Surveillance and Advisory Project (CROPSAP), Maharashtra was awarded 'Prime Minister's Award for Excellence in Public Administration' for the year 2012–13.



E-Governance Gold Medal

Crop Pest Surveillance and Advisory Project (CROPSAP), Maharashtra was also given National e-Governance awards- 2012: Gold medal for exemplary use of ICT-based solutions, at the 15th National

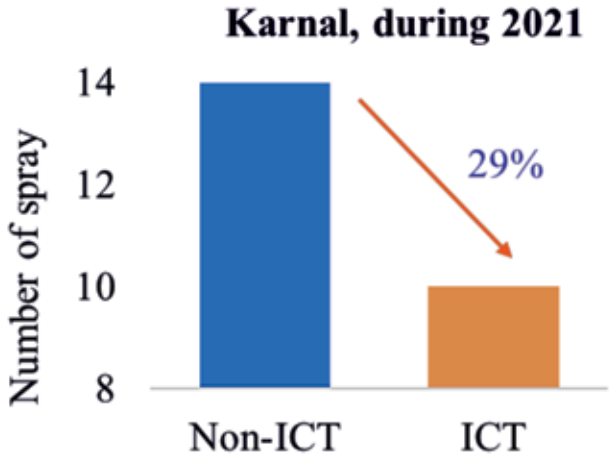
Conference on e-Governance held during 9-10 Feb 2012 at Bhubaneshwar, Odisha.

