NCIPM

Success Stories of Integrated Pest Management in India

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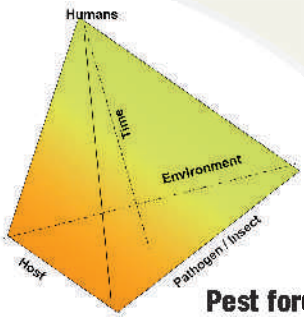
Farmers' needs

Pest (including pathogen, weed, etc.) identification (diagnostics)... at border, during crop surveillance



Pest forecasting

Pest surveillance, monitoring
Modern-day need is E-pest surveillance at National / Global level
IPM begins pre-border (avoidance)

Dissemination of expert information on pest management for quick action to solution

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Foreword

India has moved from scarcity and technological fatigue to technological resurgence and self-reliance in securing food through the route of intensive agriculture by use of chemical fertilizers and pesticides apart from the genes that provided the green revolution. While reaping the benefits of agricultural intensification, India is witnessing signs of its ill-effects that are severely threatening sustainability and safety of human health and environment. Now the question is do we have enough food, feed and fuel for the future? Today we are faced with challenges of climate variability, declining state of natural resources, input use inefficiencies, changing scenario of biotic, abiotic stresses, crop and post-harvest losses and difficulties with access to market. Thus, to trigger hope among the growers, there is need to make farming attractive through improvements in sustainability indices so that while maximizing profits we do not lose sight of minimizing risks, safeguarding whatsoever is produced.

I am extremely pleased to see that ICAR-National Research Centre for Integrated Pest Management is bringing out a compilation of Success Stories of Integrated Pest Management with detailed insights into the strategies developed by NCIPM for different crops suited to varied agro-climatic locations. This publication is not only a technical primer but a way to understand how to implement IPM in the field. It is a publication on 'do how' which would be an addition to knowledge about IPM. It would be of great help to all the stakeholders of IPM including researchers, policy makers, literate community including students and field functionaries. I feel this work will be a stimulant to the agricultural community for practical information and tips for planning, execution and evaluation of IPM. All the chapters written in this book are based on the work pioneered by NCIPM, and are technically sound. I congratulate the scientists of NCIPM for their untiring efforts. I wish them all the best for their future endeavours of IPM, and hope that this publication will be one of the most useful contributions in the area of crop protection.

29/12/15

(Jeet Singh Sandhu)
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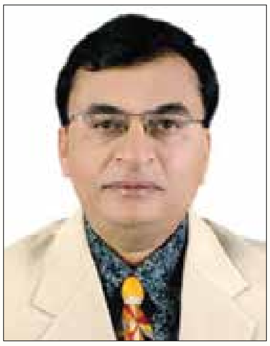

Foreword

Agriculture holds a pivotal role in promoting food and nutritional security of people, supporting livelihoods of farmers and ensuring sustainable development of nations like India. Agriculture today is increasingly affected by degradation and over-exploitation of natural resources, increased frequency of extreme weather events influenced by climate change and excessive application of synthetic inputs on farms including injudicious use of pesticide or even use of banned or spurious ones. Under such a situation Integrated Pest Management (IPM) offers an alternative that is safer for human and environmental health.

IPM is an ecosystem approach to crop protection and production that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. IPM encompasses a series of pest management evaluations, decisions and control methods to reduce pest populations to levels where pests cannot cause significant economic loss. IPM strategy includes the use of pest-resistant crop varieties, modification of agronomic practices, biological control, other innovative approaches, need-based and judicious use of chemical pesticides to reduce pest incidence.

One of the greatest limitations in successful spread of IPM is the lack of adequate awareness among farmers, and often a lack of trust and confidence about the technology among the implementers. Besides, the timely availability of critical inputs, like seeds and good quality biocontrol agents as well as different bio pesticides is critical. Under such a situation validation of IPM strategies in farmers' fields, involving them will help instill faith and confidence in the technology prompting their adoption readily. The whole hearted adoption and internalization of IPM for crop management would also need hand-holding and technology back stopping till farmers develop enough confidence.

During 25 years of its existence scientists of ICAR-NCIPM have strived hard to develop IPM for a number of cropping systems which they successfully validated in farmers' fields. Through their ingenious efforts and acumen, scientists have been able to convince farmers about the benefits of IPM while demonstrating the technologies in their farms and involving them in their endeavours and decision making.

I am glad that some of the success stories on IPM synthesized and validated by the scientists of ICAR-NCIPM have formed a part of this compilation. I am also confident that many more such technologies that have been demonstrated, perfected or validated in pilot scales will be up scaled and translated into success stories in future.

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Preface

Integrated Pest Management (IPM) is a component of integrated crop management that harnesses the practices of crop production in a holistic manner. At first instance, IPM aims to prevent the buildup of harmful organisms (insect-pests, mites, nematodes, vertebrate pests, microbial pathogens *viz.,* fungi, bacteria and viruses), and crop damage from reaching pest status by utilizing a combination of suitable methods such as the use of resistant cultivars, exploitation of natural enemies, augmentation of applied biological control, modification of cultural practices, employing mechanical, physical methods and need-based legislations in an ecologically compatible, economically viable, environmentally sound and pragmatically feasible manner. Secondly, chemical pesticides are used only after monitoring pests following established guidelines as a curative action against the target organism(s) wherein toxicants are chosen judiciously to minimize hazards to crops, human health and the environment. Applied systems research at ecosystem level accounting for interactions of important system variables *viz.,* crop, pests, natural enemies, cropping practices and patterns is a necessity to improve decision making on profitable and sustainable IPM in the era of information technology and precision farming has been the way in India ever since IPM has been adopted as a National policy since 1985.

The ICAR-National Research Centre for Integrated Pest Management (NCIPM) has been validating and refining IPM strategies and practices since its birth in 1988, with the mission of maximizing crop yields through minimization of yield losses due to pests across major agricultural and horticultural crops in tune with the emerging problems across geographical locations of the country. Assimilation of knowledge base on pests, plant protection practices, products and personnel of the country, linking public (institutes of Indian Council of Agricultural Research, State Agricultural Universities, *Krishi Vigyan Kendras* and State Department of Agriculture) and private institutions (non-governmental organisations and industries) for an effective large-scale IPM implementation fortified through trainings-cum-consultancies have been in vogue for an efficient and improved crop protection across the country. NCIPM envisages larger role in making IPM more effective through higher levels of integration of multidisciplinary technologies including information and communication technology (ICT), and of stakeholders by means of improved research, education, training and extension for an enhanced crop and ecological health, and sustainable agricultural growth. Achievements made by the Centre over the past 25 years have been through successive experiences gained through the farmer participatory implementation of IPM at farm fields. Pre-season pest management practices, guidance in selection of crops and cultivars suited to soils, timely planting, continuous monitoring of crop health and pest status, conservation practices for native natural enemies, use of timely and quality inputs of bio-rationals integrated with location-specific crop production practices formed the basis of IPM. Real time pest-status based management advisories including the right selection of synthetic pesticides at accurate dosages applied using appropriate appliances and method successfully demonstrated the IPM strategy with increased net returns accrued to the farmers.

The publication of successful technologies of IPM for various field and (rice and pulses), commercial (cotton and oilseeds), vegetable (cauliflower and cabbage) and fruit (kinnow and *khasi* mandarins) crops, development of light traps and implementation of area-wide ICT-based e-pest surveillance, and advisories through short message services to farmers with the needful creation of IPM awareness has been the result of hard work by scientists, technical, administrative and supporting staff of NCIPM along with many other researchers and field functionaries engaged in the field of plant protection across the country. At this point, I take privilege to salute the guidance, support and encouragement from ICAR Headquarters [led by Director Generals Dr. RS Paroda, Dr. Mangala Rai and Dr. S Ayyappan], Deputy Director Generals, Assistant Director Generals (Plant Protection), Hon'ble members of Quinquennial Review Teams, Research Advisory Committees, Institute Management Committees, funding agencies, leadership of former Directors of ICAR-NCIPM and all the collaborators that the Centre received to script these successes. While I appreciate the successful journey of ICAR-NCIPM over time and space, it is expected that this publication would serve as a land mark for furthering the cause of IPM in crops in the coming days.

18 Jan 2016

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Editors and authors of all the eleven chapters of "Success Stories of Integrated Pest Management in India" thankfully acknowledge the sincere and active participation of individual as well as team of researchers, extension personnel and farmers across the country for the effective implementation of IPM at field level. The administrative and technical support rendered by co-opted centers including the Department of Agriculture across crops and States deserve grateful appreciation. Much of the successes of IPM quoted in this book have been the result of the financial impetus provided by the Ministry of Agriculture and Farmers' Welfare through various schemes and programmes for which ICAR-NCIPM remains highly thankful. The interest shown by the planners, policy makers, and practitioners of IPM, and the assistance of field staff engaged for pest observations together elevated the level of IPM validations and demonstrations across the country. We extend our deep appreciations for Dr. S. Ayyappan, Secretary, DARE & DG, ICAR, Dr. J. S. Sandhu, DDG (CS), ICAR and Dr. P. K. Chakrabarty, ADG (PP&BS), ICAR for their constant guidance and encouragement. Commendations are all due for the stewardship provided by the erstwhile research managers *viz*., Drs. B. L. Jalali, S. N. Puri, Amerika Singh and O.M. Bambawale of ICAR-NCIPM. Resource persons of ICAR, SAUs, *KVK*s, SDAs and suppliers of IPM inputs (biocontrol laboratories, seed, fertilizer and pesticide industries) and non-governmental organizations, who have played the role of IPM promotion merit our profound thankfulness. We express our gratitude to all the administrative, technical and supporting personnel besides the research associates, senior research fellows and skilled professionals of NCIPM and associated institutions who joined hands in various programmes for the cause of plant protection in the selected agricultural and horticultural crops including trainings and exhibitions of IPM held then and now. We are also thankful for the timely help and technical support rendered by Dr V. K. Bharti, Mrs. Neelam Mehta, Mr. Satendra, Ms. Kanchan Sharma and Mr. Amit Kumar for preparation of this publication. Design, type setting and printing done by National Printers, Naraina, New Delhi are gratefully acknowledged.

Editors and Authors

Abbreviations

AAU	Assam Agricultural University
ADO	Agriculture Development Officer
AICRP	All India Coordinated Research Project
ALS	Alternaria Leaf Spot
ARS	Agricultural Research Station
ASP.NET	Active Server Pages in .NET framework
BAU	Birsa Agricultural University
BHU	Banaras Hindu University
BLB	Bacterial Leaf Blight
BPH	Brown Plant Hopper
CCRI	Central Citrus Research Institute
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
cfu	Colony Forming Units
CICR	Central Institute for Cotton Research
CIPHET	Central Institute of Post-Harvest Engineering and Technology
CIPMC	Central Integrated Pest Management Centre
CRIDA	Central Research Institute for Dryland Agriculture
CROPSAP	Crop Pest Surveillance and Advisory Project
CRSV	Citrus ring spot virus
CTV	Citrus Tristeza virus
DAC	Department of Agriculture and Cooperation
DAP	Di Ammonium Phosphate
DAS	Days After Sowing
DAT	Days After Transplanting
DDVP	Dichlorovinyl Dimethyl Phosphate
DGR	Directorate of Groundnut Research
DVD	Digital Versatile Disc
EIQ	Environmental Impact Quotient
EPA	Environmental Protection Agency
ETL	Economic Threshold Level
FDL	Fully Damaged Leaves
FFS	Farmer Field Schools
FNP	Field Nematode Population
FPT	Farmers' Participatory Training
FYM	Farm Yard Manure
GIS	Geographic Information System
GPS	Global Positioning System
HortiSAP	Horticulture Surveillance and Advisory Project
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICM	Integrated Crop Management
ICT	Information and Communication Technology
IIPR	Indian Institute of Pulses Research
INM	Integrated Nutrient Management
INR	Indian Rupees

IPM	Integrated Pest Management
IPR	Intellectual Property Rights
ISAP	Indian Society of Agribusiness Professionals
IST	India Standard Time
ITK	Indigenous Technical Knowledge
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
KVK	*Krishi Vigyan Kendras*
LLS	Late Leaf Spot
MAU	Marathwada Agricultural University
MRL	Maximum Residue Level
NAA	Naphthalene Acetic Acid
NCIPM	National Research Centre for Integrated Pest Management
NCR	National Capital Region
NFSM	National Food Security Mission
NICRA	National Innovations on Climate Resilient Agriculture
NIPM	Non Integrated Pest Management
NISPM	National Information System for Pest Management
NPK	Nitrogen, Phosphorous and Potassium
NSKE	Neem Seed Kernel Extract
OPMAS	On-Line Pest Monitoring and Advisory Services
PAU	Punjab Agricultural University
PCT	Patent Cooperation Treaty
PMU	Pest Monitoring Unit
PSB	Phosphate Solubilizing Bacteria
PSND	Peanut Stem Necrosis Disease
RHC	Red Hairy Caterpillar
RKN	Root Knot Nematode
RKVY	*Rashtriya Krishi Vikas Yojana*
RRS	Regional Research Station
RTPD	Real Time Pest Dynamics
SKNAU	Sri Karan Narendra Agriculture University
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SMD	Sterility Mosaic Disease
SMS	Short Message Service
SMW	Standard Meteorological Week
SQL	Structured Query Language
SRI	System of Rice Intensification
SSP	Single Super Phosphate
TAP	Technical Assistance Programme
UAHS	University of Agricultural and Horticultural Sciences
UAS	University of Agricultural Sciences
UHAS	University of Health and Allied Sciences
URL	Uniform Resource Locator
WBPH	White Backed Plant Hopper
XML	Extensible Markup Language
YSB	Yellow Stem Borer
ZARS	Zonal Agricultural Research Station
ZREAC	Zonal Research and Extension Advisory Committee

Contents

INTEGRATED PEST MANAGEMENT IN COTTON AT ASHTA VILLAGE

OP Sharma[1], KS Murthy[1], SN Puri[1], RC Lavekar[2] and CD Mayee[3]

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INTRODUCTION

Cotton is a key cash crop having direct bearing on socio-economic structure of farmers of Marathwada region of Maharashtra. It continues to suffer heavily from a complex of insect-pests and diseases, which affect the crop from seedling to harvest stage. The losses due to pests amount to 50-60% resulting in substantial yield reduction. Attaining the projected demand of 24 million bales of cotton by the end of 2020 will be a daunting task despite the intensive cropping and pest management systems that are currently available. Calendar-based application of chemical insecticides and their injudicious use was the prime strategy to manage the various pests during 1980s. Though the crop occupied only 5% arable land, it consumed 54% of the total chemical pesticides before introduction of transgenic cotton in 2002. The altered cropping systems, multiplicity of non-descript cultivars, imbalanced fertilizer use, and intensive cultivation have aggravated the problems of pests and environmental hazards. IPM strategies had become imperative to sustain productivity of cotton in an ecofriendly manner. A bio-intensive IPM module with much reliance on conservation and promotion of naturally occurring bioagents, biopesticides and botanicals as tools for sustainable production of cotton was validated over 200 hectares under farmers' field conditions at Ashta village located in Nanded district of Maharashtra State (MS), a predominantly rainfed cotton belt.

ASHTA – THE IPM VILLAGE

Ashta is located in the tribal belt of Kinwat tehsil of Nanded district (Marathwada region of Maharashtra) on the border of districts of Adilabad (Andhra Pradesh) and Yavatmal (Maharashtra). Major crops such as cotton intercropped with pigeonpea, blackgram, jowar, groundnut, maize, soybean and chickpea covered the total arable land of 935 ha. The soil is light black alluvial.

REASONS FOR THE SELECTION OF ASHTA

Ashta was selected for implementing sustainable cotton IPM strategy on a village basis for two reasons:

i) It was representative of rainfed cotton growing conditions of 11 districts of Maharashtra and four districts of Andhra Pradesh.

ii) The village had experienced a large-scale epizootic of *Helicoverpa armigera* in 1997-98 season and faced a total crop failure, and the farmers had decided to shift to other crops in the subsequent year.

Scenario of cotton production practices

The village was found to be vulnerable to recurrent pest attacks due to the following reasons:

- **Multiplicity of cotton cultivars:** Farmers were growing 8-10 varieties/hybrids of cotton as a risk cover.
- **Staggered sowing:** The sowing operation spread from May end to early July. As a result, the vulnerable stages of the crop (buds and bolls) were available for a longer duration.
- **Imbalance in use of fertilizers:** Excessive use of nitrogen fertilizer resulted in higher vegetative growth which attracted more pests.
- **Continuous availability of *Helicoverpa* hosts in the cropping system:** Pigeonpea and chickpea grown in the cotton-based cropping system provided for sustenance of the pest cycles.
- **Sanitation:** Cotton stalks after the seed cotton harvest were not removed from the

field immediately, which provided niche for continuation of the pink bollworm population.

- **Ratooning:** Some farmers practised ratooning of cotton.

Scenario of cotton protection practices

Among the insecticides, monocrotophos (17.35%) was the most widely used by Ashta farmers followed by endosulfan (12.26%), dimethoate (10.8%), cypermethrin (9.95%) and fenvalerate (7.35%) were widely used amongst the chemical pesticides. Among the combinations of pesticides used, endosulfan + dimethoate ranked first and was adopted by 56.5% of the farmers. Cypermethrin + monocrotophos or monocrotophos + dimethoate combination was used by 13.5% farmers. Methomyl + Neemark accounted for 23.66% adoption. All these streams of practices coupled with the predisposing ecological factors contributed to the pest problems, particularly bollworms and grey mildew. The seed cotton yield ranged from a minimum of 0.75 q/ha to a maximum of 3.75 q/ha with an average of 2.20 q/ha despite heavy dependence of the farmers on the use of chemical pesticides. Thus, the village offered ample challenge and scope for implementation of the IPM approach.

CREDIT AVAILABILITY FOR FARMERS

In the absence of any institutional credit facility, the farmers had to depend on the local money lenders (mostly the pesticide dealers) who became their local advisors for the selection of chemical pesticides taken on credit. Cotton being the sole cash crop of the area, the farmers were reluctant to take any risk, and solely depended on chemical pesticides for the management of pest problems.

DEVELOPMENT AND VALIDATION OF THE IPM MODULE

Existing literature and the work carried out by various ICAR institutes as well as SAUs on rainfed cotton pest management formed foundation to formulate IPM modules for their field testing during 1995. Since the Marathwada region was well suited for testing of technology the co-operation of Marathwada Agricultural University, Parbhani was sought. It was decided to carry out experimentation at Agricultural College, Nanded in collaboration with Cotton Research Station, MAU, Nanded. Four IPM modules were synthesized *viz.,* bio-intensive, bio-control + insecticides, biocontrol + intercrop and chemical modules.