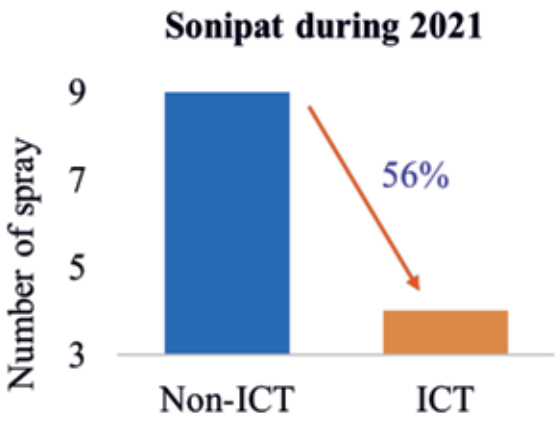


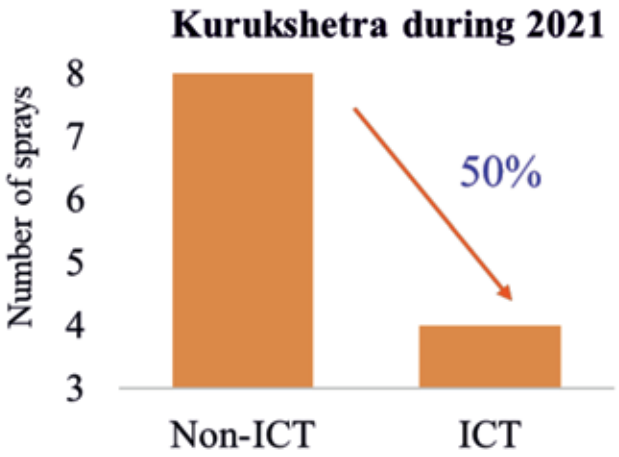


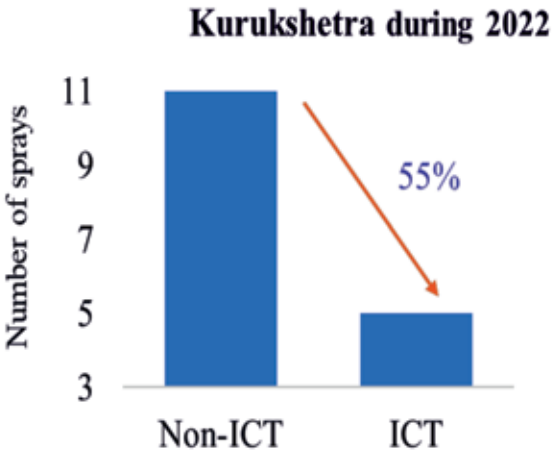
Haryana

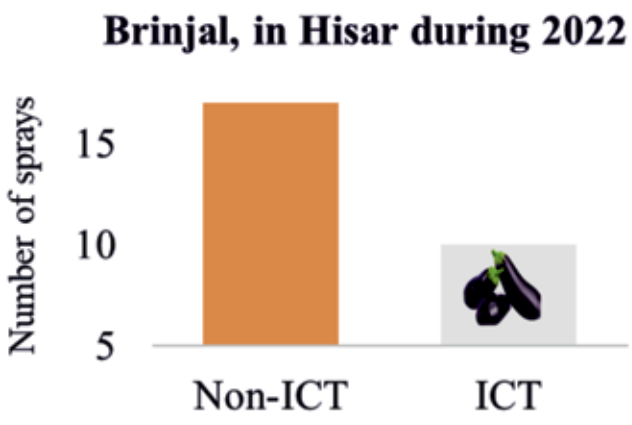
Impact of ICT based pest surveillance and advisory system in management was assessed using previous and correct pesticide consumption details for different crops grown in various districts of Haryana state.

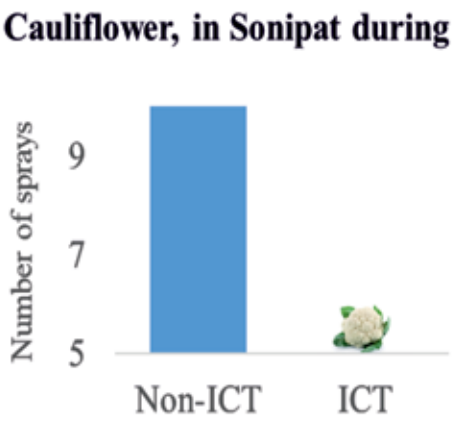


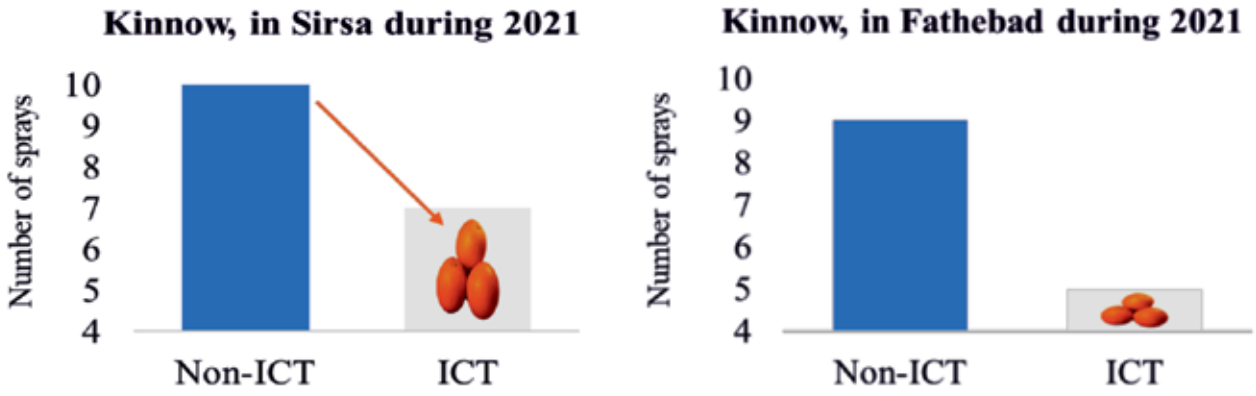












Small study was also done to assess the economic impact of ICT based pest surveillance and advisory system in management of late blight in tomato crop in Karnal district of Haryana state, during 2023-2024. The results are detailed below in the table.

Loss due to biotic stresses in Karnal	30%
Loss in neighbouring areas of Punjab	70%
Average potential yield t/acre	20
Monitory loss (based on potential yield in 400 acres of Karnal, @Rs 15,000/t)	3.6 crore
Monitory Loss (based on potential yield in 400 acres of neighboring states)	7.2 crore
Benefit (Estimate, based on survey)	3.6 crore

ICT-based Pest Surveillance and Advisory System – A success story, why?

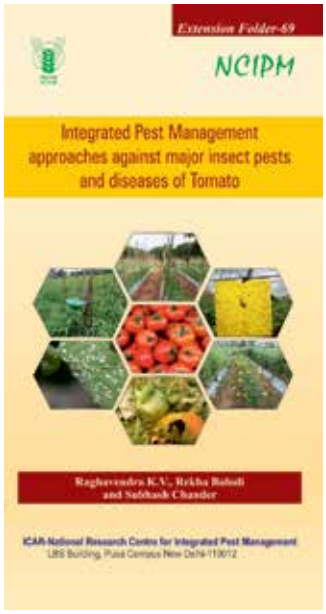
- ICT-based pest surveillance and real time advisory dissemination system is need of the hour for minimisation of yield losses under the fast-changing pest scenario due to changing weather/climate.
- Multi stakeholder involvement brought in harmony to the technicalities of pest surveillance and management
- Advisory capsules are scientific as they are formulated in consultation with domain experts, which improves the implementation of pest management recommendations.
- Engagement of trained human resource for pest surveillance, data feeding and advisory dissemination ensures regular pest surveillance and need based pest management amongst farmers.
- Regular trainings to staff (departmental staff of department of Agriculture, pest scouts, pest monitors and data entry operators) to impart the do-how of pest surveillance and pest management empowered capacity building.
- Exposure visits to the department officials and farmers updated their knowledge and enhanced the vision and skills on crop production and protection.
- The real time pest status based on ETL and management advisories resulted in the judicious use of pesticides.

Abbreviations

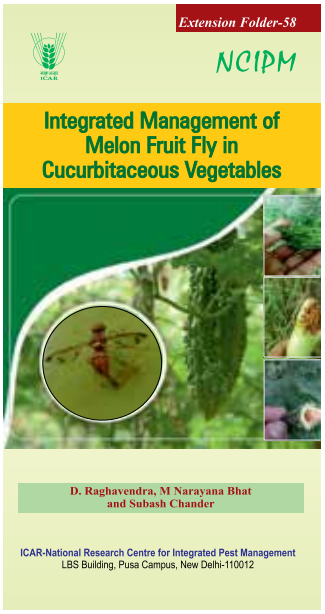
a.i.	Active ingredient
%	per cent
ADG	Assistant Director General
AICRP	All India Coordinated Research Project
AINP	All India Network Programme
AUDPC	Area Under Disease Progression Curve
BB	Black Bug
BLAST	Basic Local Alignment Search Tool
BLB	Bacterial Leaf Blight
bp	BASE PAIR
BPH	Brown Plant Hopper
Bt	*Bacillus thuringiensis*
CAC	Codex Alimentarius Commission
CAFRI	Central Agroforestry Research Institute
CF	Culture Filtrate
CFU	Colony Forming Unit
CLCuD	Cotton Leaf Curl Virus Disease
CIBRC	Central Insecticides Board & Registration Committee
CROPSAP	Crop Pest Surveillance and Advisory Project
DARE	Department of Agricultural Research and Education
DAS	Days After Sowing
DDG	Deputy Director General
DG	Director General
DOGR	Directorate of Onion and Garlic Research
DSI	Draslovka Services India
DSR	Direct Seeded Rice
DSS	Decision Support System
EC	Emulsifiable Concentrate
EFC	Expenditure Finance Committee
EIQ	Environmental Impact Quotient
EPN	Entomopathogenic Nematode
ETL	Economic Threshold Level
FAO	Food and Agriculture Organization
FAW	Fall Armyworm
FFS	Farmers Field School
FMF	Fruitfly Managed Field
FP	Farmers Practice