The higher seed cotton yield obtained in bio- intensive + insecticide module signifying higher population of predators and parasitoids in 1996 indicated promise for an eco-friendly pest management approach. Consequently, the trial was repeated for the second year (1997) in the same area along with its implementation on pilot scale in 5 ha of a progressive farmer's field at village Barad located in Nanded (MS) district. During 1997 the (bio-control + intercrop) module proved very effective in managing not only aphids but also jassids, thrips and whiteflies.

COMPONENTS OF THE BIO-INTENSIVE MODULE

As per feedbacks and observations made during three years (1995-1997) of validation, a number of modifications were made in the module. The successfully tested module comprised use of bioagents, biopesticides and botanicals based on scouting and constant monitoring of pests and their economic threshold levels (ETL) with introduction of suitable crop management practices. The management practices adopted in the bio-intensive module were:

- Mass motivation of farmers for large-scale field sanitation.
- Uniform sowing windows using certified acid delinted seeds of single hybrid (NHH-44) and a variety (Renuka) in the entire village. Synchronized sowing was completed within a week in the entire village, soon after the onset of monsoon rains, which usually coincide with last week of June.
- Seed treatment with imidacloprid @ 7 g a.i./kg of seed.
- Use of recommended spacing of 90 cm x 60 cm and 60 cm x 30 cm, respectively for the hybrid and the variety. Planting of maize as border crop interspersed with cowpea to provide substrate for buildup of coccinellid (lady bird beetles) predators and their migration to cotton.
- A row of *Setaria* was planted between every 9 or 10 rows of cotton to enhance the activity of predatory birds by serving as food source and acting as live perch.
- *Trichogramma chilonis* @ 1,50,000/ha was released in cotton fields when 2-8 adult moths of *H. armigera* per pheromone trap were captured continuously for 3-4 days in a week.

- Neem seed kernel extract (NSKE) 5% (w/v) was sprayed a week after release of *T. chilonis*.
- Application of *Ha*NPV @ 250 LE/ha was made based on the ETL of *H. armigera*.
- Low incidence of diseases did not warrant management at the whole village level. However, in some pockets, the crop at the first picking in the later stage was found severely affected with grey mildew (*Ramularia areola*). Such a situation in 1999-2000 season was managed with either carbendazim or wettable sulphur.

A comparison of IPM interventions with main stream practices as adopted by farmers in the adjoining village Murli (referred as non-IPM) were also taken up.

SCOUTING AND MONITORING FOR CROP PROTECTION DECISIONS

Regular field scouting formed a vital component of the pest management as it provided reliable information on the time when pest reached the economic threshold level. Management measures were applied when pest population reached ETL.

FARMER FIELD SCHOOLS (FFS) APPROACH TO IPM IMPLEMENTATION

Scientists and farmers collaborated as partners in farmer participatory trials for IPM development. In order to have continuous interactions, farmers field school mode was adopted to seek solutions to the identified constraints. To enable develop confidence in the farming community to abandon calendar-based preventive schedule and make their own decisions based on farm-specific needs, considerable understanding of agro-ecological processes, particularly the role of natural enemies was developed. They were trained in specific skills like identification and differentiation between beneficial and harmful insects, methods of scouting and use of pheromone traps.

There were no standard recommendations or package of practices but use of inputs were need-based. In the FFS, farmers were encouraged to collect pest/disease data and undertake action accordingly. Farmers became active learners and independent decision makers through the process of learning by doing. Early harvest and stalk destruction were promoted as the most effective cultural and mechanical practices for managing pink bollworm on community basis. These practices reduced the habitat and food available to the pink bollworm, *Helicoverpa* bollworm and *Spodoptera litura*.

IMPACT OF ASHTA IPM

Insect pest and disease scenario

Prior to 1998 the emerging seedlings suffered attack by millipedes under conditions of heavy monsoon rains. Seed treatment with imidacloprid since 1998 provided an umbrella of protection in IPM fields while in the adjoining non-IPM Murli village, the farmers had to resow the crop owing to reduced plant stand caused by seedling mortality due to millipedes. The seed decay as well as seedling mortality caused due to *Alternaria* spp., *Aspergillus* spp., *Colletotrichum gossypii*, *Chaetomium* spp., *Fusarium* spp., *Pythium* spp., *Rhizopus* spp., *Macrophomina phaseolina*, *Rhizoctonia bataticola*, *R. solani*, *Sclerotium rolfsii*, and *Xanthomonas axonopodis* pv. *malvacearum* were noticed at moderate levels in the non-IPM village. However, these were only in traces at Ashta and appeared to have been taken care of by the field sanitation measures followed and acid-delinting of seeds. The crop though was affected by a number of foliar diseases *viz., Alternaria macrospora*, *Myrothecium roridum*, *Cercospora gossypina* and *Colletotrichum gossypii*, the disease development was restricted to early stage due to unfavourable microclimate resulting from an adopted crop architecture. Most of foliar diseases dependent on free water or high humidity could not prevail there due to free air flow provided by wider spacing between the rows and plants. Grey mildew did appear in severe form at boll dehiscence stage which warranted fungicidal (wettable sulphur or carbendazim) application in 1999. Due to heavy rains crop suffered to some extent heavily due to boll rot caused by a number of opportunistic pathogens viz., *Fusarium moniliforme*, *F. compactum*, *Phytophthora* spp., *Myrothecium roridum*, *Alternaria macrospora* and *Colletotrichum capsici*.

Most of the dried bolls were having clear marks of bollworm injury with the frequency of double seeds caused by pink bollworm. Sap sucking pests like jassids (*Amrasca devastans*), aphids (*Aphis gossypii*), thrips (*Thrips tabaci*) and whiteflies (*Bemisia tabaci*) and bollworms *viz.*, spotted bollworm (*Earias insulana*), pink bollworm (*Pectinophora gossypiella*) and American bollworm (*Helicoverpa armigera*) were recorded in IPM (Ashta) as well as non-IPM (Murli) fields as per standard methods, and the average pest population was assessed. The population of sucking pests in general was low in

IPM fields as compared to non-IPM. Seed treatment with imidacloprid kept the sucking pests at bay for more than 50 days of the crop. Apart from this, the higher incidence of coccinellids and chrysopids in IPM fields and planting of maize interspersed with cowpea as border crop provided optimal conditions for multiplication and conservation of these natural enemies which regulated the population of the sucking pests as compared to non-IPM plots.

The number of bollworm larvae (*E. insulana*, *P. gossypiella* and *H. armigera*) per plant showed that population of *Helicoverpa* were less by half (0.13 larvae/plant) in comparison to non-IPM. Similarly, marked differences existed in the population of pink bollworm (0.17 and 0.30) and spotted bollworm population (0.09 and 0.14), respectively in IPM and non-IPM fields. Parasitisation of the bollworm larvae by the natural enemies was critical under least chemical interventions (0.3 and 0.1 per plant of coccinellids and 0.5 and 0.2 eggs of *Chrysoperla*/plant in IPM and non-IPM, respectively). Also the reduction in bollworm population in IPM field can be attributed to the growing of a row of *Setaria* after every 10^{th} row of cotton. *Setaria* flowers attracted birds (myna, finches and black jay) and provided perch which in turn predated upon the larvae pest on cotton crop.

ECONOMICS OF IPM

The IPM module resulted in substantial reduction of chemical insecticide use and avoided overhead expenditures on crop protection, conserved natural fauna and created a congenial atmosphere for the natural force of defense to act. The bio-intensive technology provided higher net returns and yields over the farmers' practices (non-IPM) during 1997 crop season. The average seed cotton yield was 962.5 kg/ha as compared to 220 kg/ha during the previous season (1997), which reflected a difference of 742.50 kg/ha or an increase of 77.1% (4.37 times) over the 1997, while in the neighbouring village Murli, the yields of seed cotton under farmers' practice was 577.5 kg/ha.

The yields from cotton were supplemented by yields of *Setaria* and provided additional net returns and remuneration. The total cost of IPM inputs exclusive of the labour charges amounted to ₹1545/ha which downsized the expenditure on cost of plant protection by over ₹1680/ha as compared to the input cost under the farmers' practices (₹3225/ha) that reflected a decrease in the cost to the tune of 52.1% over the previous season. The cost benefit ratio of IPM over the farmers' practice (non-IPM) at Ashta was 1:10.69, while at Murli the ratio was 1:5.01. The IPM practices resulted higher in monetary gains of ₹ 17,705 as compared to ₹ 9950 in non-IPM (farmers' practices) with IPM gains to the tune of 56.2% per hectare.

The general impacts of the Ashta IPM are as below:

- Conservation and enhancement in the activity of the natural enemies (predators and parasites)
- Reduction in the quantity of chemical insecticides used
- Environmental safety as evident by increase in the number of bird population in the crop.
- Compensatory yields and higher net returns

IMPACT ON ENVIRONMENT

Regular crop health monitoring revealed that the use of eco-friendly bio-pesticides and conservation of egg parasites and predators had resulted in restoration of clean environment. The population of predatory lady bird beetles was 0.04-0.36 adults/plant under the non-IPM practices compared to the 3.00 to 4.8 adults/plant in IPM fields. The population of green lace wing (*Chrysoperla*) was negligible in non-IPM plots compared to 1.4 eggs/plant in IPM plots. Planting *Setaria* as intercrop between 9^{th} and 10^{th} row of cotton and providing bird perches enhanced the activity of the predatory birds (bulbul), and the predation of bollworm larvae was to the extent of 52-54%. Field collected bollworm larvae had shown 100% parasitisation. The conservation of natural enemies and reduced usage of chemical pesticides had made the cotton ecosystem, a habitat congenial for the birds to build their nests, which was hitherto an unusual phenomenon. All the practices under the IPM provided for a safe environment.

LESSONS LEARNT FROM ASHTA

- Performance depends on the active participation of the farmers and co-operation of developmental agencies.
- Women participation and motivation aids in quicker dissemination of the technology.
- Training is mandatory for successful implementation and adoption.
- IPM impacts are visible only when adopted on a large scale and
- Timely supply of inputs is indispensable.

Indian Council of Agricultural Research

ICAR Award for Team Research, 2001-2002

The ICAR Award for Team Research
for the Biennium 2001-2002
is presented to

Prof. Amerika Singh, Dr O.M. Bambawale, Dr O.P. Sharma, Shri R.C. Lavekar, Dr A. Dhandapani, Dr S.N. Puri, Dr C.D. Mayee and Dr S.K. Murthy

for their outstanding research contribution in the field of

Pest Management

New Delhi
19 October 2004

Mangala Rai
Director-General

Sharad Pawar
Union Minister for Agriculture

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

ICAR AWARDS FOR OUTSTANDING MULTI-DISCIPLINARY TEAM RESEARCH IN AGRICULTURE AND ALLIED SCIENCES FOR THE BIENNIUM 2001-2002

CITATION

The ICAR Award for Team Research for the Biennium 2001-2002 is given to Prof. Amerika Singh and his team for their significant contribution in handling different components of pest management in an eco-friendly manner.

Cotton in India occupies around 9 million ha supporting 60 million people. Due to increased pest attack, cultivation of cotton has not only become costly but also very risky. It has become a challenge to plant-protection specialists to develop suitable technology. A landmark in cotton production has been the validation of IPM incorporating ICM practices and Habitat management involving entire village of Ashta, District Nanded (1998-2001), a representative of > 2 million ha rainfed cotton in Central India, in a Farmers' Participatory Mode. The system successfully faced varying pest situations during the four years including the onslaught of *H. armigera* in 2001, mainly through conservation of natural enemies and is sustainable even after withdrawal of direct support from 2002. The cost of plant protection reduced by 31.3%, chemical pesticide consumption reduced by 94.3% and seed cotton yield increased by 56.9%. The successful Ashta experience prompted its adoption as a role model under Technology Mission on Cotton. The Ashta model has also been found indispensable in drawing maximum benefits from Bt transgenic cotton. The massive effort spread across 8 years from its inception to sustainable stature involved continued, harmonious team effort and has shown a way for similar efforts in other crops.

The research work was conducted at the National Centre for Integrated Pest Management, IARI Campus, New Delhi.

I really enjoy how rewarding it is to provide peace of mind to people in a panic by solving their pest problems

– Jesse Huie, IPM Specialist

IPM FOR CROP HEALTH CARE IN *BT* COTTON

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INTRODUCTION

Commercialization of *Bt* transgenic genotypes in 2002 brought revolution in cotton production in India as a result of which during 2009-10 area under cotton reached the highest in the world *i.e.,* 10.33 m ha that produced 29.5 m bales. India became the second largest producer of seed cotton globally. The contribution from *Bt* cultivars was nearly 90% which occupied 8.4 m ha. Up to 69% reduction in usage of chemical pesticides was achieved by growing *Bt* transgenic cotton. Further commercialization of Bollgard-II (2006) expressing Cry1Ac and Cry2Ab together almost erased lepidopterous pests from the cotton crop scenario that paved way for dominance of sucking insect-pests. By 2010 six different *Bt* transgenic events had been approved for commercial cultivation in India followed by many more in the following years.

As transgenic *Bt* cotton effectively managed specific lepidopterous species, the technology resulted in significant reduction in the use of chemical insecticides. *Bt*-cotton hybrids have effectively protected the crop from bollworms. But due to lack of resistance against emerging insect-pests and the changes in pest management systems with reduction in chemical pesticides, sucking species have become more significant in *Bt* cotton. As a predicted phenomenon newly emerged insect-pests especially sucking pests became an issue in sustainability of *Bt* cotton in India among several countries. During 2004, cotton mealybug made its first appearance in *Bt* cotton in Gujarat and by 2006 acquired the status of major pest not only in Gujarat but also in all other major cotton growing areas. The incidence, spread and management of mealybug *Phenacoccus solenopsis* Tinsley (Pseudococcidae: Hemiptera) during 2006-2009 in India stands as a land mark. In the management of mealybug, ICAR- National Research Centre for Integrated Pest Management played a pivotal role in collaboration with other agencies. The present contribution is the summary of the work undertaken for mealybug awareness programme along with recent efforts made at Jind (Haryana) towards conservation of natural enemies in *Bt* cotton.

MEALYBUG AWARENESS PROGRAMME

Mealybug (*P. solenopsis*), a pest never reported earlier in India, made its appearance for the first time on *Bt* cotton in Gujarat in 2004 and became a threat to cotton by 2005-06. The pest entered into Punjab in 2006 along with *Bt*-seed cotton and by 2007 acquired the status of major pest in all the eight major cotton-growing districts of Punjab causing a loss of ₹ 1590 millions to the farmers. Its epizootic in Punjab was threatening the crop in adjoining states of Haryana and Rajasthan. To overcome the mealybug menace, NCIPM developed an integrated management strategy, which was successfully implemented through the *Mealybug Awareness Programme-Punjab* (sponsored by Ministry of Agriculture, Government of India to NCIPM) in collaboration with PAU Regional Research Station, Faridkot, State Agriculture Department, Punjab and CIPMC, Jalandhar during 2008-09 in eight districts of Punjab *viz*., Ferozepur, Moga, Faridkot, Muktsar, Bhatinda, Mansa, Barnala and Sangrur. In Punjab 320 villages were covered under the surveillance programme as fixed villages, whereas another 160 villages were randomly surveyed at weekly intervals. Surveillance activity was focused on the species composition and infestation of mealybug on cotton crop and its secondary host, *i.e.*, *Parthenium* throughout the cotton season of 2008-09. Accordingly, suitable alerts were issued to Chief Agriculture Officer of respective districts for further dissemination and management at hotspots.

TRAINING AND EXTENSION

Master Trainers were trained from eight cotton-growing districts of State Agriculture Department (Punjab) on identification, life cycle, dispersal and management strategies of mealybug. During the training they were provided with extension material such as posters and folders, for further multiplication and distribution to farmers (Table 1). The master trainers in-turn trained the progressive farmers of the 950 selected villages, who further imparted the knowledge to other fellow farmers in their respective villages. A video film in Hindi titled "*Kapas mein mealybug ka samekeet prabhandhan*" (13 min) was prepared by ICAR-NCIPM. Punjabi version of the DVD "*Kapas che mealybug da sarvapakkhi prabhandhan*" was also prepared in collaboration with CIPMC, Jalandhar (Punjab). Around 1000 copies each of Hindi and Punjabi DVDs were produced and distributed to the extension functionaries throughout the country. The Punjabi DVDs were also distributed to the "*Sarpanchs*" of 320 villages for onward dissemination of the knowledge to the farmers through "*Panchayat Ghars*". The knowledge and management strategy for the emerging pest, mealybug was disseminated to majority of farmers, improvising their knowledge to tackle the likely menace during 2008-09 season.

Management strategies

- Application of chlorpyriphos in neglected unattended fields having weeds such as *Trianthimum monogynae*, *Parthenium*, etc. infested with mealybug.

Fig. 1 : Dry cotton sticks stacked in field carrying mealybugs during off season; yellow arrow indicates a barrier of insecticide applied to prevent movement of crawlers and ants

- Removal of *Parthenium* and other weeds near residence premises, roads, railway line, dumping them in trenches and spray with *Verticillium lecanii* / chlorpyriphos (June to September)
- Application of malathion dust around heaps of dry cotton sticks. Dry cotton sticks used as fuel by farmers in different states are generally stacked in the fields or near the villages which act as a reservoir for spread of mealybugs. During winter, the mealybug remains on these sticks in the form of ovisacs or female mealybugs and on arrival of favourable weather conditions during January, the

Table 1: Trainings and awareness material (numbers) of NCIPM multiplied and distributed by State Agriculture Department, Punjab

District	Master trainers	Trainings of progressive farmers	Villages covered	Posters displayed	Folders multiplied and distributed	Press clippings in newspapers
Barnala	2	10	50	6000	7000	1
Bhatinda	9	4	200	56000	20000	3
Ferozepur	10	22	200	320	-	-
Faridkot	10	96	100	8000	29000	-
Mansa	5	30	150	15000	25000	2
Moga	7	10	50	40000	12000	3
Sangrur	4	10	50	-	37000	3
Muktsar	3	30	150	-	37000	-
Total	50	212	950	125320	167000	12

crawlers emerge from the ovisacs and move to nearby crops or weeds. To prevent such spread of mealybug, the disposal of cotton sticks was advocated. The remaining cotton stacks were applied with malathion dust on the boundary as a layer (Fig. 1) to prevent crawling of mealybug nymphs from cotton sticks to nearby crops / weeds.

- Regular monitoring for mealybug appearance in cotton and spot application of profenophos only on infested plants at early stage instead of spraying the whole field, conserved the natural ecosystem and saved the cost incurred on chemical pesticides (for spraying the whole field).
- Proper precautions were taken while conducting survey as any person entering the field could act as a carrier of mealybug crawlers. Similarly all the equipment needed proper cleaning while moving from one field to another to avoid the transport of mealybug crawlers.
- Need-based application of appropriate chemical pesticides in highly infested fields.
- Organizing periodic meetings with farmers to bring awareness about mealybugs and their management.
- Avoidance of chemical pesticide application if natural parasitoids are observed in fields.