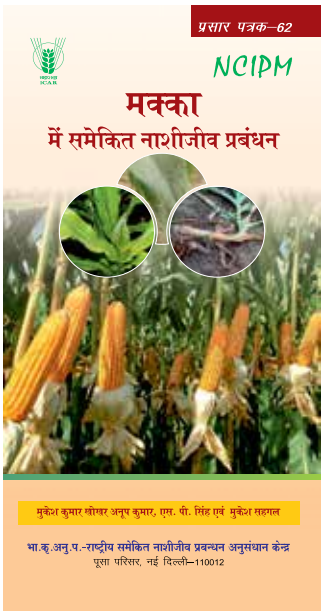
FUMF	Fruitfly Unmanaged Field
FYM	Farm Yard Manure
g	Gram
GAP	Good Agricultural Practices
GLH	Green Leaf Hopper
GR	Gram Reaction
Ha	Hectare
HORTSAP	Horticulture Pest Surveillance and Advisory Project
HYPM	Half-Yearly Progress Monitoring
IAA	Indole Acetic Acid
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agriculture Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IIAB	Indian Institute of Agricultural Biotechnology
IIHR	Indian Institute of Horticultural Research
IISS	Indian Institute of Seed Science
IPM	Integrated Pest Management
IPS	Indian Phytopathological Society
ITK	Indigenous Technical Knowledge
kg	Kilogram
KVK	*Krishi Vigyan Kendra*
LF	Leaf Folder
LWI	Leaf Water Index
Ma	*Metarhizium anisopliae*
MGMG	Mera Gaon Mera Gaurav
ml	Mililiter
MP	Madhya Pradesh
MBr	Methyl Bromide
MPUAT	Maharana Pratap University of Agriculture and Technology
MRL	Maximum Residue Limit
NaCl	Sodium chloride
NBAIR	National Bureau of Agricultural Insect Resources
NCBI	National Centre for Biotechnology Information
NGOs	Non-Governmental Organization
NIASM	National Institute of Abiotic Stress Management
NRCIPM	National Research Institute for Integrated Pest Management
NS	Non-Significant
PBW	Pink Bollworm
PEG	Poly Ethylene Glycol
PGI	Percent Growth Inhibition

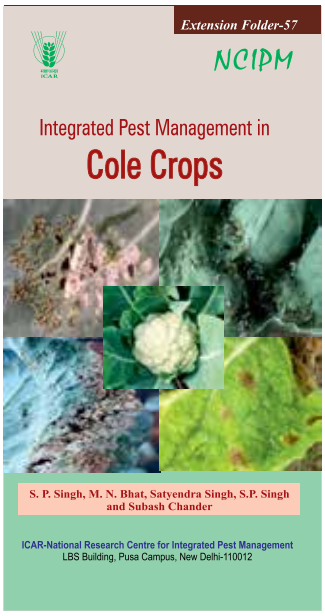
PLW	Physiological Loss in Weight
PMIS	Pest Management Information System
PP&BS	Plant Protection and Biosafety
ppm	Parts Per Million
PPT	Parts per Trillion
PH_3	Phosphine
QRT	Quinquennial Review Team
QPS	Quarantine and pre-shipment
RAC	Research Advisory Committee
RKN	Root-Knot Nematode
RVSKVV	*Rajmata Vijayraje Scindia Krishi Vishwa Vidyalaya*
SAUs	*State Agricultural* Universities
SC	Suspension Concentrate
SCSP	Scheduled Caste Sub Plan
SMS	Short Message Services/ Subject Matter Specialist
SMW	Standard Meterological Week
STSP	Scheduled Tribe Sub Plan
SVPUAT	Sardar Vallabhbhai Patel University of Agriculture & Technology
Th	*Trichoderma harzianum*
TNAU	Tamil Nadu Agricultural University
TPR	Transplanted Rice
TSP	Tribal Sub Plan
UAHS	University of Agricultural and Horticultural Sciences
UP	Uttar Pradesh
UV	Ultra Violet
VAM	Vesicular-Arbuscular Mycorrhiza
VPKAS	*Vivekananda Parvatiya Krishi AnusandhanSansthan*
WAS	Weeks After Sowing
WBPH	White Backed Plant Hopper
WDG	Water Dispersible Granule
WG	Wettable Granules
WHO	World Health Organization
WLH	White Leaf Hopper
WP	Wettable Powder
WSB	White Stem Borer
WSG	Water Soluble Granule
YSB	Yellow Stem Borer
ZARS	Zonal Agricultural Research Station


Extension Folder-69
NCIPM
Integrated Pest Management approaches against major insect pests and diseases of Tomato
Raghavendra K.V., Rekha Rohdi and Subhash Chander
ICAR-National Research Centre for Integrated Pest Management

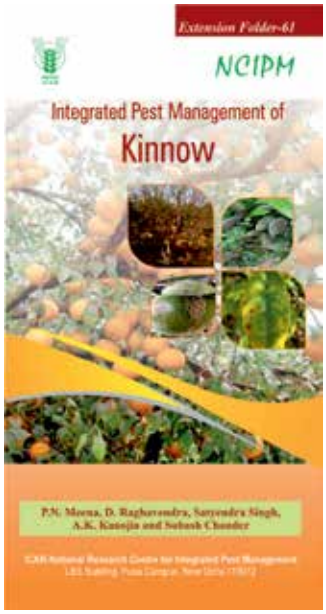

Extension Folder-64
NCIPM
Integrated Pest Management of
Mango
D. Raghavendra, P.N. Meena and Subash Chander
ICAR-National Research Centre for Integrated Pest Management
LBS Building, Pusa Campus, New Delhi-110012

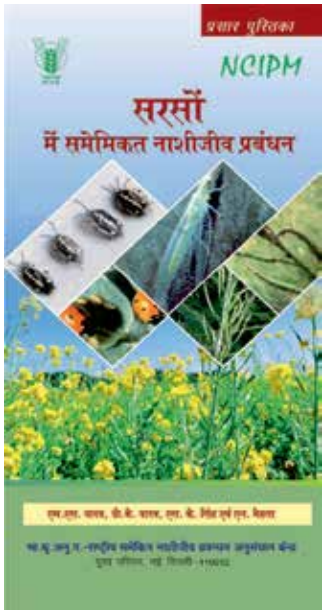

Extension Folder-58
NCIPM
Integrated Management of Melon Fruit Fly in Cucurbitaceous Vegetables
D. Raghavendra, M Narayana Bhat and Subash Chander
ICAR-National Research Centre for Integrated Pest Management
LBS Building, Pusa Campus, New Delhi-110012


प्रसार पत्रक–62
NCIPM
मक्का
में समेकित नाशीजीव प्रबंधन
मुकेश कुमार खोचर अनूप कुमार, एस. पी. सिंह एवं मुकेश सहगल
भा.कृ.अनु.प.-राष्ट्रीय समेकित नाशीजीव प्रबन्धन अनुसंधान केन्द्र
पूसा परिसर, नई दिल्ली–110012


Extension Folder-57
NCIPM
Integrated Pest Management in
Cole Crops
S. P. Singh, M. N. Bhat, Satyendra Singh, S.P. Singh and Subash Chander
ICAR-National Research Centre for Integrated Pest Management
LBS Building, Pusa Campus, New Delhi-110012