Survey for natural enemies of mealybug at national level

Periodical field surveys were conducted by cotton team of ICAR-NCIPM during 2007-09 in different cotton-growing areas of Haryana, Rajasthan and Punjab in the North Zone and Madhya Pradesh, Maharashtra and Gujarat in the Central Zone. During the survey, it was observed that *P. solenopsis* was the major species of mealybug in cotton in North as well as Central zones except at Gujarat where *Ferrisia virgat* Cockerrel was also recorded. Infestation of mealybug at most of the places in North and Central zones ranged from mild (10-20%) to high (40-60%). During 2007 an efficient natural biocontrol agent, *Aenasius bambawalei* (Chalcidoidea: Encyrtidae) (a new species; Fig. 2) was recorded for the first time on mealybug, *P. solenopsis* on different host plants such as cotton, *Parthenium hysterophorus*,

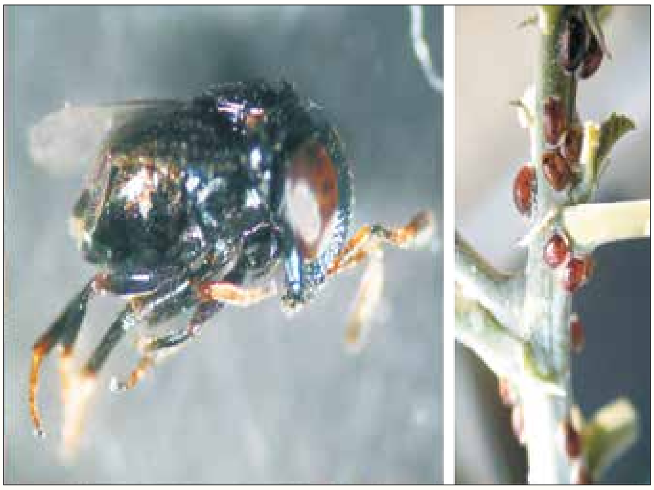

Fig. 2: Female of *Aenasius bambawalei* (Left); Cocoons of *A. bambawalei* on *Achyranthes aspera* (Right).

Xanthium strumonium, *Achyranthes aspera*, etc. The parasitoid was first recorded in Delhi by NCIPM in July 2008 and by 2009 it was found to occur in most of the cotton-growing districts of North and Central zones (Table 2, 3 and 4). Its natural parasitization on *P. solenopsis* could reach more than 90 per cent at many locations. At certain locations, the parasitoids could parasitize the mealybug even at low level of infestation. This is the most successful example of biological control of mealybug.

IMPACT

By creating awareness among the farmers as well as dissemination of surveillance-based advisory, application of chemical pesticides against mealybug was reduced from 2-3 to only spot application at early stage and/ or one application of chemical pesticide, if needed.

In 2008-09, and the subsequent seasons, the mealybug was successfully managed and the epizootic situation did not recur in Punjab. On an average, the farmers applied three rounds of chemical pesticides to contain the mealybug infestation which costed ₹ 1500 per ha (approx.) during 2007-08. Integrated management strategy as well as surveillance-based advisory was able to reduce the chemical pesticide load to spot or one application. Further, due to the establishment of natural parasitoid, *A. bambawalei*, no chemical pesticide was required, at least for mealybug management, as the parasitoid successfully managed the pest. The cost for mealybug management thereby gradually came down to negligible amount.

Table 2 : *Phenacoccus solenopsis* infestation and its parasitization on cotton in the North zone (2007-09)

State	District	Village	*P. solenopsis* infestation (%)			Parasitoids recorded		
			2007	2008	2009	2007	2008	2009
Delhi	New Delhi	IARI Research Farm	20-40	10-20	Tr.	-	*A. b.*	*A.b., P.u.*
Haryana	Hisar	Dhiranwas, Bhatla, Muklan and Raipur Rani	10-20	20-40	Tr.	-	*A. b.*	*A.b., P.u.*
	Fatehabad	Dhangur and Mattana	10-20	20-40	Tr.	-	-	*A.b., P.u.*
	Sirsa	Sahuwala and Peeply	10-20	20-40	Tr.	-	-	*A.b., P.u.*
Punjab	Firozpur	Bhagwanpura and Balluana	40-60	20-30	Tr.	-	-	*A.b., P.u.*
	Muktsar	Kaundal, Mohlan, Mahabadar, Bhalliana and Kotbhai Dhani	40-60	20-30	Tr.	-	-	*A.b., P.u.*
	Bhatinda	Giddarbha and Behman Diwan	40-60	10-20	Tr.	-	-	*A.b., P.u.*
Rajasthan	Hanumangarh	Sangaria	Tr.	20-30	Tr.	-	-	*A.b., P.u.*
		Bhagatpura	Tr.	Tr.	Tr.	-	-	*A.b., P.u.*

(A.b. - A. bambawalei; P.u. - Promuscidea unfasciativentris (a common hyperparasitoid); Tr. - Traces; - no parasitization)

Table 3: Infestation and parasitization of mealybug in different villages of Gujarat during 2008

District	Village	*P. solenopsis* infestation (%)	Parasitoids recorded
Vadodara	Karavan, Kandha and Pingalwada	10-20	*A. b., P. u.*
	Timbermava and Dhavat	20-40	*A. b., P. u.*
	Vemur	40-60	*A. b., P. u.*
Bhavnagar	Dhanduka and (Dhanduka Taluka), Botado (Botado Taluka) Tagadi (Dhanduka Taluka)	Tr. 40-60	*A. b., P. u.*
	Tagadi*	>60	*A. b., P. u.*
	Hamapur and Madavadhal (Gadyhada Taluka)	40-60	*A. b., P. u.*
Rajkot	Vadod	20-60	*A. b., P. u.*
Surendranagar	Thikariayala and Shaikpur	Tr.	-
	Sanosara	40-60	*A. b., P. u.*
	Bhaduka	40-60	*A. b., P. u.*
	Lakhtar and Sardo**	No infestation	-

(A. b.-A. bambawalei; P. u.- Promuscidea unfasciativentris; Tr. –Traces; no parasitoid)
**Desi variety was free from mealybug infestation; **Only Desi variety was grown*

Table 4 : Mealybug infestation and its parasitization by hymenopterous parasitoids in different Tehsils of Parbhani (Maharashtra) during 2008

	Village	Mealybug infestation (%)	Parasitization (%)	Parasitoids recorded
Parbhani	Hasnapur	30.4	33.7	*A. b., P. u.*
	Brahamangaon	60.3	17.4	*A. b., P. u.*
Manwat	Kolhawadi	30.8	75.6	*A. b., P. u.*
	Manawat	25.3	-	*A. b., P. u.*
Pathri	Pathri	Tr.	-	*A. b., P. u.*
	Jaydapur	Tr.	-	*A. b., P. u.*
	Veta	60.6	38.5	*A. b., P. u.*
Gangakhed	Mahatpuri	11.3	-	*A. b., P. u.*
	Sayala	10.4	87.3	*A. b., P. u.*
Sonpet	Shalegaon	5.6	-	*A. b., P. u.*

(A. b.-A. bambawalei; P. u.- Promuscidea unfasciativentris (a common hyperparasitoid); Tr. –Traces; - no parasitization)

NON-INSECTICIDE PEST MANAGEMENT IN COTTON AT JIND

Recent whitefly epidemic in Haryana and Punjab has threatened the sustainability of *Bt* technology. *Bt* should not be blamed for this epizootic as the gene provided protection against lepidopteran pests and not against sucking pests. Sowing of *Bt* hybrids ignoring instructions from ICAR-CICR and State Department of Agriculture may be responsible for it. IPM which emphasizes on conservation and augmentation of natural enemies with need-based application of recommended pesticides appears to be the only solution for the emerging problems. During 2014, ICAR-NCIPM identified a group of farmers under '*Keet Saksharta Samuh*' who manage the cotton pests by conservation of natural enemies and for many years have never used any chemical pesticide against insect-pests and diseases in cotton in a few villages of Jind district.

At a time when whitefly attack triggered suicides by farmers in Punjab and Haryana, nearly 250 farmers of Jind district obtained good yield of cotton crop and that too, without using chemical pesticides. In Jind, 676, 5904 and 2915 ha of cotton had whitefly infestation levels of 33-50%, 51-75% and 76-100%, respectively. State agriculture department officials claimed that farmers from over 12 villages in Jind adopted pesticide-free farming resulting in whitefly attack only in 400 ha. Instead of using chemical pesticides, the farmers used home made sprays to strengthen the plants. Their spray is a mix of di-ammonium phosphate, urea, zinc and water, and is called 'Dr Dalal solution' (named after an agriculture development officer of Haryana, Dr. Surender Singh Dalal who started this style of farming about eight years back in Jind). The concept grew popular after his death (2013) two years ago, and many farmers replaced chemical pesticides with Dr. Dalal Solution. This spray as claimed by farmers beat the impact of whiteflies in an affordable way. Instead of spending about ₹ 12,500 per ha to manage whitefly on insecticides, they invested ₹ 1245 per ha (number of sprays is six and cost of

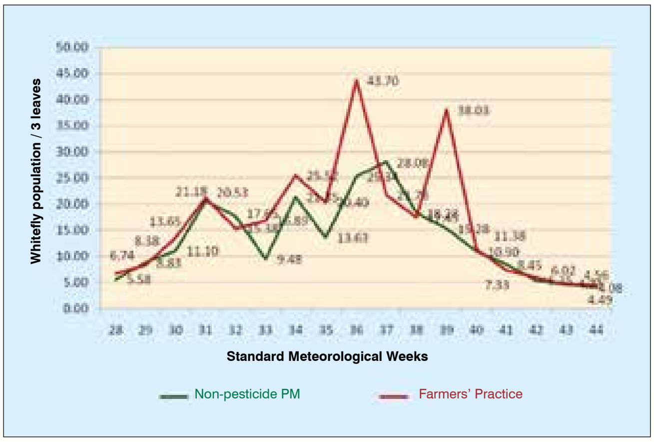

Fig. 3 : Whitefly population in non-pesticide and farmers' practices in *Bt* cotton at Jind during 2015.

one spray in 0.4 ha is ₹ 83). Nearly 250 farmers, including 100 women from 16 villages of Jind - Nidana, Nidani, Joura, Lalit Khera, Radana, Chabri, Samla, Chabra, Igra, Rajpura Bhain, Mohangarh, Samla, Khargram Ji, Hathangarh, Aleva and Chati Sampla - have been working as ambassadors to spread awareness about the campaign. These farmers have been motivating and imparting training to farmers of other districts to identify "friend" and "enemy" insects and avoid the use of chemical pesticides. It is a fact that the crop of farmers associated with this campaign has not suffered any loss due to whitefly attack. In contrast, those who resorted to chemical pesticides suffered heavy losses.

ICAR-NCIPM in collaboration with Jind group initiated research and extension activities during 2014 cotton crop season to compare the non-pesticide and farmers' practices in *Bt* cotton. Farmers associated with *Keet Saksharta Samuh* never used any chemical pesticide for pest management in *Bt* cotton. Other farmers were not aware of the biocontrol, and were dependent on 6-20 sprays of chemical insecticides for pest management in *Bt* cotton. Average whitefly population across the locations ranged 4.1-28.1 adults / nymphs per 3 leaves (near ETL) in non-pesticide pest management fields compared to 4.5-43.7 adults / nymphs per 3 leaves (> ETL on a few occasions) in farmers' practice in Jind (Fig. 3). The population of whitefly could not cross the economic threshold level in non-pesticide pest management whereas in farmers' practice it crossed the ETL (8-10 nymph/adult whiteflies per leaf) on a few occasions. This could be due to conservation of natural enemies in fields with non-pesticide practices, which in turn managed the whitefly population. In other words, these farmers of this area have learnt the art of maintaining pest defender ratio in such a manner that the natural could take care of the pests by not allowing insect population to cross the economic threshold level.

Let New India arise out of the peasant's cottage, grasping the plough out of the huts of the fisherman...... Let her emerge from groves and forests, from hill and mountains

– Swami Vivekananda

VALIDATION OF IPM IN *BASMATI* RICE

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ICAR: National Research Centre for Integrated Pest Management, New Delhi

INTRODUCTION

Basmati is a long-grain aromatic rice grown in several States of India and Pakistan. India is the leading exporter of the *Basmati* rice to the global market. *Basmati* rice is cultivated in about 2.0 million hactares. In 2014-15, out of the total production of 8.70 mt of *Basmati* rice from 2.10 million hactares, 3.7 mt worth INR ₹ 275.979 billion was exported. (*http://apeda.gov.in/apedawebsiteon20Dec2015,1405hrsIST*). Punjab and Haryana account for about 70 per cent of total *Basmati* grown in India *(http://www.business-standard.comarticle/market/basmati-rice-acreage-to-go-uo-despite-lower-realization-last-year-11505327_1.html)*. The yield potential of commonly grown *Basmati* cultivars *viz.,* Pusa *Basmati* 1, Taraori *Basmati* and Dehraduni *Basmati* is severely hampered by biotic stresses as there is no inbuilt resistance in them to any of the pests. Extensive surveys of *Basmati* growing areas by ICAR: National Research Centre for Integrated Pest Management (NCIPM) revealed excessive and injudicious use of chemical pesticides and fertilizers by farmers that aggravated the pest menace, secondary pest outbreaks, residue problems in grains, soil and water, environmental degradation and rejection of many export consignments. Recently, the appearance of bakanae in the widely cultivated, *cv*. Pusa 1121 has exaggerated the pest problem. An inter-disciplinary and inter-institutional team took up the challenge at NCIPM to address these problems through holistic IPM tactics. IPM strategies were synthesized and validated at village level in *Basmati* growing areas of Uttar Pradesh, Haryana and Uttarakhand.

IPM VALIDATION

Locations

IPM validation trial was initiated at Baraut (Dist. Baghpat, UP) during 1997-98 in an area of 10 ha with cv. Pusa *Basmati* 1. Selection of village was based on baseline information collected from the farmers, which had shown indiscriminate use of chemical pesticides (phorate, endosulfan, etc.) to an extent of 4-6 sprays for suppression of insect-pests and diseases. During 1999, the trial was shifted to a nearby village, Shikohpur over an area of 40 ha which in subsequent years were extended to 120 and 160 ha during 2000 and 2001 seasons, respectively. After the success of IPM validation at Shikohpur in Pusa *Basmati*1, the technology was taken up in Chhajpur Khurd (Panipat) village, Haryana with Taraori local *Basmati* variety. At Chhajpur a total of 28, 80 and 140 ha area was under IPM during *kharif* 2002, 2003 and 2004, respectively. Gradually the technology by its own spread to 25 adjoining villages. During 2005 to 2010 the technology was validated in Uttarakhand State at Tilwari and Doodhali villages (Dehradun) in 40 and 25 ha, respectively, with Dehraduni *Basmati* (Type 3) and Kasturi.

During 2005 the high yielding variety of *Basmati* cv. Pusa 1121 introduced by ICAR-IARI became very popular among farmers. Presently, this variety has spread to over 84% of the total *Basmati* area in Punjab, 78% in Western Uttar Pradesh, 68% in Haryana, 30% in Uttarakhand, 8% in Jammu and Kashmir and is grown over 1000 ha area in hill state of Himachal Pradesh. However, the variety is highly susceptible to bakanae foot rot disease (*Fusarium fujikuroi)* (Fig. 1). The problem became more serious with increase in area under *cv.* Pusa *Basmati* 1121. Hence, IPM module was fine-tuned to overcome

Fig. 1: Symptoms of bakanae infested plant (tall and yellow) at tillering stage

the problem of bakanae along with other pests. IPM package was validated at two locations, Atterna and Sibouli (Sonipat, Haryana) in 40 ha each during 2006-2010. The IPM module was further extended to a cluster of villages (350 ha) during 2010-15 in farmers' participatory mode at Bambawar and adjoining villages *i.e.* Aakilpur, Hassanpur, Mahawad and Rajatpur in Gautam Budh Nagar district of Uttar Pradesh (Fig. 2).

Baseline information

Yellow stemborer (YSB: *Scirpophaga incertulas*), brown plant hopper (*Nilaparvata lugens*), white backed plant hopper (WBPH: *Sogatella furcifera*) and leaf folder (*Cnaphalocrocis medinalis*) are the major insect-pests, whereas blast (*Pyricularia oryzae*), bacterial leaf blight (BLB) (*Xanthomonas oryzae* pv. *oryzae*), brown leaf spot *(Cochliobolus miyabeanus)* and sheath blight (*Rhizoctonia solani*) are the major diseases of *Basmati* rice.

- No seed treatment was carried out by farmers.
- Farmers did not grow *Sesbania*/ *Vigna radiata* for green manuring.
- Only one seedling was transplanted per spot in Haryana and Uttar Pradesh whereas in Uttarakhand, 6-7 seedlings were transplanted at one spot.
- Farmers, in general, applied higher nitrogenous fertilizers than the recommended dosages in Haryana and Uttar Pradesh. Very low dosages of fertilizers were applied in Uttarakhand. No zinc was applied by farmers.
- Farmers were not able to identify insect-pests, diseases and natural enemies.
- Farmers followed the advices of pesticide dealers and relied on chemical pesticides for pest management. 4-6 sprays of chemical pesticides were undertaken by farmers to overcome pest menace.

Year	Uttar Pradesh	Haryana			Uttarakhand		U.P.	Area (ha)
	Shikohpur	Chhajpur	Dharampur	Atterna & Sibouli	Tilwari	Doodhali	Bambawad	
2000								120
2001								170
2002								250
2003								340
2004								360
2005								376
2006								440
2007								450
2008								490
2009								490
2010								510
2011								570
2012								610
2013								685
2014								765
2015								830

Farmers' participatory trial conducted by NCIPM

Follow up visit to get feed back

Fig. 2: Spread of IPM in *Basmati* Rice

- Common chemical pesticides used were phorate, fipronil, endosulfan, monocrotophos, dichlorvos, methyl parathion, mancozeb and carbendazim.
- Farmers were unaware of any IPM strategy.

IPM module

A basic IPM module as a part of integrated crop management was developed accounting the pest prevalence and the information available from literature. IPM strategies were based on key agronomic components like *in situ* soil incorporation of green manure (*Sesbania / Vigna radiata*), balanced use of fertilizers with more emphasis on supplementation of potash, application of zinc, and biotic stress management by regular crop and pest monitoring, conservation and augmentation of natural enemies, use of bio-pesticides and need (economic threshold level) - based application of chemical pesticides.

IPM strategies adopted as a part Integrated Crop Management (ICM)

Crop stage	Target events/pests	IPM strategies (including crop management options)
Pre *kharif* crop	Enriching soil nutrients	Sowing of green manure *Sesbania / Vigna radiata. In situ* trampling of green manure after 45-50 DAS after picking of mature pods Puddling of field
Nursery	Beds for healthy nursery	Nursery on raised beds of 10 X 1.5 sq.m with a gap of 30 cm. FYM enrichment and use of recommended NPK
	Diseases	Use of certified seeds Soaking paddy seeds in 2% salt solution for about 15 minutes followed by discarding of floating seeds and washing the heavy seeds Seed treatment with carbendazim 50 WP @ 2g/kg
	Weeds	Hand weeding
	Blast	Need-based spray of carbendazim 50% WP @ 250-500 g/ha or isoprothiolan 40% EC @ 750 ml/ha or tricyclazole 75% WP @ 300-400 g/ha
	BLB	Need-based spray of streptomycin sulphate 9% + tetracycline hydrochloride 1% SP @ 100-150 ppm
Transplant-ing	Recommended dosages of fertilisers	Basal fertilizer dose of N:P:K: 25:50:50; and application of $ZnSO_4$ @ 25 kg/ha (after one week)
	Scirpophaga incertulas (YSB), *Dicladispa armigera* (Hispa)	Clipping of leaf tips of seedlings
	Soil borne diseases(*)	Seedling root dip in *Pseudomonas fluorescens* (3.0 X 10^{10} cfu; 5 ml/l of water) for 30 minutes
	Uniform plant population	Planting 2-3 seedlings/ hill with spacing of 20 and 15 cm between rows and hills, respectively.
	Weeds	Hand weeding
Early to late tillering & Pre flowering till crop maturity	*S. incertulas* (YSB)	Fixing of pheromone traps @ 5 traps/ha for monitoring
	Spider conservation	Fixing of straw bundle @ 20/ha for conservation of natural enemies esp. spiders
	YSB, Cnaphalocrocis medinalis (LF)	Release of egg parasitoid, *Trichogramma japonicum* @ 0.15 million/ha (affixed as *Tricho* cards) (based on pest monitoring).
	Sheath blight (*Rhizoctonia solani*)	Apply validamycin 3% L @ 2000 g/ha or hexaconazole 5% EC @ 1000 ml/ha or propiconazole 25% EC @ 750 ml/ha or propiconazole 10.7% + tricyclazole 34.2% SE @ 500 ml/ha Draining-off water
	BLB (*Xanthomonas oryzae* pv. *oryzae*)	Spray streptocycline @ 100 to 150 ppm at early root stage (subjected to appearance of symptoms) Remaining N in two split doses (30 kg/ha each) 30 and 50 days after transplanting
	Blast (*Pyricularia oryzae*)	As for sheath blight
	WBPH (*Sogatella furcifera*)/BPH	Spray of ethofenoprox 10% EC @ 500-750 ml/ha or acephate 75% SP @ 666-1000 g/ha or buprofezin 25% SC @ 800 ml/ha

**Sheath blight, sheath rot, etc.*

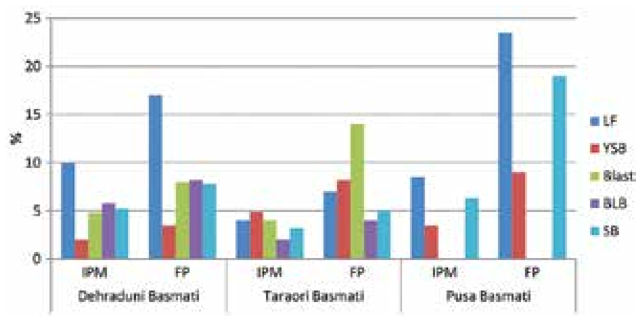
#Application of chemical pesticide was based on the ETL levels: YSB-2 egg-mass/m² or 10% dead heart or 1 moth/m² or 25 moths/trap/week; LF-2 Fully damaged leaves (FDL) with larva/hill; BPH- 10-15 hoppers/hill; BLB -2-3 infected leaves/m²; Sheath blight-Lesions of 5-6 mm in length & 2-3 infected plants/m²; Neck blast 2-5 neck infected plants/m²

Note: In the present trial no chemical was used against LF and YSB as the pest never crossed ETL; Cartap hydrochloride 4% granules @18750 g/ha or cartap hydrochloride 50% SP @ 1000 g/ha or monocrotophos 36% SL @ 625-1250 ml/ha were advised as the last option if the pests crossed the ETL.

IMPACT OF THE IPM STRATEGY

In all the IPM validation trials, incidence of insect-pests and diseases remained low (Fig. 3; Table 1); whereas yield as well as benefit-cost (B-C) ratio remained higher (Table 2) in IPM as compared to farmers' practices (FP).

Samples of *Basmati* grains collected from IPM and FP trials at Bambawad for residue analysis of carbendazim, phorate and buprofezin indicated the residual below (< 0.001-0.05 μg/g) Maximum Residue Level (MRL) in all the samples; this enabled the produce to fetch ₹ 200/- per quintal more than the prevailing market price for *Basmati* rice.



(LF-Leaf folder; YSB-Yellow stem borer; WBPH-White backed plant hopper; Blast (leaf and neck); BLB-Bacterial Leaf Blight SB-Sheath Blight)

Fig. 3: Incidence of insect-pests and diseases in IPM and farmers' practices (FP) in different varieties of *Basmati*

Table 1: Pest incidence in IPM and farmers' practices (FP) in cv. Pusa *Basmati* 1121

Pest	Atterna		Sibouli						Bambawad									
	2008		2008		2009		2010		2010		2011		2012		2013		2014	
	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP	IPM	FP
Yellow stem borer (%)	3.0	6.5	2.5	6.0	3.5	17.1	1.9	9.6	4.5	14.5	0.05	0.5	0.69	1.7	0.14	0.8	0.07	0.7
Leaf folder (%)	6.5	10.0	7.5	9.5	4.5	7.5	4.5	8.6	8.7	21.3	0.05	0.3	0.13	0.3	0.09	0.3	0.14	0.3
BPH (No./hill)	17.5	35.0	15.0	38.0	1.5	6.5	7.8	32.5	7.5	35.5	6.9	8.7	1.25	1.4	0.49	0.8	0.49	0.8
Neck blast (%)	7.0	18.0	9.5	18.5	7.3	16.5	3.5	7.8	-	-	-	-	-	-	-	-	-	-
BLB (%)	5.0	9.0	3.5	7.5	4.1	11.4	4.9	12.6	4.2	11.3	-	-	-	-	-	-	-	-
Bakanae (%)	3.5	8.0	3.0	9.5	Tr	19.6	Tr.	23.4	Tr.	28.3	5.5	17.8	3.34	14.71	0	19.0	0.05	9.8

Table 2: Yield levels and economics in IPM *versus* farmers' practices (FP)

Parameters	IPM						FP					
	1st yr	2nd yr	3rd yr	4th yr	5th yr	Mean	1st yr	2nd yr	3rd yr	4th yr	5th yr	Mean
Pusa Basmati 1 at Shikohpur (Uttar Pradesh) (2000-02)												
Mean yield (q/ha)	58.0	57.4	51.6	-	-	55.7	48.2	45.6	43.5	-	-	45.8
Benefit/cost ratio	3.2	3.2	2.2	-	-	2.8	2.3	2.1	1.6	-	-	2.0
Taraori Basmati at Chhajpur, Panipat (Haryana) (2002-04)												
Mean yield (q/ha)	28.3	26.7	26.2	-	-	27.1	22.2	22.1	22.6	-	-	22.3
Benefit/ cost ratio	3.5	2.1	2.8	-	-	2.8	2.3	1.4	1.9	-	-	1.9
Dehraduni Basmati at Tilwarai, Dehradun (Uttarakhand) (2005-06)												
Mean yield (q/ha)	21.2	24.3	-	-	-	22.7	18.1	19.8	-	-	-	19.0
Benefit/cost ratio	3.0	3.4	-	-	-	3.2	2.90	3.3	-	-	-	3.08
Pusa Basmati 1121 at Atterna, Sonipat (Haryana) (2008-10)												
Mean yield (q/ha)	41.0	-	-	-	-	41.0	35.8	-	-	-	-	35.8
Benefit/cost ratio	6.4	-	-	-	-	6.4	5.3	-	-	-	-	5.3
Pusa Basmati 1121 at Sibouli, Sonipat (Haryana) (2008-10)												
Mean yield (q/ha)	36.0	53.5	48.5	-	-	46	30.5	43.6	38.5	-	-	37.5
Benefit/ cost ratio	5.5	7.5	5.8	-	-	6.3	4.5	5.8	4.0			4.9
Pusa Basmati 1121 at Bambawad, Gautam Budh Nagar (Uttar Pradesh) (2010-14)												
Mean yield (q/ha)	33.2	33.9	39.8	34.6	38.5	36.0	16.2	20.9	33.2	27.7	33.2	26.2
Benefit/ cost ratio	3.8	2.4	3.6	5.2	3.5	3.7	1.8	1.4	2.8	3.6	2.2	2.3

FEATURES OF IPM IMPLEMENTATION

Farmer field schools

Organizing Farmer Field School at 10-15 day intervals during each crop season was an important step for dissemination of IPM strategies. It helped in developing strong linkages among farmers, scientists and extension workers. Farmers got educated at different stages of the crop growth especially on the identification of insect-pests, diseases and beneficial organisms. All the farmers followed the IPM interventions as advised and the applied chemicals as a last option only when needed.

Pest monitoring

Imparting training to a few progressive farmers on identification and recording insect-pests and diseases at weekly intervals using data sheets helped the farmers to understand the concept of ETL and empowered them to take their own decisions on need-based application of chemical pesticides. The farmers are using the pheromone traps for monitoring the population of YSB moths.

Availability of quality bioagents

Bioagents *viz*., *Pseudomonas fluorescens* were made available by the State Agricultural Department personnel with the help of State Biocontrol Laboratory. Such a support system ensured timely availability of quality bioagents for field application by farmers.

Communication

Mobile numbers of rice researchers of NCIPM given to the progressive farmers of the IPM villages helped them to seek proper pest management advice and disseminate among other farmers of the villages whenever needed.

Empowerment and skill development in IPM

Adoption of IPM technology empowered the farmers in following ways:

1. Farmers understood the role of crop management practices (like judicious use of fertilizers, growing of *Sesbania* for green manuring) in rice pest management.
2. Farmers are able to distinguish between harmful and beneficial insects.
3. Farmers ability to identify major diseases improved.
4. Farmers of IPM villages presently understand the role of monitoring, concept of ETL and need-based application of chemical pesticides.
5. Farmers practice only spot application of chemical pesticides.
6. Decision making on release of parasitoids or pesticide application is done by farmers themselves.

Indian Council of Agricultural Research

ICAR Award for Team Research in Agriculture and Allied Sciences for the Biennium 2005–2006

The ICAR Award for Outstanding Interdisciplinary Team Research in Agriculture and Allied Sciences for the Biennium 2005-2006 is presented to

Dr. D.K. Garg, Dr. M.D. Jeswani, Dr. R.K. Tanwar, Shri Vikas Kanwar, Shri S.P. Singh, Dr. V.P. Singh, Dr. Ashok Mehta and Dr. O.M. Bambawale

for their outstanding research contribution in

Crop Improvement

16 July, 2008
New Delhi

Mangala Rai
Director-General

Sharad Pawar
Union Minister for Agriculture

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

ICAR AWARDS FOR OUTSTANDING INTERDISCIPLINARY TEAM RESEARCH IN AGRICULTURE AND ALLIED SCIENCES FOR THE BIENNIUM 2005–2006

CITATION

The ICAR Award for Team Research for the Biennium 2005–2006 is given to Dr D. K. Garg and his team for developing holistic IPM strategy to improve and sustain productivity of Basmati rice.

Extensive surveys of Basmati-growing areas revealed excessive and injudicious use of pesticides by farmers which aggravated pest menace, secondary pest outbreaks, residue problems in grains, soil and water, environmental degradation and rejection of several export consignments. Many of the desperate farmers were contemplating shifting to other crops due to fear of crop failure. The holistic approach included IPM strategy of incorporation of green manure in soil, balanced use of fertilizers, regular monitoring and spot application of pesticides that increased mean yield of Basmati cultivars to 20.9% and benefit : cost ratio to 31.9%. The IPM implementation resulted in decline in pesticide applications from 4–5 sprays to less than one spray, resulting in low residue level in produce and also succeeding in restoring natural enemy diversity.

The research work was conducted at the National Centre for Integrated Pest Management, Pusa Campus, New Delhi.

For all the pests that out of earth arise the earth itself the antidote supplies

– Lithica, c. 400 BC

IPM FOR TRADITIONAL RICE

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Rice (*Oryza sativa* L.) commands recognition as a supreme commodity to mankind because its cultivation is a tradition and a means of livelihood to millions. Rice is the food for about 50 per cent of the world's population residing in Asia, where 90 per cent of the world's rice is grown and consumed. In Asia, India has the largest area under rice (44.6 million ha) accounting for 29.4% of the global rice area (Hedge and Hedge, 2013). Of the total harvested area, about 46% is irrigated with 28% rainfed lowland, 12% rainfed upland and 14% flood prone. Projection of Indian rice production target for 2025 AD is 140 mt, which can be achieved only by increasing the rice production by over 2 mt per year in the coming decade and this has to done against back drop of diminishing natural resources such as land and water. Assam (4.2%), Karnataka (3.7%), West Bengal (13.8%) and Uttar Pradesh (13.3%) are important rice producing States wherein the traditional (non-*Basmati*) rice is commonly grown. In these States either the rice is grown as a single crop or rice-rice cropping systems is in vogue. A number of pests cause nearly 23% yield loss. Validation and promotion of IPM in rice for different agro-climatic zones was initiated in 2007 at Mandya (Karnataka), Golaghat (Assam) and after successful IPM interventions the programme was also extended to Shivamogga, Karnataka as well as in *Boro* rice in Kalyani, West Bengal.

LOCATION: MANDYA, KARNATAKA

Several biotic stresses including insect-pests, diseases and plant parasitic nematodes cause about 18% yield loss. Stem borer (*Scirpophaga incertulas*) among insect-pests, and blast (*Pyricularia oryzae*) among diseases are economically important. Besides, root-knot nematode, *Meloidogyne graminicola* has emerged as a new threat to rice cultivation. For the first time, severe incidence of root-knot nematode (*M. graminicola*) was observed during *kharif* 2002 in nurseries of few villages of K.R. Pet taluk, Mandya district which took a more severe turn during the following years and spread to other rice growing areas as well. This nematode has become a 'State pest', appearing in most of the rice growing tracts due to its devastating effect on rice seedlings in nursery and later, in the main field.

Symptoms of *M. graminicola* were more pronounced in dry than wet nurseries. In some of the transplanted fields, the crop was showing yellowing symptoms with stunted growth in patches on all the popular varieties *viz.*, Jyothi, Intan, Ko 4, IR 64, etc., grown in the area. It was also observed that the nematode was spreading through channel irrigation water, especially in Hemavathi, Cauvery and Bhadra command areas.

In order to combat major pests *viz.,* stem borer, blast and root-knot nematode on rice with an integrated approach, an effort was made in collaboration with the UAS Bangalore Karnataka, AICRP (Rice), V.C. Farm, UAS, Mandya, Office of the Joint Director of Agriculture, Mandya and Assistant Director of Agriculture, K.R. Pet, Mandya.

Various activities carried out include the selection of villages that were hot spots for nematodes, *viz.,* Hariharapura (441/200 cc soil, 32 galls/plant) and Akkihebbalu villages (436/200 cc soil, 42 galls/plant), K.R. Pet, Mandya district, application of fertilizers (N:P:K, 60:50:40 kg/ha) and use 25 kg/ha $ZnSO_4$, installation of pheromone traps for stem borer monitoring, release of *Trichogramma joponicum* (need-based), spot application of Carbendazim (for blast), Streptocycline (for bacterial leaf blight), manual weeding, systematic pest monitoring and conducting of farmers' field schools.

Thirty nine farmers in village Akkihebbalu were selected for practicing integrated pest management strategies in rice on 36 ha. In nursery beds Carbofuran @ 0.3 g a.i./m^2, *Pseudomonas fluorescens* (1x10^9 cfu/g) @ 20 g/m^2 were applied separately in the nursery beds. For need-based management of insect-pests Chlorpyriphos @ 2 ml/l or Imidacloprid @ 1 ml/4 l of water was sprayed. The fungicides Carbendazim (1 g/l) or Tricyclazole (0.5 ml/l) were sprayed as per requirement in nursery for the management of rice blast. The observations on galling due to root-knot nematode, rice blast disease severity and insect-pest damage were recorded. (Tables 1-2).

In the main fields, pheromone traps were installed in the IPM fields for monitoring the population of stem borer in the field. Carbofuran 3G @ 3-4 kg/ha was applied to the fields to manage nematode while Imidacloprid and Tricyclazole were sprayed to manage stem borer and blast disease, respectively on need basis. Manual weed management was practised regularly.

Carbofuran application in nursery in addition to main field after 45 DAT recorded more number of tillers, improved plant height, least galls, less dried shoots due to stem borer and also recorded more yield over *P. fluorescens* treated and control fields.

Impact of validation programme

The awareness created about the diagnosis of rice root-knot nematode as the cause of seedling death in nursery and increase in the number of rice seedlings increased the yield to the extent of around 10 q/ha. Those farmers who did not follow nematode management understood the need for critical interventions and followed in the subsequent seasons.

LOCATION: SHIVAMOGGA, KARNATAKA

In Shivamogga, rice occupies 5.09 lakh ha (35%) with a production of 13.2 (36%) lakh tonnes with an average yield of 2593 kg/ha across seven districts under the purview of University of Health and Allied Sciences (UHAS), Shivamogga. However, the productivity of the region decreased from 30 quintal/acre in 1970 when and chemical fertilizers were introduced to 8 to 10 quintals today. Most of the rice growers are small and marginal farmers who are ignorant and do not follow the recommended package of practices.

Major production constraints of rice

1. Lack of suitable hybrids / varieties with high yield potential: for normal planting condition (medium duration), early sowing conditions (medium to late duration) and varieties / hybrids resistant to blast, bacterial leaf blight, sheath blight, sheath rot and a new problem of the rice root-knot nematode in the region.
2. Soil organic matter status and over all fertility is declining due to mono-cropping.
3. Large area is rainfed leading to scarcity of moisture during grand growth period and flowering stage.
4. Prevalence of biotic stresses like rice root-knot nematode, blast, bacterial leaf blight, sheath blight and sheath rot.