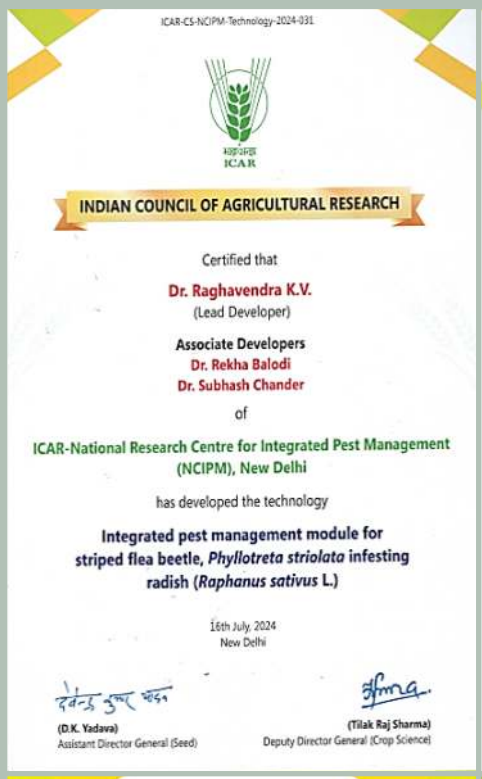

प्रसार पत्रक–71
NCIPM
स्पलेट तकनीक (SPLAT) द्वारा
कपास में गुलाबी सुंडी का प्रबंधन
भा.कृ.अनु.प.-राष्ट्रीय समेकित नाशीजीव प्रबन्धन अनुसंधान केन्द्र
पूसा परिसर, नई दिल्ली–110012


Extension Folder-61
NCIPM
Integrated Pest Management of
Kinnow
P.N. Meena, D. Raghavendra, Satyendra Singh, A.K. Kanojia and Subash Chander


प्रसार पुस्तिका
NCIPM
सरसों
में समेमिकत नाशीजीव प्रबंधन


NRIIPM/ICT/ Ext.-Folder/2025/1
NRIIPM
भारत सरकार / Government of India
कृषि एवं किसान कल्याण मंत्रालय / Ministry of Agriculture & Farmers Welfare
कृषि एवं किसान कल्याण विभाग / Department of Agriculture & Farmers Welfare
NPSS
National Pest Surveillance System (NPSS)
Niranjan Singh
Anoop Kumar, Manoj Choudhary, D Raghavendra,
S. K. Singh and Meenakshi Malik

ISBN No. : 978-81-999165-4-8


ICAR-CS-NCIPM-Technology-2024-031

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr. Raghavendra K.V.
(Lead Developer)

Associate Developers
Dr. Rekha Balodi
Dr. Subhash Chander

of

ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

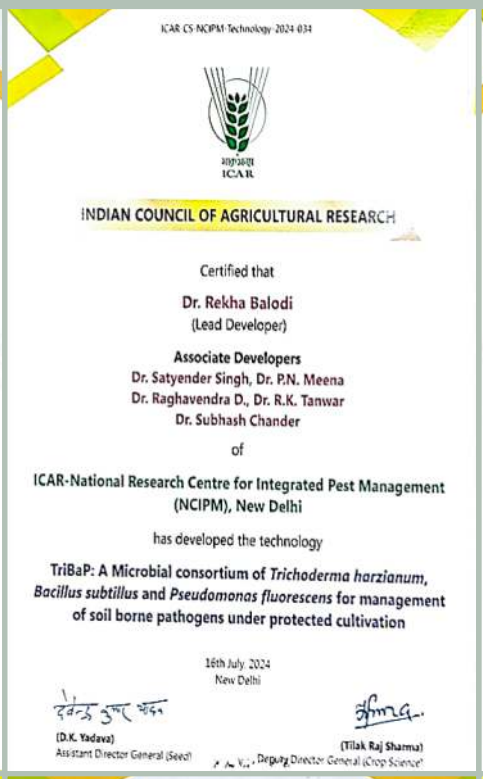
has developed the technology

Integrated pest management module for striped flea beetle, *Phyllotreta striolata* infesting radish (*Raphanus sativus* L.)