Table 1 : Severity of root knot and blast in nursery

Treatment	Nematode population/ 200cc	Galls/20 seedlings	Blast incidence (%)
Carbofuran in nursery+ 40 DAT	224	21.5	2.6
P. fluorescens in nursery	285	34.3	2.5
Untreated control	418	78.3	2.8

Table 2 : Growth, pest severity and yield in IPM main field

Treatment	No. of tillers / plant	Number of galls / 20 plants	Severity of blast (%)	No. of dried shoots due to stem borer/sqm	Yield q/ha	BC ratio
Carbofuran in nursery+40 DAT	14	88	8.2	7.2	67.4	3.3
P. fluorescens in nursery	13	102	10.9	8.3	58.3	2.9
Untreated control	11	283	18.7	17.0	40.6	—

5. Insufficient knowledge of farmers on rice production technology.

6. Lack of crop management strategies for adaptability to changing climate scenario.

Rice root-knot nematode appeared in devastating form in parts of major rice growing areas of Shivamogga during 2001, which was the first report from Karnataka and subsequently, reported from Mandya district. Initially, it was noticed only in aerobic condition (drill sown and SRI methods). Since 2011, it has been observed appearing in all types of rice cultivating situations. Hither to, only tobacco farmers were having awareness about the nematodes where the impact of damage was felt and suitable management practices were followed. Now, the rice farmers and extension workers are feeling the nematode problem in rice and are compelled to adopt management practices. Looking to the severity of the nematode spread in the state, a *RKVY* project was sanctioned wherein studies were conducted on various aspects including the preparation of Nematode Atlas with digital maps depicting distribution of rice root-knot nematode across all the 29 rice growing districts in Karnataka.

An IPM validation programme in collaboration with NCIPM, New Delhi, was also taken up in different taluks and villages of Shivamogga and Davangere districts. Three villages were selected based on rice cultivation practices *viz.,* Chikadakatte: Rice-Rice-Rice, Purale: Rice-Rice-Green gram and Pillangere: Rice-vegetables.

Symptoms were more pronounced in aerobic than in wet nurseries. In some of the transplanted fields, the crop was showing yellowing symptoms with stunted growth in patches on all the popular varieties *viz*., Jyothi, Intan, IR 64 and MTU 1001. It was also observed that, the nematode was spreading through channel irrigation water, especially in Tungabhadra command area.

In order to manage the major pests *viz*., root-knot nematode, (RKN), blast, BLB diseases and stem borer on rice with an integrated approach, an effort was made in collaboration with UAHS Shivamogga Karnataka with the objectives *viz.,*

- Extensive survey for the identification of nematode hot spots
- To develop RKN map of Karnataka
- To estimate crop losses in farmers' fields in relation to different agro ecosystems
- To develop IPM package for managing insect-pests and diseases
- Supplying critical inputs to rice farmers to manage RKN and other pests
- Creating awareness among rice farmers regarding IPM practices

IPM implementation

Three main villages, Chikadakatte of Davangere district, Purale and Pillangere from Shivamogga district, were considered as hot spots for the incidence of *M. graminicola* and hence, these spots were chosen for the IPM validation on rice.

Around 2000 ha of rice growing areas have been found to be infested with rice root-knot nematode (*Meloidogyne graminicola*) in Shivamogga and Davangere districts of Karnataka with average initial nematode population of 550 J2/200 cm^3 soil and 20 galls/plant in the paddy nursery. Twenty farmers in village Chikadakatte, 10 farmers from Purale and 15 farmers from Pillangere were selected for practicing integrated pest management strategies in rice in 60 ha.

Various activities carried out after the selection of nematode hot spot villages included balanced application of fertilizers (N:P:K, 60:50:40 kg/ha), installation of pheromone traps for stem borer monitoring, release of *Trichogramma joponicum* (need-based), spot application of Carbendazim (for blast), Streptocycline (for bacterial leaf blight), manual weed management, systemic monitoring of insects, diseases and nematodes and organisation of farmer field schools. Fields were visited once a fortnight and the farmers were advised about the practices of integrated pest management in rice. Demonstrations and training programmes were conducted to train the farmers on IPM in rice. Pheromone traps (100 numbers) were fixed at IPM fields in the above mentioned villages for the management of stem borer.

The effective treatments for management of rice root-knot nematode infecting rice developed under AICRP (Nematodes) were included for validation trial. In nursery beds, carbofuran @ 0.3 g a.i./m^2, *Pseudomonas fluorescens* @ 20 g/m^2 were applied separately in the nursery beds. For need-based management of insect-pests Chlorpyriphos @ 2 ml/l or Imidachloprid @ 1 ml/4 l of water was sprayed. The fungicides Carbendazim (1 g/l) or Tricyclazole (0.5 ml/l) were sprayed in nursery for the management of rice blast disease as per requirement.

The nursery management of rice root-knot nematode, insect-pests and diseases were taken up by 45 farmers covering 60 ha. The observations on root-knot index, blast disease severity and damage due to insect-pests were recorded (Tables 3-4).

Application of Carbofuran in nursery along with field application 45 DAT recorded increased number of tillers, pronounced plant height, least galls and less dried shoots due to stem borer and also recorded more yield over *P. fluorescens* treated and control fields.

Impact of IPM validation

- Awareness was created among the farmers regarding rice root-knot nematode as a main cause for death of the seedlings in nursery.
- Farmers were convinced about IPM practices as beneficial to them.
- There is an enhancement of yield up to 10 quintals/ha.
- Drastic reduction occured in the incidence of root-knot nematode (*i.e.*, 60-70%).
- The incidence of blast disease and stem borer was reduced.
- Reduction in number of chemical pesticide sprays from 8 to 2.
- Cost of cultivation was reduced up to 40%.
- In the neighbouring farmers' fields, there were ununiform growths compared to treated fields.
- Higher yields were recorded in Carbofuran treated plots (2 q/ha).
- Enquiries were made by neighbouring farmers regarding the management practices adopted. In summer paddy season *i.e.*, January, in the same nurseries the gall indices were very less.

The farmers are very confident about the IPM interventions and eager to continue and spread the message to fellow rice farmers regarding the incidence, spread and management of rice root knot nematode.

LOCATION: ASSAM

In Assam, Golaghat is a major rice growing district which is surrounded by the river Brahmaputra in the North, the State of Nagaland to the South, Jorhat district to the east and Karbi Anglong and Nagaon districts to the West. Two villages *viz*. Danichapori and Kocharipam of district Golaghat situated about 15-20 km away from the town Dergaon grow both direct-seeded upland and transplanted *Sali* rice predominantly. The surveys conducted by NCIPM and Assam Agricultural University found rice root knot nematode *M. graminicola* as a threat to rice cultivation especially in upland rice and in nursery. It was observed that nematodes caused rice yield loss up to 20-30%. Furthermore, the outbreak of *M. graminicola* infestation was witnessed in about 3000 ha in Golaghat, Assam. An Attempt was made to manage nematodes under a collaborative and participatory programme with cooperating centre of AICNP of Jorhat and farmers, respectively by

Table 3 : Overall severity of root knot, blast and insect damage at nursery

Treatment	FNP/200 cc in nursery	Galls/20 seedlings	Blast Incidence (%)
Carbofuran in nursery + 40 DAT	172	20.6	1-6
P. fluorescens in nursery	189	24.2	2.2
Untreated control	317	80.6	3.4

Table 4 : Growth, pest severity and yield in IPM main field

Treatment	Main field					
	No. of tillers / Plant	Number of galls / 20 plants	Severity of blast (%)	No. of dried shoots due to stem borer/sqm	Yield (q/ha)	BC ratio
Carbofuran in nursery+ 40 DAT	16	65	7.1	4.2	58.4	4.2
P. fluorescens in nursery	21	122	9.9	10.3	54.3	3.9
Untreated control	11	1253	17.7	18.0	43.6	—

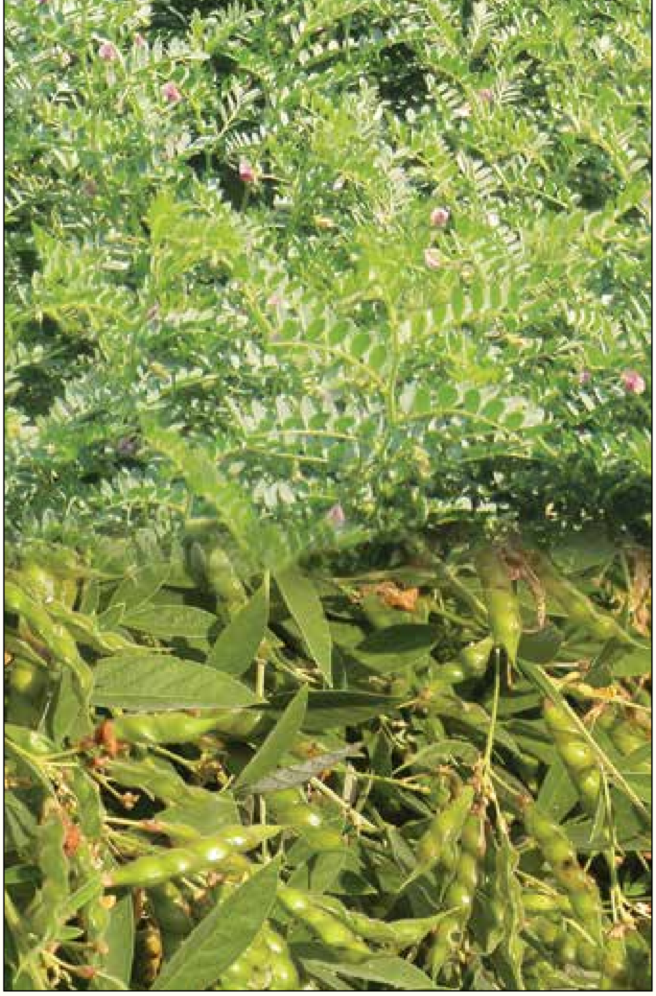
NCIPM, New Delhi. Validation of IPM for rice was carried out at farmers' fields in two villages *viz.* Danichapori and Kocharipam of Golaghat over five years (2009-13) in 12, 16, 24, 28 and 40 ha covering 12, 16, 20, 22 and 24 farm families, respectively. IPM for rice comprising of nursery bed treatment of carbofuran @ 0.3 g a.i./m^2 followed by its field application @ 1 kg a.i./ha at 45 DAT or application of bioagent *Pseudomonas fluorescens* @ 20 g/m^2 in nursery or seed treatment with *Trichoderma viride* @ 10 g/kg seed in nursery was implemented with each treatment in 3 ha in each village. Seedlings from carbofuran treated nursery transplanted in the field were further supplemented with another dosage of carbofuran @ 1.0 kg a.i./ha (45 days after transplanting). Pooled data of 5 years showed that carbofuran treated nursery beds had 100 galls/20 seedlings *while P. fluorescens* and *T. viride* had 115 galls/20 seedlings and 118 galls/20 seedlings, respectively in the first year (2009). A demonstration was carried out in the field of five farmers of each village and the farmers were asked to prepare 3 seed beds. One seed bed was treated with Carbofuran @ 0.3 g a.i./m^2, another with *P. fluorescens* @ 20 g/m^2 and another was kept as untreated control. Talc formulation of *P. fluorescens* was applied with finely powdered cow dung before sowing of seeds. Thirty day old seedlings were transplanted separately in nine plots each of 2500 sq.m. The farmers were asked to follow all the intercultural operations. The scientists of Jorhat centre recorded the initial and final nematode population in the field. Root Knot Index at harvest, other pests and yield. The scientists involved in the project regularly conducted the farmers' field school in the village. In the first year there was reduction in the nematode population. The area under demonstration trials was increased every year and at the end of year 2013 total area under IPM was 80 ha. The same fields were continued for INM technology with better nutrient management and adoption of recommended practices. During 2013 yield in carbofuran treated plots was 39.6 q/ha and before intervention 40.5 q/ha while it was 35.2 q/ha and 36.6 q/ha in *P. fluorescens* treated plots and 33.0 q/ha and 34.7 q/ha in Danichapori and Kacharipam, respectively. In untreated control, 30.8 q/ha and 31.2 q/ha of paddy yield was recorded in respective

villages. At the time of application of chemicals, bio-agents and at the time of harvesting, the neighbouring village farmers were invited for highlighting the merits of IPM practices.

Impact of validation trials

- An increase in yield of rice by 26.1% in carbofuran and 13.1% in *P. fluorescens* treated plots over untreated control was noted.
- Reduced population of root knot nematodes in treated plots.
- Decreased incidence of soil borne diseases and insect-pests in treated plots.
- Number of chemical pesticide sprays was less.
- Reduction in cost of cultivation.
- Higher yield was recorded in carbofuran treated plots.
- Carbofuran was found better than *P. fluorescens* in reducing nematode population and increasing yield.
- The incidence of root knot nematode was reduced in the next season.
- Neighbouring villages started adopting the management of rice root knot nematode.

INTENSIVE APPLICATION OF IPM FOR INCREASING PRODUCTION OF PULSE CROPS



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INTRODUCTION

Sensitivity to weather aberrations and pest complex numbering 200 in pulses pose innumerable problems towards realizing the economic yields, leading to imports. Imports of 4.6 million tonnes of pulses happen annually. *Helicoverpa armigera*, a major insect-pest on pulses has been reported to cause losses to the tune of ₹ 45 thousand million per annum. Indiscriminate use of chemical pesticides has further compounded the pest management due to development of resistance to pesticides besides causing environmental pollution leading to human health hazards. The environmentalists and society at large is expressing their concerns through various pressure groups with a vision of “poison and debt free agriculture”. Pulses are highly sensitive to attack by a wide range of pests (diseases, insects and weeds) both in the fields (at various stages of crop growth) as well as storage conditions. Most of the pests attack the crop at reproductive (flowering & pod) stage causing direct losses to the tune of 70%. In absence of resistant varieties, insect-pest and diseases are the major bottlenecks in realizing higher yields. Of late, adverse impacts of pests have been compounded by the changing climate which is quite visible in terms of resurgence of diseases and changing forage habit of insect-pests. In order to manage pest situations without compromising yield levels while keeping the cost of cultivation within limits, optimization of crop protection measures in crop production has attracted the attention of planners, scientists as well as pulse growers. The solution to a greater extent lies in the adoption of Integrated Pest Management (IPM) for managing pests. Hence, DOAC, New Delhi supported present studies under the ambit of National Food Security Mission.

MAJOR PRODUCTION CONSTRAINTS IN PULSE CROPS

- Shortage and lack of timely availability of quality seeds having in built resistance against local pests.
- Cultivation on marginal and sub-marginal lands deficient in nutrients with low inputs.
- Lack of basic information related to pest biology, and real time pest status.
- Lack of appropriate pulse production and protection technologies.
- Major pulse producing areas are deficient in water holding capacity making them vulnerable to heat stress often resulting in terminal drought, and
- Poor post-harvest technology, storage infrastructures and *dal* processing units.

SPECIFIC PLANT PROTECTION CONSTRAINTS IN PULSE CROPS

In pulses, an average of 30-80% losses valued at ₹ 40-50 thousand million occurs due to insect-pests. At times, it is difficult to estimate losses caused by pests as plants have good ability to compensate for defoliation up to 50% even if it occurs in the podding stage. During nineties in Northern Karnataka, application of broad spectrum chemical insecticides failed to reduce the extensive damage (70 to 90%) and incurred loss to the tune of ₹ 4000 million. The post scenario analysis indicated that due to desperation and lack of knowledge, farmers adopted calendar-based application of chemical insecticides. In the absence of water, farmers resorted to dust formulation, which obviously did not reach the target sites. Excessive use of these chemical pesticides resulted in development of resistance by pests against individual as well as group of pesticides.

THRUST ON IPM IN PULSE CROPS

Anticipating the benefits of IPM in pulse crops, the responsibility of popularization of IPM on farmers' fields as a sub-component of NFSM was assigned to NCIPM in a partnership mode with State Agricultural Universities, Research Centres and IIPR, Kanpur with generous financial outlay. Major pulse growing States namely, Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Uttar Pradesh were taken up during 2010-11 and till August 2014. Later on IPM implementation was expanded by including 3 more centres at *KVK,* Bidar of UAS, Raichur (Karnataka), *KVK*, Lohardaga of BAU, Ranchi (Jharkhand) and Mirzapur of BHU, Varanasi (Uttar Pradesh).

OBJECTIVES

- To develop cluster of "nuclear model villages" in selected districts for demonstrating IPM modules adopting farmers' participatory mode to suit their cropping systems
- Capacity building of Technical Assistants of different blocks, district/block level officers and farmers to enhance their capabilities towards healthy crop production through IPM strategies
- To establish centralized "National Pest Reporting and Alert System" through networking of pulse growers, in addition to strengthening of pest-diagnostic laboratory and
- To develop and carryout awareness campaigns through print and electronic media, to reach areas not covered under this program

APPROACHES TO IPM IMPLEMENTATION

Baseline surveys of target agro-ecological zones in Karnataka and review of historical data helped in identifying specific production constraints and to formulate strategies to mitigate their effect. These strategies were aimed at cultivating a healthy crop with the help of soil nutrients in areas having specific deficiency and reduce yield losses caused by combined effect of insect-pests and diseases. Plant protection strategies were based on decision support system derived from regular monitoring of the crop health through "e-pest surveillance" as well as installed pheromone traps and subsequent application of strategies giving priority to eco-friendly or green label pesticides to minimize pest incidence/ intensity below ETL.

Key production constraints of pigeonpea as well as chickpea in the clientele fields are:

SOIL NUTRIENTS	Status
Low Carbon	Sporadic
Deficiency of Zinc	Common
Deficiency of Sulphur	Common
PESTS	
Pigeonpea (*Cajanus cajan*)	
Seedling wilt (*Fusarium* sp.)	Sporadic
Fusarium wilt (*Fusarium udum*)	Common
Phytopthora blight (*Phytophthora drechsleri* f. sp. *cajani*)	Sporadic
Sterility mosaic virus	Endemic
Cercospora leaf spot (*Cercospora canescens*)	Sporadic (emerging)
Powdery mildew (*Leveillula taurica*)	Sporadic (emerging)
Pod borer (*Helicoverpa armigera*)	Wide spread
Spotted pod borer (*Maruca vitrata*)	Sporadic
Plume moth (*Exelastis atomosa*)	Sporadic
Webber (*Grapholita critica*)	Sporadic (increasing trend)
Pod bug (*Clavigralla gibbosa*)	Sporadic (increasing trend)
Podfly (*Melanagromyza obtusa*)	Spreading
Borer (*Batocera* spp.)	Sporadic (localized)

Chickpea (*Cicer arietinum*)	
Soft rot (*Sclerotium rolfsii*)	Sporadic
Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*)	Common
Dry root rot (*Rhizoctonia bataticola*)	Sporadic
Pod borer (*Helicoverpa armigera*)	Widespread
Defoliator (*Spodoptera exigua*)	Common
Cutworm (*Agrotis ipsilon*)	Common
Termites (*Odontotermes* spp.)	Common
Lentil (*Lens culinaris*)	
Dry root rot (*Rhizoctonia bataticola*)	Sporadic (emerging)
Collar rots (*Sclerotium rolfsii*)	Sporadic
Stem rot/ blight (*Sclerotinia sclerotiorum*)	Sporadic
Fusarium wilt (*Fusarium oxysporum* f. sp. *lentis*)	Widespread
Rust (*Uromyces fabae*)	Sporadic
Ascochyta blight (*Ascochyta lentis*)	Sporadic
Pod borer (*Helicoverpa armigera*)	Widespread
Cutworm (*Agrotis ipsilon*)	Widespread
Termites (*Odontotermes* spp. and *Microtermes* spp.)	Common
Mung (*Vigna radiata*) and Urd bean (*Vigna mungo*)	
Yellow mosaic disease	Common
Cercospora leaf spot (*Cercospora canescens*)	Common
Leaf crinkle	Sporadic
Powdery mildew (*Erysiphe polygoni*)	Sporadic
Anthracnose (*Colletotrichum* spp.)	Common
Whitefly (*Bemisia tabaci*)	Common
Aphids (*Aphis craccivora*)	Common
Stem fly (*Ophiomyia phaseoli*)	Widespread
Termites (*Odontotermes* spp.)	Common

INTEGRATED NUTRIENT MANAGEMENT

Low carbon content is a common feature of soils of target areas. Most of the pulse growing areas are also low in NPK status. Sulphur deficiency ranged 20-60%. Zinc as well as iron are deficient among micronutrients. Zinc sulphate was provided @15.0 kg/ha as a part of minikit. Similarly, sulphur was given in the form of Sulphur Bethonite @ 5kg/ha to replenish the soil sulphur. The application of sulphur has resulted in development of healthy flowers and pods bearing bold seeds in comparison to conventional system.