16th July, 2024
New Delhi

(D.K. Yadava)
Assistant Director General (Seed)

(Tilak Raj Sharma)
Deputy Director General (Crop Science)


ICAR-CS-NCIPM-Technology-2024-034

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr. Rekha Balodi
(Lead Developer)

Associate Developers
Dr. Satyender Singh, Dr. P.N. Meena
Dr. Raghavendra D., Dr. R.K. Tanwar
Dr. Subhash Chander

of

ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

has developed the technology

TriBaP: A Microbial consortium of *Trichoderma harzianum*, *Bacillus subtillus* and *Pseudomonas fluorescens* for management of soil borne pathogens under protected cultivation

16th July, 2024
New Delhi

(D.K. Yadava)
Assistant Director General (Seed)

(Tilak Raj Sharma)
Deputy Director General (Crop Science)


ICAR-CS-NCIPM-Technology-2024-030

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr. Niranjan Singh
(Lead Developer)

Associate Developers
Dr. P. Jey Kumar, Dr. S. Vennila
Dr. S.K. Singh, Dr. O.M. Bamwale
Dr. H.R. Sardana, Dr. D.B. Ahuja
Dr. R.K. Tanwar, Dr. A.K. Kanojia
Dr. S. Chander

of

ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

has developed the technology

E-Pest Surveillance and Advisory System

16th July, 2024
New Delhi

(D.K. Yadava)
Assistant Director General (Seed)

(Tilak Raj Sharma)
Deputy Director General (Crop Science)


ICAR-CS-NCIPM-Technology-2024-033

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr. Ajanta Birah
(Lead Developer)

Associate Developers
Dr. Anoop Kumar, Dr. M.K. Khokhar
Dr. Richa Varshney, Dr. O.P. Navik, Dr. Ajay Mitkari
Dr. S.V. Sonune, Dr. Lakhan Singh

of

ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

has developed the technology

Cotton IPM technology with major focus on the management of pink bollworm (*Pectinophora gossypiella*)

16th July, 2024
New Delhi

(D.K. Yadava)
Assistant Director General (Seed)

(Tilak Raj Sharma)
Deputy Director General (Crop Science)


ICAR-CS-NRIPM-Process-2025-030

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr Sumitra Arora
(Lead Developer)

Associate Developers
Dr Chitra Srivastava, Dr J. Stanley
Dr Ramya R.S., Dr Navik Omprakash, Dr Mayabini Jena
Dr Naveenkumar B. Patil, Dr Totan Adak

of

ICAR-National Research Institute for Integrated Pest Management New Delhi

has developed the technology

Phosphine fumigation protocol for Quarantine Pre Shipment Treatment and long-term storage against storage insect pests

16th July, 2025
New Delhi

(Poonam Jasrotia)
Assistant Director General
(Plant Protection & Biosafety)

(D.K. Yadava)
Deputy Director General
(Crop Science)


ICAR-CS-NCIPM-Technology-2024-032

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Certified that

Dr. Mahender Singh Yadav
(Lead Developer)

Associate Developers
Dr. C. Chattopadhyay
Dr. S.K. Singh
Dr. Subhash Chander

of

ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

has developed the technology

Integrated Pest Management Technology package for Indian Mustard (*Brassica juncea*) for Better Economic Benefit

16th July, 2024
New Delhi

(D.K. Yadava)
Assistant Director General (Seed)

(Tilak Raj Sharma)
Deputy Director General (Crop Science)

भा.कृ.अनु.प.-राष्ट्रीय समेकित नाशीजीव प्रबंधन अनुसन्धान संस्थान
राजपुर खुर्द, नई दिल्ली -110 068
ICAR-National Research Institute for Integrated Pest Management
Rajpur Khurd, New Delhi-110 068