MONITORING-BASED PEST MANAGEMENT STRATEGIES

Extent of crop yield reduction depends on the duration of pest attack as well as their density/ intensity. Hence, monitoring of the crop health for timely detection is the most crucial factor governing the economics of crop production, success of IPM strategies, adoption and effectiveness of plant protection tools. There is need to have a real-time database of pests along with a built-in support system to take timely decisions. These objectives could be fulfilled by developing "National Pest Reporting and Alert System" using the "e-Pest surveillance" data through *http://www.ncipm.org.in/A3P/UI/HOME/Login.aspx*. It has an inbuilt decision support system and dissemination of advisories to individual farmers through short message services (containing alerts as well as advisories in local languages). The technical assistants (pest scouts) were entrusted to visit pre-designated farms on regular basis and record pest information by sampling plants. Adult catches of *H. armigera* caught in the pheromone traps deployed across fields were noted on standard datasheets. The accumulated data were screened by pest experts and when needed management strategies based on preventive and curative measures using latest chemical molecules were initiated.

While the IPM strategies revolved around pod-borer, and root wilt complex initially, the scenario has completely changed since 2012, and warranted revisit of strategies. During this period the lesser known diseases (*Phytophthora*, leaf spots, powdery mildew and rusts) and insect-pests (spotted pod borer, podbugs, podfly and beetles) have become a major threat in pigeonpea for which majority of stakeholders were neither prepared nor have any strategy. Provision of pest scouts has enabled monitor and report the occurrence of these emerging pests and new host records. Despite continuing incidences of previously known pests, implementation of field tested IPM strategies could help in achieving higher pulse production and restoring confidence among farmers to the recommended technologies.

INTEGRATED PEST MANAGEMENT STRATEGIES

Pigeonpea

- Adopt field sanitation by removing un-decayed plant/crop residues to prevent foliar diseases (powdery mildew and *Cercospora* leaf spot).

- Adopt soil application of Sulphur @ 20 kg/ha (*e.g.*, through SSP, Gypsum or elemental) and Zn as $ZnSO_4$, which will lead to healthy crop and impart general resistance.
- Select fields with no water logging or provide with good drainage system or follow ridge sowing to reduce the incidence of *Phytophthora* blight. Use certified seed of recommended variety having resistance/tolerance to key insect pests/diseases.
- Adopt recommended plant to plant and row distance as per chosen variety and location. Advocate larger row to row space in the late as well as transplanted pigeonpea.
- Treat the seeds with biofertilizers (PSB + *Rhizobium* + Zn solubilizing bacteria) as per recommended dosages, giving preference to local resources such as State bio-control lab as well as University. Treat seeds with recommended dose of locally available *Trichoderma* formulations (10g/kg of seeds), to prevent seedling from soil borne and vascular diseases (*e.g.*, *Sclerotium* soft rot and *Fusarium* wilt), nematodes at vegetative stage.
- Once the crop attains bud forming stage install pheromone traps @ 5/ha for monitoring of pod borer (*H. armigera*) adults in the field. Conventional light traps may also be installed. Crop needs to be surveyed for presence and stages of larvae. In case of high infestation in terms of catches (2-5 adult) per week or 1 larvae per plant (ETL) follow spray schedule. This spray schedule will hold good for *Maruca* web as well as leaf folders, which infest at vegetative and flowering stages.
- Spray with either 5% crude neem seed extract or with neem oil (3000 to 5000 ppm) will act as anti-feedant as well as repellent to most insect-pests.
- Spray 450 LE of *Ha*NPV admixed with UV retardant (*e.g.*, Ranipal), if the infestation by *H. armigera* larvae is on increase.
- Spray some ovicide (*e.g.*, Profenophos or Chlorpyriphos).
- If the infestation by larvae (pod borer or webber or blue butterfly) is causing higher damage spray green label pesticides *e.g.*, Emamectin benzoate or Chlorantraniliprole (Rynaxypyr) to save the crop. Repeat spray if necessary.
- During green pod stage look for damage caused by pod-fly in the immature pods and spray with insecticides *e.g.*, dimethoate.
- Watch for early morning foggy weather for flower drops and examine closely for black spots. In case of black spots on petals and pedicle, spray with fungicide *e.g.,* Carbendazim; else if dropped flowers are free of spots irrigate the crop and spray with hormones *e.g.*, NAA (@1.5ml/ha), which will further prevent flower drops.
- Harvested grains should be dried on cemented floor to prevent excessive moisture, which otherwise will help bruchids to survive during storage.

Chickpea

- Adopt field sanitation by removing un-decayed plant/crop residues to prevent soil borne diseases (*e.g.*, wilt, black rot and soft rot).
- Adopt soil application of Sulphur @ 20 kg/ha (*e.g.*, through SSP, Gypsum or elemental Zn as $ZnSO_4$), which will lead to healthy crop and impart general resistance.
- Use certified seeds of recommended variety having resistance/tolerance to key insect-pests and diseases.
- Adopt recommended plant to plant and row distance as per chosen variety and location. Advocate larger row to row and plant to plant space to prevent foliar (*Ascochyta*) and floral (*Botrytis*) diseases. Advocate inter-cultivation of "Coriander/Linseed" at every 10th row to build up natural enemies.
- Treat the seeds with biofertilizers (PSB + *Rhizobium* + Zn solubilizing bacteria) as per recommended dose, giving preference to local resources such as State bio-control lab as well as University. Treat seeds with recommended dose of locally available *Trichoderma* formulations (10g/kg of seeds), which will prevent seedling as well as vascular diseases (*e.g.*, Sclerotium soft rot and *Fusarium* wilt), nematodes at vegetative stage.
- Install inanimate bird perches @ 20/ha to encourage predatory bird population.
- Once the crop attains bud forming stage install pheromone traps @ 5/ha for monitoring of *H. armigera* adults in the field. Adult catches will help in getting ready for monitoring-based

spray schedules. Conventional light traps may also be installed. Followed by adult catches, crop need to be surveyed for presence and stages of larvae. In case of higher catches (2-5 adults) per week or 1 larvae per meter row (ETL) adopt plant protection interventions.

- Spray with either 5% crude neem seed extract or with neem oil (3000 to 5000 ppm), which will act as anti-feedant as well as repellent to most of insect-pests.
- Spray with 250 LE of *Ha*NPV admixed with UV retardant (*e.g.*, Ranipal), if the infestation by larvae is still on increase.
- Spray some ovicide (*e.g.*, Profenophos or Chloropyriphos).
- If the infestation by larvae (podborer) is still on increase and larvae beyond 3rd instar are visible spray with green label pesticides *e.g.*, Emamectin benzoate to save the crop. Repeat spray if necessary.
- Watch for early morning foggy weather for flower mottling and drying and examine closely for cottony growth. In case of cottony growth on petals and pedicles spray with fungicide *e.g.*, Carbendazim.
- Harvested grains should be dried on cemented floor to prevent excessive moisture, which otherwise will help bruchids (*Callosobruchus* spp.) to survive during storage.

Mungbean and Urdbean

- Advocate field sanitation, deep summer ploughing and augmentation of de-oiled neem cake @ 5 q/ha.
- Apply balanced dosages of fertilizer, including K to assure pest tolerance in crop.
- Use varieties with resistance for foliar diseases (yellow mosaic virus, powdery mildews).
- Seed treatment with Carbendazim @ 1g/kg seed or *Trichoderma* (4 g/kg seed) + carboxin (1 g/kg seed) for disease management and imidacloprid or thiomethoxam 70WS @ 5g/kg seed for early stage insect pest management or soil application of Imidacloprid 0.3G @15kg/ha for longer effect against sucking insects-pests.
- Intercropping with sorghum, sesame and finger millet as per ratio recommended for the particular location. Adopt regular monitoring of the crop for the occurrence of diseases and pests.
- Use pheromone trap (only in podborer endemic areas) for insect monitoring. With moth catches of 4-5 per trap for 3-4 nights spray as recommended.
- First spray of Profenophos 50EC @ 2ml/l of water.
- If insect-pests continue to prevail apply second spray with NSKE (5% w/v).
- Spray 0.05% Carbendazim @ 5 g a.i./10 l water if powdery mildew, anthracnose or *Cercospora* leaf spot infection is observed to have initiated on the crop (not at advanced stage of disease).

Lentil

- Advocate field sanitation, deep summer ploughing and augmentation of deoiled neem cake @ 5 q/ha.
- Apply balanced use of fertilizer, including K to assure pest tolerance in crop.
- Use varieties with resistance to foliar rust.
- Seed treatment with Carbendazim @ 1g/kg seed or *Trichoderma* (4 g/kg seed) + Carboxin (1 g/kg seed) for disease management and Imidacloprid 70WS @ 5g/kg seed for early stage insect pest management.
- Seed treatment with Carbendazim (1g a.i./kg seed) + Thiram (2 g/kg seed), or *Trichoderma* (4 g/kg seed) + Carboxin (1 g/kg seed).
- Timely sowing as per recommendation for the particular location to avoid rust.
- Intercropping or mixed cropping with linseed or mustard as per ratio recommended for the particular location.
- Regular monitoring of the crop for presence of diseases as well as sucking insect-pests.
- Foliar spray of Profenophos 50 EC @ 2 ml/l water or Dimethoate 30 EC @ 2 ml/l water in case of aphid infestation.
- Foliar spray of Wettable Sulphur (2 g/l water) or Mancozeb (2 g/l water) against rust (number of sprays depend on the disease severity, progress of disease).

SMS ADVISORY CHART FOR THE PULSE PEST MANAGEMENT

Pigeonpea

May:

- Plough the field deep to expose and kill pupae, pupating larvae, fungal pathogens and clean the debris of last crop.
- Go for soil testing at the government soil testing labs and follow their suggestions for the micronutrient and fertilizer applications.

June:

- Apply 125 kg of farm-yard manure mixed with 5 kg of *Trichoderma* sp./ha before sowing to reduce wilt disease.
- Treat seeds with *Trichoderma viride* @ 10 g/kg to check wilt disease.
- Sow the disease/pest resistant varieties in respective endemic areas.
- Intercrop with sorghum to reduce wilt incidence and conserve beneficial insects and to serve as perches for insectivorous birds.
- Plant by mid-June to avoid pod borer *H. armigera*.
- Sowing should be done in rows (North to South).
- Apply Pendimethylin 30 EC or Alchlor 50 EC @ 3.75 ml/l within 2 days after sowing (DAS), for weed management.

July:

- If the weedicide has not been applied weeds should be hand-picked after 20-25 days after sowing. If needed handpicking should be done as and when required.
- Look for any soft rot/collar rot affected plant and in case of high incidence apply soil drenching with Carbendazim 50 WP @ 1.0 g/l.

August:

- Look for wilted plants, rogue out and destroy.
- In case of increased number of wilted plants apply Carbendazim 50 WP @ 1 g/l or Mancozeb 45 WP 2.0 g/l.
- Remove and destroy sterility mosaic affected plants as they serve as source of secondary spread.
- If the number of sterility mosaic disease plant increases, spray Dicofol 18.5 EC @ 2.5 ml/l or Oxydemeton methyl 25 EC @ 2.0 ml/l or Dimethoate 30 EC @ 1.7 ml/l.

September:

- In case of increased wilted plants in the field, apply Carbendazim 50 WP @ 1 g/l or mancozeb 45 WP 2.0 g/l.
- On the reappearance of sterility mosaic disease, spray Dicofol 18.5 EC @ 2.5 ml/l or Oxydemeton methyl 25 EC @ 2.0 ml/l or Dimethoate 30 EC @1.7 ml/l.
- In case of aphids infected plant blackens, spray Dimethoate 30EC @ 1.7 ml/l or Acephate 75 SP @ 1.0 g/l or Quinalphos 25 EC @ 2.0 ml/l.
- Look for blister beetle and collect them mechanically in polythene bags and kill them.
- In case blister beetle population increases, apply Acephate 75 SP @ 1.0g/l or Methomyl 40 SP @ 0.6 g/l or quinalphos 25 EC @ 2.0 ml/l or Chlorpyriphos 20 EC @ 2.5 ml/l.
- Fix pheromone trap @ 5-10/ha for the monitoring of *H. armigera* population.
- Plant marigold as trap crop on borders or interspersed with crop for pod borer management.

October:

- In case of massive attack of defoliators apply Acephate 75 SP @ 1.0 g/l or Methomyl 40 SP @ 0.6 g/l or Quinalphos 25 EC @ 2.0 ml/l or Chlorpyriphos 20 EC @ 2.5 ml/l.
- Spray *Ha*NPV @ 450 LE/ha @ 1.0 ml/l alongwith Teenopol (to minimize UV inactivation) to manage *H. armigera* population.

November:

- Monitor the population of pod borer larva, eggs on the crops and the adults in pheromone trap as pod borer is one of the major pests of pigeonpea.
- If more than 1 pod borer larvae or 2 eggs/plant or 4-5 moths / trap/ day (ETL) is observed, spray Profenophos 50 EC @ 2.0 ml/l or Thiodicarb 75 WP @ 0.6 ml/l or Indoxacarb 14.5 SC @ 0.3 ml/l or Emamectin benzoate 5 SG @ 0.2 g/l or *Ha*NPV @ 450 LE/ha @ 1.0 ml/l or NSKE 5% @ 50 g/l or Neem oil 3000 ppm @ 20 ml/l.

- In case of severe damage by *Cercospora,* spray Mancozeb 75 WP @ 2.0 g/l or Carbendazim 50 WP @ 1.0 g/l.
- On the appearance of sterility mosaic diseases spray Dicofol 18.5 EC @ 2.5 ml/l or Oxydemeton methyl 25 EC @ 2.0 ml/l or Dimethoate 30 EC @1.7 ml/l.
- The pods from the early maturing varieties should be harvested as soon as they mature.
- The seeds should be sun-dried properly before it is placed in a clean, beetle-proof storage container.
- In case of infestation by bruchids before the time of harvest spray Triazophos 40 EC (in field at harvest) @ 2.0 ml/l or 10 ml/kg of seeds.
- Clean the stores and destroy the residual bruchid population.
- Mix edible oils like mustard oil or neem oil @ 10 ml/kg seed along with charcoal powder @ 10 g/kg of seed.
- If bruchids infestations is high under storage fumigate with Ethylene dibromide @ 3 ml/100kg of seed.

December:

- Frequently monitor the pod fly and pod sucking bugs as they are major pests of pigeonpea.
- If more than 2.5% of pods are damaged (ETL) by the pod fly, apply Acephate 75 SP + jaggery (1%) @ 1.0 g + 10 g/l or Imidacloprid 17.5 SL+ jaggery (1%) @ 0.2 ml + 10 g/l or Thiomethoxam 25 WG + jaggery (1%) @ 0.3 ml + 10 g/l or Thiodicarb 75 SP+ jaggery (1%) @ 0.6 ml + 10 g/l.
- In case the population of pod sucking bugs is above 2 bugs/plant (ETL) apply Acephate 75 SP @ 1.0 g/l or Quinalphos 25 EC @ 2.0 ml/l or Chlorpyriphos 20 EC @ 2.5 ml/l

January:

- If more than 1 pod borer larvae or 2 eggs / plant or 4-5 moths / trap/ day or the pod damage of more than 5% observed (ETL), spray Profenophos 50 EC @ 2.0 ml/l or Thiodicarb 75 WP @ 0.6 ml/l or Indoxacarb 14.5 SC @ 0.3 ml/l or Emamectin benzoate 5 SG @ 0.2 g/l or *Ha*NPV @ 450 LE/ha @ 1.0 ml/l or NSKE 5% @ 50 g/l or Neem oil 3000 ppm @ 20 ml/l

February:

- In case of population of pod sucking bugs is above 2 bugs/plant (ETL), apply Acephate 75 SP @ 1.0 g/l or Quinalphos 25 EC @ 2.0 ml/l or Chlorpyriphos 20 EC @ 2.5 ml/l.
- If more than 1 pod borer larvae or 2 eggs / plant or 4-5 moths / trap/ day or the pod damage of more than 5% observed (ETL), spray Profenophos 50 EC @ 2.0 ml/l or Thiodicarb 75 WP @ 0.6 ml/l or Indoxacarb 14.5 SC @ 0.3 ml/l or emamectin benzoate 5 SG @ 0.2 g/l or NSKE 5% @ 50 g/l or Neem oil 3000 ppm @ 20 ml/l.
- If more than 2.5% of pods are damaged by the pod fly (ETL), apply Acephate 75 SP + jaggery (1%) @ 1.0g + 10 g/l or Imidacloprid 17.5 SL+ jaggery (1%) @ 0.2 ml + 10 g/l or Thiomethoxam 25 WG + jaggery (1%) @ 0.3 ml + 10 g/l or Thiodicarb 75 SP+ jaggery (1%) @ 0.6 ml + 10 g/l.

March & April:

- Spray Triazophos 40 EC (In field at harvest) @ 2.0 ml/l or 10 ml/kg of seeds.
- The seeds should be sun-dried properly before it is placed in a clean, beetle-proof storage container.
- Clean the stores and destroy the residual bruchid population.
- Mix edible oils like mustard oil or neem oil @ 10 ml/kg seed along with charcoal powder @ 10 g/kg of seed.
- If bruchids infestations is high under storage fumigate with Ethylene dibromide @ 3 ml/100kg of seed.

Chickpea

October:

- Apply well decomposed FYM or neem cake in fields having disease problems in previous years.
- Treat the seeds with recommended dosage of *Rhizobium* and with local strain of *Trichoderma* @ 10g/kg of seeds.
- Intercrop with linseed/coriander/mustard and "sprinkle" with sunflower to promote bioagent activity. Complete planting by mid-October to escape pod borer activities.

November:

- Carry out intercultural operation and hand weeding to keep the fields free from weeds and cut worms.

- At 8 weeks detop or carry out nibbling of crops to induce profuse tillering.
- Carry out regular monitoring for occurrence of pod borer damage.

December:

- Look for rot caused by wilt, collar rot and dry root rot diseases. Collect and burn them for further spread in the fields.
- Look for pod borer egg laying/infestations and apply neem seed extract/neem oil as deterrent.

January:

- Look for flower drops for *Botrytis* disease and spray with Carbendazim 50 WP @ 2 g/l or with other recommended pesticides.
- If fog persists carry out regular monitoring for yellowing of the crop often caused by *Sclerotinia* blight and spray with Chlorothalonil or Mancozeb.
- In case of pod borer infestation, spray with Chlorantraniliprole 18.5% SC @ 0.15 ml/l or Emamectin benzoate 5 SG @ 0.2 g/l, or Novaluron 10 EC @ 1.5 ml/l or Ethion 50 EC 2 ml/l or Monocrotophos 36 SL @ 0.04% (1 ml/l of water or Chlorpyrifos 20 EC @ 0.05% (3.5 ml/l of water) or Deltamethrin @ 0.5 ml/l of water 500 or 600 litres of water/ha or dust Quinalphos 1.5 D, or Chlorpyrifos 1.5 D @ 25 kg/ha.

February:

- Carry out intensive monitoring of the crop for pod borer damage and spray with Chlorantraniliprole 18.5% SC @ 0.15 ml/l or Emamectin benzoate 5 SG @ 0.2 g/l, or Novaluron 10 EC @ 1.5 ml/l or Deltamethrin @ 0.5 ml/l of water 500 or 600 litres of water/ha or dust Quinalphos 1.5 D, or Chlorpyrifos 1.5 D @ 25 kg/ha.

March & April:

- The seeds should be sun-dried properly before it is placed in a clean, beetle-proof storage container.

  In case of bruchid infestation before the time of harvest spray Triazophos 40 EC (in field at harvest) @ 2.0 ml/l or 10 ml/kg of seeds.
- Clean the stores and destroy the residual bruchid population.
- Mix edible oils like mustard oil or neem oil @ 10 ml/kg seed along with charcoal powder @ 10 g/kg of seed.
- If bruchid infestations are high under storage fumigate with Ethylene dibromide @ 3 ml/100 kg of seed.

AWARENESS CAMPAIGNS THROUGH PRINT AND ELECTRONIC MEDIA

IPM being knowledge intensive is the main constraint in adoption by majority of farmers and their promoters. In view of this, farmers knowledge was upgraded by organizing Farmer Field Schools (FFS) during the crop season, and during this process "pest scouts" could reach areas not covered earlier. Apart from this several resource material with coloured field photographs were developed and popularized during annual *Rabi* and *Kharif* campaign meets.

CAPACITY BUILDING

In order to popularise pest management based on real-time pest surveillance, information retrieved from "e-Pest Surveillance" training of State Govt officials (UP, MP, Chhattisgarh, Karnataka, Rajasthan, Bihar, Jharkhand, Andhra Pradesh, Maharashtra, West Bengal, Assam and Tamil Nadu) were carried out in collaboration with Department of State Agriculture at selective states. Trainees were imparted with basic knowledge on use of software, decision to select pesticides, safer molecules and changing pest scenario.

EXPANSION OF IPM AREA THROUGH FARMERS' PARTICIPATION

Cluster of "Nuclear Model Villages" was selected in collaboration with State Departments of Agriculture to avoid duplication. Farmers irrespective of land holdings were selected in different districts for demonstrating IPM modules comprising field tested plant protection strategies. Different IPM components were procured based on Govt approved rates and distributed among adopted farmers belonging to IPM. The programme was implemented in farmers' participatory mode to suit their cropping systems. After collection of baseline data plant protection strategies were implemented based on real-time pest information. The decisions pertaining to chemical spray with selective group of pesticide were conveyed through farmers meet as well as advisories sent through SMS.

DETAILS ON AREA OF OPERATION AND BENEFICIARIES

Pigeonpea and Chickpea

Year	Area (ha)		No. of beneficiaries*		No. of taluks		No. of villages covered	
	Pigeonpea	Chickpea	Pigeonpea	Chickpea	Pigeonpea	Chickpea	Pigeonpea	Chickpea
Gulbarga (Karnataka)								
2010-11	7000	5000	3301	1499	5	5	34	23
2011-12	6773.6	3896.8	3142	2372	6	4	39	44
2012-13	5000	4000	1808	1104	3	3	21	11
2013-14	3525.62	3904	2197	968	3	3	18	14
Bidar (Karnataka)								
2012-13	846	354	35	267	4	4	35	40
2013-14	2000	1000	21	900	5	3	21	8
Anantapur (Andhra Pradesh)								
2010-11	1000	1000	500	1000	1	12	5	12
2011-12	1000	2000	684	1912	3	2	4	10
2012-13	500	500	517	466	1	1	9	2
2013-14	400	400	174	386	1	1	4	1
Naigaon (Maharashtra)								
2010-11	1000	586.8	930	814	1	1	6	7
2011-12	1090	1024.91	1330	1429	1	1	7	12
2012-13	501.2	500	548	523	1	1	1	2
2013-14	500.2	500.2	509	624	1	1	2	2
Osmanabad (Maharashtra)								
2010-11	2035	2000	1556	1678	3	1	7	6
2011-12	1596	1691.6	1071	1227	1	1	3	5
Badnapur (Maharashtra)								
2010-11	1000	0	732	0	2	0	7	0
2011-12	1000	0	680	0	2	0	7	0
2012-13	200	100	443	180	2	1	4	1
2013-14	240	215	191	164	1	2	2	3
Parbhani (Maharashtra)								
2010-11	2000.54	2000	1341	1095	2	2	6	7
2011-12	2000	2000	1108	1222	2	2	7	8
2012-13	500	500	470	299	3	1	5	3
2013-14	500	500	450	317	3	2	4	4
IIPR, Kanpur (Uttar Pradesh)								
2010-11	2198	333	2987	671	3	2	65	12
2011-12	2932	686	3000	875	3	2	72	20
2012-13	226	475	325	450	1	1	9	15
2013-14	258.56	450	366	465	1	1	11	15
Mirzapur (Uttar Pradesh)								
2012-13	645	770	1008	677	3	3	18	24
2013-14	75	351	175	410	1	3	5	14
Jabalpur (Madhya Pradesh)								
2010-11	3000	2000	2853	1708	6	2	111	55
2011-12	3000	2000	2754	1688	3	1	108	33
2012-13	200	600	198	446	1	1	3	10
2013-14	100	315	90	336	1	1	3	6
Lohardaga (Jharkhand)								
2012-13	500	300	492	296	5	4	10	6
2013-14	500	300	494	302	4	5	10	11
Total	55842.72	41938.31	20345	13061	89	80	683	445

Lentil

Year	Area (ha)	No. of beneficiaries	No. of taluks	No. of villages covered
Jabalpur (Madhya Pradesh)				
2012-13	100	69	1	5
2013-14	100	100	1	4
Lohardaga (Jharkhand)				
2012-13	100	283	4	16
2013-14	100	182	4	6
Mirzapur (Uttar Pradesh)				
2012-13	130	61	1	8
2013-14	288	112	2	10
Total	1018	394	13	49

Mung and Urd bean

Year	Area (ha)	No. of beneficiary farmers	No. of taluks	No. of villages covered
Badnapur (Maharashtra)				
2012-13	249	212	2	2
2013-14	169	169	2	3
Total	418	381	4	5

**Every year beneficiaries i.e., farmers were different*

YIELD LEVELS AND PESTICIDE USE IN IPM *VERSUS* NON IPM (NIPM)

Pigeonpea and Chickpea

Year	Average yield (q/ha)				% increase		% increase over State average		No. of sprays of chemical pesticides				Reduction in pesticide use	
	Pigeonpea		Chickpea		Pige-onpea	Chick-pea	Pige-onpea	Chick-pea	Pigeonpea		Chickpea		Pige-onpea	Chick-pea
	IPM	NIPM	IPM	NIPM	IPM	NIPM	IPM	NIPM	IPM	NIPM	IPM	NIPM	IPM	NIPM
Gulbarga (Karnataka)														
2010-11	10.0	8.7	11.2	9.4	12.5	16.7	117.4	103.8	6	13	2	3	7	1
2011-12	8.2	7.0	10.9	8.9	14.5	16.9	60.0	19.0	5	12	3	4	7	1
2012-13	10.7	9.2	11.6	10.0	13.9	15.0	44.7	147.4	3	5	2	3	2	1
2013-14	10.6	9.1	11.7	9.7	13.7	17.0	43.0	75.4	2	4	3	4	2	1
Bidar (Karnataka)														
2012-13	13.5	9.1	14.7	11.2	32.5	23.6	189.5	210.1	4	5	3	5	1	2
2013-14	13.7	8.2	13.5	10.5	40.0	22.2	147.0	184.0	5	6	6	5	1	1
Anantapur (Andhra Pradesh)														
2010-11	4.0	4.0	15.9	12.5	0.0	21.4	104.5	12.6	1	4	2	4	3	2
2011-12	2.5	1.8	16.5	21.0	27.1	27.3	54.0	-	5	7	2	5	2	3
2012-13	4.3	4.1	8.4	9.7	4.6	16.2	-	-	3	3	4	5	0	1
2013-14	7.1	6.4	12.7	9.4	9.5	26.3	35.0	35.0	4	2	4	2	-2	2
Naigaon (Maharashtra)														
2010-11	9.5	4.1	19.3	11.0	57.0	42.2	77.5	185.4	5	7	2	4	2	2
2011-12	9.4	5.9	15.7	10.1	37.3	35.4	45.8	49.1	5	6	4	5	1	1
2012-13	10.6	8.8	20.5	9.2	16.9	55.1	21.6	58.4	4	8	3	4	4	1
2013-14	11.0	8.3	21.5	8.5	24.6	60.4	21.6	65.5	4	4	4	4	0	1

cont...

Osmanabad (Maharashtra)														
2010-11	8.6	7.9	18.7	16.6	8.7	11.2	61.1	176.1	4	5	1	4	1	3
2011-12	7.7	-	14.4	6.8	-	52.8	18.5	55.2	5	6	4	4	1	0
Badnapur (Maharashtra)														
2010-11	9.1	8.4	-	-	7.7	-	70.0	-	4	3	-	-	-1	-
2011-12	13.7	9.0	-	-	34.5	-	72.0	-	5	4	-	-	-1	-
2012-13	10.0	7.0	11.0	5.5	30.0	50.0	-	-	6	5	4	5	-1	1
2013-14	16.0	8.1	8.5	-	49.1	0.0	190.0	101.0	3	4	3	2	1	1
Parbhani (Maharashtra)														
2010-11	10.1	8.3	9.3	7.4	17.9	20.4	68.8	37.5	5	6	3	3	1	0
2011-12	9.6	9.6	9.4	7.4	0.0	21.9	-	-	4	6	3	4	2	1
2012-13	11.1	-	11.3	-	-	-	-	-	6	9	3	5	3	2
2013-14	12.1	10.6	12.1	-	12.4	-	-	-	3	8	3	7	5	4
IIPR, Kanpur (Uttar Pradesh)														
2010-11	9.7	6.8	14.6	11.7	29.8	20.0	13.6	44.3	3	5	4	5	2	1
2011-12	-	-	17.5	11.7	-	33.0	-	46.7	4	5	2	4	1	2
2012-13	11.5	8.5	15.4	10.8	25.8	29.9	29.4	24.1	4	6	2	4	2	2
2013-14	15.7	11.5	15.4	8.5	27.0	44.8	11.2	-	3	5	2	4	2	2
Jabalpur (Madhya Pradesh)														
2010-11	3.0	2.0	17.5	-	33.3	-	169.6	45.8	4	7	2	4	3	2
2011-12	13.7	8.9	19.4	-	34.6	-	53.9	44.4	4	7	2	0	3	2
2012-13	11.0	6.4	15.7	10.6	41.3	32.4	76.4	10.8	2	3	4	5	1	1
2013-14	13.1	7.5	14.5	9.0	42.8	37.9	49.8	15.8	3	3	3	3	0	0
Lohardaga (Jharkhand)														
2012-13	16.5	15.5	13.0	10.4	6.1	20.0	-	-	5	2	6	-	-3	-
2013-14	13.6	9.8	11.9	8.7	27.6	26.9	-	13.1	4	4	3	2	0	-1

Lentil

Year	Average Yield (q/ha)		% increase	% increase over State average	No. of sprays of chemical pesticides		Reduction in pesticide
	IPM	NIPM			IPM	NIPM	
Jabalpur (Madhya Pradesh)							
2012-13	12.9	10.0	22.6	39.9	1	1	0
2013-14	13.5	10.0	26.0	56.7	1	1	0
Lohardaga (Jharkhand)							
2012-13	12.5	9.4	24.8	13.4	1	2	1
2013-14	9.5	7.3	23.2	15.4	1	2	1
Mirzapur (Uttar Pradesh)							
2012-13	12	8	33.3	41.7	1	0	-1
2013-14	-	-	-	-	2	0	-2

Mung and Urd bean

Year	Average Yield (q/ha)		% increase	% increase over State average	No. of sprays of chemical pesticides		Reduction in pesticide
	IPM	NIPM			IPM	NIPM	
Badnapur (Maharashtra)							
2012-13	6.0	4.5	25.0	91.0	2	3	1
2013-14	4.5	-	-	95.0	2	2	0

YIELD AND ECONOMICS OF IPM

The implementation of IPM with the holistic crop health approach has led to increased pulse production (15-20%) due to reduction in pest incidence/intensity at field level across the centres. “National Pest Reporting and Alert System” led to timely action against insect-pests and diseases, thus improving the economic benefits.

Due to monitoring system in place identification of the powdery mildew, *Batocera*, *Cercospora* leaf spot disease, *Macrophomina* blight in pigeonpea and powdery mildew, rust and leaf malformation in chickpea were noted as emerging pest problems in southern and central India.

Crop/ location	% increase in yield	BC Ratio
Pigeonpea		
Gulbarga	66.5	3.4
Bidar	168.2	4.0
Anantapur	64.5	2.1
Naigaon	41.6	3.0
Badnapur	110.7	5.6
Parbhani	8.8	3.4
IIPR, Kanpur	8.0	2.8
Jabalpur	87.4	2.9
Chickpea		
Gulbarga	86.2	2.6
Badnapur	101.0	2.5
Bidar	197.0	2.4
Anantapur	23.8	2.0
Naigaon	89.6	1.8
Parbhani	37.5	1.8
Kanpur	38.4	3.1
Lohardaga	13.1	2.8
Jabalpur	29.2	2.3
Mung and Urd bean		
Badnapur	93.0	4.5
Lentil		
Jabalpur	48.3	4.4
Lohardaga	14.4	2.1

The B:C ratio indicates that IPM farmers have been benefited more economically in comparison to non-IPM due to savings accrued by less spray and vigorous crop health due to INM provided under IPM kit.

The mean value of output on IPM farmer was about 10% higher than NIPM farms. The cost per unit output under different technological options is an indicator of their economic efficiency. The economic analysis clearly indicated that IPM strategies with focus on timely intervention can pay dividends in the long run and will also help in reducing impact of climate change.

ENVIRONMENTAL BENEFITS

Use of eco-friendly chemical pesticides has helped in promotion of beneficial insects, *viz.*, spiders, coccinellids and *Chrysoperla.* Spiders are very effective in minimizing the population of insect-pests. Since it is very difficult to rear, they were conserved by minimizing the chemical pesticide sprays. Build-up of lady bird beetles (*Coccinella*) and the occurrence of green lacewing (*Chrysoperla*) could be observed for 45 days of crop growth. They feed on jassids and eggs of lepidopteran insects. While the population of spiders and *Chrysoperla* was more during peak flowering than pod development stage, coccinellids were more during the later stage. Population of beneficial was more in IPM as compared to NIPM fields across all the taluks and seasons. Spider population was more in IPM as compared to NIPM. The occurrence of green lacewing (*Chrysoperla*) could be observed for 45 days of crop growth.

ECOLOGICAL BENEFITS

With growing awareness on the environment, all government agencies are emphasizing on sustainability through eco-friendly technologies. Hence, an attempt has been made to analyze the impact of IPM strategies on environment and farm workers. The benefit incurred to the environment was assessed based on total EIQ, farm workers, honey bees as pollinators, consumers as well as natural defenders. IPM strategies have reduced use of chemical pesticides leading to improvement in ecological niche.

SOCIAL BENEFITS AND AWARENESS

Attempt under IPM programme has been made to benefit maximum number of farmers and helped them to be decision makers of their own farms. The advisories received by them through SMS have enabled them to take timely action with the critical inputs provided. The farmers have opportunity to try new methods under assured supervision of University staff. The success of technology has made them to believe in scientific findings of University and enjoyed the opportunity to have face to face interactions. Non-IPM farmers also got interested in the fields of IPM farmers due to better crop health with lesser inputs and taken peer guidance.

- Established and strengthened the critical IPM inputs producing units at SAUs (UAS, Raichur and MAU, Parbhani) and served as source for quality critical IPM input (*Trichoderma* formulations), making it popular among farmers;
- The farmers were educated to differentiate between the beneficials and harmful pests so as to become decision makers of their own farm;
- IPM program has resulted into healthy crop and reduced the dependence on chemical pesticides specially the organochlorines, organophosphates and neonicotinoids. Impact of A3P could be observed by drastic reduction in usage of dust formulations from 24.6 to 0.6%. The pesticide use data has been quantified and grouped into categories for policy makers. Soil health has improved in terms of conservation of soil inhabiting beneficial flora (*Trichoderma* and *Pseudomonas fluorescens*) and fauna;
- The impact on environment calculated on the patterns of EPA, indicated reduction in toxicity leading to increase in the population of beneficial insects and micro-organisms;
- Most of the farmers (>95%) understood the concept of rotation of broad spectrum chemical insecticides with new molecules. Survey has initiated the interest in use of botanicals and *Ha*NPV. Farmers themselves (0.1 to 0.8%) understood the know-how and do-how about *Ha*NPV production technology and usage for the management of pod borer;
- Six technical bulletins, four books and 15 extension folders have been published to serve as resource material for the farmers, govt. officials and extension functionaries of different states and collaborators;
- Provided first level training to the officials (more than 500 trainees) of State Agriculture. Departments (UP, MP, Chhattisgarh, Karnataka, Rajasthan, Bihar, Jharkhand, Andhra Pradesh, Maharashtra and Tamil Nadu) and course curriculum for second and third level training was also prepared and sent to States.

ADOPTION OF IPM *VIS-À-VIS* EMPLOYMENT: ESTABLISHMENT OF *DAL* MILL BY IPM FARMERS

Success of IPM can be measured from the changing economic status of farmers in the vicinity. The farmers who are the beneficiaries of IPM Project (2010-11) of Afzalpur taluk were economically benefitted due to the technology and envisioning future prospects, formed the *Sangha*/societies. One of the lead *Sangha* is *"Annadaata Savayava Krishikara Sangha"* at village Gangapur that had approached the different Government funding agencies for the financial support to establish *dal* mill. The Indian Society of Agribusiness Professionals (ISAP) came forward to provide 50 per cent financial support to establish the *dal* Mill. The *dal* mill was opened on 13 Dec 2011 and milled 80 tons of *dal* by the end of February 2012. The capacity of *dal* mill is 5 q/hr with a milling recovery of 80%. The farmers send the *tur* for milling with detail information about name of the farmer, village, variety of *tur*, and production technology followed. The mill accepts such produce and processes it. After milling, 5 per cent of *dal* is retained by *Sangha* for the maintenance and improvement. Remaining quantity is given to concerned farmers. The society signed agreements with several Governmental farming missions for selling of *dal* directly to them.

FUTURE DIRECTIONS

IPM led pulse production has been heralded as a means to enhance agricultural profits and living standards of people, while reducing risk from chemical pesticides to human health and the natural environment. During last two years, DAC programme in major pulse grown areas have sought to encourage e-pest surveillance-based IPM methods. "Just in time" delivery of "Advisories" ahead of farmers optional decisions has helped in effective pest management with minimum use of correct pesticides and their doses. The anticipatory "teachable moments" based on reporting system has helped farmers in greater prospects. This programme has been expanded recently in tandem with policies designed to reduce human exposure to chemical pesticide risk while making agriculture sustainable. This success story may be a role model for farmers to adopt the technology in other parts of the country having similar agro-climatic conditions. The effectiveness of the integrated crop management (ICM) based strategies in increasing production are undoubtedly a positive indicator that there is no technological fatigue and same can be effectively utilized. Apart from economic benefits, the technology also provides opportunity to promote eco-friendly methods which helps in conservation and promotion of predators, parasitoids and soil-based useful microorganisms.

In the above stated lines, NCIPM proposes to expand its activity in terms of acreage with the help of new partners which includes Mission Directors of State Departments of Agriculture of Jharkhand, Bihar, West Bengal, Gujarat, Rajasthan, Andhra Pradesh, Assam and Karnataka covering other pulse crops *e.g.*, mung, urdbean and lentil. Under this proposal, watch on real time pest built up will be kept and the pest management practices will be implemented through "e-Pest Surveillance" developed under NFSM. The monitoring of crop has already helped in quantifying the impact of climatic variables on incidence of foliar diseases (*e.g.*, Powdery mildew; *Cercospora* leaf spot, and SMD) as well as root diseases (*e.g.*, dry root rot, soft rot) in chickpea. The infestation of thrips has also been recorded and was on the rise. In order to keep watch on real-time pest built-up and its spread, NCIPM could take up the responsibility for providing infrastructural as well as other technical help through the dedicated servers established at NCIPM. It is also proposed to establish a dedicated permanent data center at new NCIPM premises at Mehrauli, apart from online training facility. NCIPM could also provide above facility to other pulse growing states taking up programmes on their own.

Life of farmers is solely dependent upon the microbes present in the soil

– Parashar (Krishi Parashar, c. 400 BC)

IPM FOR GROUNDNUT AND MUSTARD

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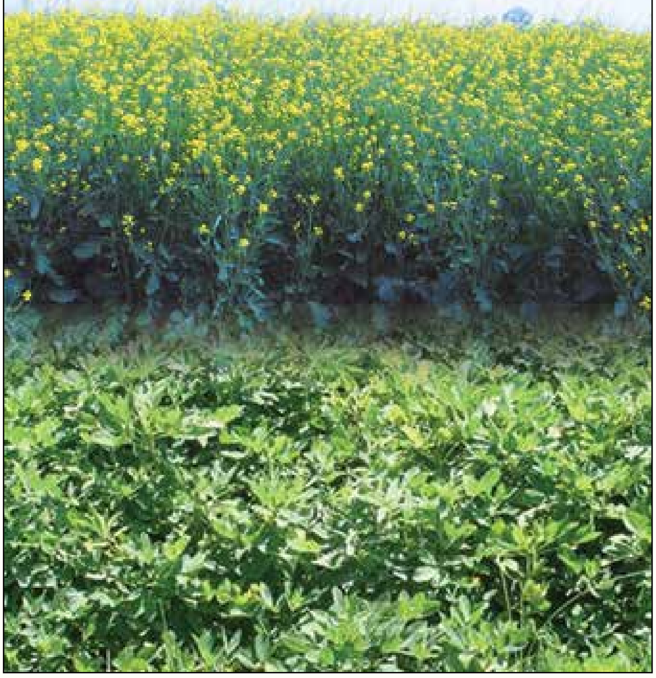


INTRODUCTION

India is a key player in the scenario of global oilseeds with 12-15, 6-7, 9-11 and 14 per cent of area, oil production, total edible oil consumption and vegetable oil imports, respectively. Inspite of a reasonably good oilseed production in India, Indian vegetable oil import is high. Groundnut (*Arachis hypogea* L.) and rapeseed-mustard (*Brassica* spp.) are the two important oil seed crops known for their multifarious utilities. In India, groundnut is mostly grown as a *Kharif* crop and contributes to 33 per cent of the total oilseed production (32.88 mt). Karnataka is the fifth largest producer of the crop with Gujarat, Andhra Pradesh, Tamil Nadu and Rajasthan occupying the higher positions. Rapeseed-mustard is the third most important source of vegetable oil in the world after soybean and oil palm, and second most consumed edible oil in India after groundnut. Rapeseed-mustard has about 24 per cent share in total oilseed production ranking second after soybean in the country. Mustard crops occupy an area of 6.7 million ha, yield 7.96 million tons with average productivity of 1188 kg/ha. Indian mustard is mainly cultivated in India, which contribute about 85 per cent of the total rapeseed-mustard production. Mustard is predominantaly grown in *Rabi* season in Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat and West Bengal accounting for 86.5 per cent of area and 91.4 per cent of production of India. Mustard, as nutritious food contains 28-36 per cent protein along with 38-45 per cent oil content. Although there has been significant improvement in both production and productivity of these oilseed crops there is a wide gap between the potential yields realized at experimental and at farmers' fields. Bridging this gap through IPM is one of the options to meet the growing demand of oilseeds.

An integrated eco-friendly system approach that reduces the usage of chemical pesticides to save the crops from pests is termed as integrated pest management (IPM). IPM uses wide array of tactics to manage pest population. The main goal of IPM has been to obtain high quality produce with minimal impact on environment and human health while providing high economic returns. Development and implementation of integrated pest management in farmers' participatory mode was considered one of the options to realize the potential yield. Field experiments at farmers' field were undertaken to evolve and validate location-specific, sustainable, eco-friendly as well as economically viable IPM in major oilseed crops.

The IPM for the groundnut and mustard crops were formulated after collecting the available and published data. Identification of key insect-pests and diseases of the particular oilseed crop under the particular agro-ecological zones was carried out for validation. The farmers of the IPM villages were educated about the IPM practices through "Farmers' Field Schools" regularly.

VALIDATION AND IMPACT OF IPM IN GROUNDNUT

Location: Anantapur, Andhra Pradesh

Groundnut and pigeonpea (*Cajanus cajan* L.) intercropping in 7:1 or 11:1 is an important cropping system grown under Rayalaseema region of Andhra Pradesh. About 0.5 m ha is grown under this system in Anantapur district alone out of 0.7 m ha under groundnut. Major constraints in production of rainfed groundnut + pigeonpea in this region are the insect-pests [white grub *Holotrichia*, red hairy caterpillar *(Amsacta)*, leaf webber *(Aproaerema)*, and thrips *Scirtothrips dorsalis* as vectors for viral diseases] and diseases like collar rot (*Sclerotium rolfsii*), late leaf spot (*Cercosporidium personatum*), peanut stem necrosis disease (PSND) (tobacco streak virus) on groundnut and ash weevil (*Myllocerus* sp.) and pod borer (*Helicoverpa armigera*) on pigeonpea.

On farm trials were undertaken to validate location specific IPM module for groundnut + pigeonpea intercropping system. The trials were conducted during 2001-02. Four villages *viz.,* Kandukuru, Alamuru (Anantapur Mandal, A.P.), Jambuladinne (Garladinne Mandal, A.P.) and Peravali (Singanamala Mandal, A.P.) were selected. The IPM module: (1) deep summer ploughing, (2) groundnut + pigeonpea intercropping (7:1 ratio), (3) growing 4 rows of pearl millet (seed rate used @ 1 kg/ha) border as crop, (4) erecting live bird perches of pearl millet/sorghum (seed rate used @ 0.25 kg/ha) mixed with pigeonpea, (5) seed treatment with chlorpyriphos 20EC @ 6 ml/kg, (6) application of fenvalerate 20EC @ 2 ml/litre (used for red hairy caterpillar management), (7) single spray at critical stage with carbendazim 0.1% + mancozeb 0.2%, (8) installation of pheromone traps for monitoring *Helicoverpa armigera* @ 10 traps/ha 30 DAS and (9) application of *Ha*NPV @ 250LE/ha. It was compared with farmers' practices (FP) which included groundnut + pigeonpea intercropping (14/18/22/26/30:1 ratios).

Late leaf spot incidence in IPM was low (22%) compared to farmers' practice (69%) due to the spray of carbendazim + mancozeb in IPM fields. The incidence of PSND was low under both indicating that the intercrop rows of pigeonpea had worked as a barrier for the movement of the thrips, the vector of PSND. The average number of thrips per leaf was high in farmers' practice (3.95) over IPM (3.19). Leaf hoppers per plant and leaf miner/sq.m did not differ between the treatments. *Helicoverpa* larvae per sq.m was higher in farmers' (3.54) as against IPM (2.65) fields. The population of natural enemies *i.e., Coccinella septempunctata* per sq.m. was higher in IPM (2.9) than farmers' practices (1.8). Farmers indiscriminately sprayed chemical insecticide (fenvalerate) that left less *C. septempunctata* population. The population of *Chrysoperla* was also high in the IPM in comparison with FP.

Mean pod yield was high (909.6 kg/ha) in IPM over FP (863.8 kg/ha) indicating that the IPM pest management strategies helped in increasing the yield of rainfed groundnut. The yield of intercrop (pigeonpea) was also significantly higher (236.2 kg/ha.) in IPM than FP (99.6 kg/ha). The benefit cost ratio in IPM was 1.28 as compared to 1.15 in FP.

Location: Sriganganagar, Rajasthan

Validation of IPM module was undertaken during *Kharif* seasons of 2006 and 2007 for groundnut in Sardarpura Ladana area, Sriganganagar district in Rajasthan. Three IPM modules were evaluated *viz.,* (I) integrated approach of summer ploughing 2-3 times during April-May before sowing to expose the hibernating pests, application of neem cake @ 500 kg/ha 15 days before sowing, spray of neem seed kernel extract (NSKE) 5% (w/v) at seedling stage upon occurrence of insect-pests, use of bio-agents (*Trichoderma harzianum*) at 10 g/kg seed or imidacloprid 17.8 SL @ 2 ml/kg seed, deployment of *Helicoverpa armigera* and *Spodoptera litura* traps @ 5/ha and erecting "T" shaped wooden bird perches at 10/ha; (II) seed treatment and soil amendments with bio-pesticides (*T. harzianum* at 10 g/kg seed and application of *T. harzianum* at 4 kg/ha pre-incubated in 50 kg of FYM for 15 days before sowing) and (III) seed treatment with safer insecticides (imidacloprid 17.8 SL at 2 ml/kg) and soil amendment with neem cake at 500 kg/ha preferably 15 days before sowing. The farmers' practice of growing crop without any soil and seed treatments and no subsequent sprays given to protect the crop against pests was used for comparison. Higher pod yield (14.82 q/ha) was obtained from IPM module I in comparison to module II, III & IV. It gave a 51.62% higher yield compared with farmers' practice, where no plant protection measures have been undertaken. The application of IPM module generated higher gross returns (₹ 29720.5/ha) in comparison to farmers' practice (₹ 14237.5/ha). The net returns obtained were also higher at ₹ 24801.5/ha with IPM, and ₹ 14237.5/ha with farmers' practice. The adoption of IPM yielded higher benefits of ₹ 10564/ha. The results showed that adoption of IPM practice has the potential to provide higher yields, with the added advantage that it has no adverse effect on the environment, natural enemies or human health.

Pest incidence amongst IPM modules and farmers' practices (FP) in groundnut at Sriganganagar, Rajasthan

Treatment	*Collar rot%			Early leaf spot score**			Late leaf spot score**			Plant mortality due to termites (%)*		
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
Module I	17.6 (24.8)	8.0 (16.4)	12.8 (20.6)	3.0 (1.7)	4.7 (2.2)	3.8 (1.9)	2.8 (1.7)	3.5 (1.9)	3.2 (1.8)	6.9 (15.2)	8.6 (17.0)	7.7 (16.1)
Module II	12.0 (20.3)	7.4 (15.8)	9.7 (18.0)	4.0 (2.0)	5.3 (2.2)	4.7 (2.1)	3.3 (1.8)	4.2 (2.0)	3.7 (1.9)	21.6 (27.7)	18.1 (25.2)	19.9 (26.4)
Module III	28.2 (32.1)	23.1 (28.7)	25.7 (30.4)	4.0 (2.0)	5.3 (2.3)	4.6 (2.1)	3.5 (1.9)	4.0 (2.0)	3.7 (1.9)	7.1 (15.4)	10.2 (18.6)	8.6 (17.0)
FP	33.3 (35.3)	34.0 (35.6)	33.6 (35.4)	4.7 (2.2)	6.0 (2.5)	5.3 (2.3)	3.8 (2.0)	4.5 (2.1)	4.2 (2.1)	24.1 (29.4)	21.7 (27.8)	22.9 (28.6)
LSD (5%)	1.9	1.6	1.8	0.1	0.1	0.1	0.2	0.2	0.2	1.2	1.1	1.2
CV %	5.6	5.4	5.5	3.1	3.1	3.1	7.4	6.6	7.0	4.5	4.1	4.3

**Values in parentheses indicate angular transformed values; **Figures in parentheses indicate square root transformed values*

Economic viability of IPM modules in groundnut at Sriganganagar, Rajasthan

Treatment	Yield (Q/ha)			Gross return (₹/ha)			Cost of treatment (₹/ha)			Net Returns (₹/ha)			Net Profit (₹/ha)		
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
Module I	14.5	15.2	14.8	26030	33411	29720.5	4919	4919	4919	21111	28492	24801.5	7251	13877	10564
Module II	11.0	11.0	11.0	19741	24235	21988	694	694	694	19047	23541	21294	5187	8926	7056.5
Module III	11.4	11.9	11.6	20556	26107	23331.5	3336	3336	3336	17220	22771	19995.5	3360	8156	5758
FP	7.7	6.6	7.2	13860	14615	14237.5	-	-	-	13860	14615	14237.5	-	-	-
CD (5%)	1.4	1.2	1.3	-	-	-	-	-	-	-	-	-	-	-	-
CV %	10.4	8.7	9.5	-	-	-	-	-	-	-	-	-	-	-	-

Selling price of groundnut : (2006: ₹1800/q; 2007: ₹ 2200/q); Labour charges ₹ 70/day; Imidacloprid @ ₹ 2540 /litre; NSKE @ ₹ 26/kg; Trichoderma harzianum @ ₹ 120/kg; Neem cake @ ₹ 565 /q and FYM @ ₹ 300/10q.

DEMONSTRATION OF GROUNDNUT IPM

Multi-locational demonstrations on groundnut IPM was also conducted at Vallabhnagar district of Udaipur (Rajasthan), Kadiri (Andhra Pradesh), Junagarh (Gujarat) during the seasons of 2007-11 and 2013-15 to spread the eco-friendly IPM technology of groundnut. A book on "Handbook on Integrated Pest Management of Groundnut" was also published from ICAR-NCIPM, New Delhi.

Interaction with farmers and celebration of "Groundnut IPM day" in Rajasthan

VALIDATION OF IPM FOR MUSTARD

ICAR-National Research Centre for Integrated Pest Management (NCIPM) has been working on synthesis and validation of IPM in mustard for over two decades. Extensive surveys of mustard growing areas revealed excessive and injudicious use of chemical pesticides and fertilizers by farmers that aggravated the pest menace, secondary pest outbreaks and caused environmental degradation. Major insect-pests of mustard include aphids (*Lipaphis erysimi*), painted bug (*Bagrada hilaris*), mustard sawfly (*Athalia lugens proxima*) and leaf miners (*Chromatomyia horticola*) threatening right from sowing till end of the crop season. *Sclerotinia* rot (*Sclerotinia sclerotiorum*), white rust (*Albugo candida*), *Alternaria* blight (*Alternaria* spp.), downy mildew (*Hyalopersonospora parasitica*), powdery mildew (*Erysipha cruciferarum*), club rot (*Plasmodiophora brassicae*), black rot (*Xanthomanas campestris*), stalk rot (*Erwinia caratovora*), mosaic (turnip virus I) and phyllody (*Phytoplasma asteris*) are the important diseases. The broomrape, a holoparasitic weed is also a serious problem. Changes in pest scenario due to introduction of new varieties / hybrids, monoculture of mustard in larger tracts of irrigated and water logged soils, closer spacing and heavy fertilization required dynamic practices of IPM. Recently, *Sclerotinia* rot (*Sclerotinia sclerotiorum*) has emerged as a serious problem in mustard because of the cultivation of few highly susceptible hybrids. IPM strategies were synthesized by an inter-disciplinary and inter-institutional team to address these problems through holistic IPM tactics. Validations of IPM at village level in mustard growing areas of Haryana and Rajasthan were done in addition to IPM demonstrations. The validated interventions of IPM for mustard across locations over seasons are furnished below.

IPM STRATEGIES FOR MUSTARD

Pre-sowing

- Destruction of previous crop residues to avoid painted bug infestation and disease causing pathogens
- Deep summer ploughing to kill fungal spores and residual population of insect-pests
- Application of 15 kg of zinc sulphate + sulphur per hectare as per location-specific recommendation
- Preparation of levelled and well-drained field
- Adoption of appropriate crop rotation
- Use of recommended dose of N60: P40: K40: S40

At Sowing

- Sowing during 15-30 Oct. It escapes the attack of pests
- Sow improved, healthy and certified seed of regional specific recommended variety
- Seed treatment with *Trichoderma* spp. @ 10g/kg seed or *Allium sativum* bulb extract (2% w/v) for the management of seed and soil borne pathogen
- In case of downy mildew endemic area, the disease is managed by treating the seeds with metalaxyl-M 31.8% ES @ 6 ml/kg seed
- Soil application of *Trichoderma* spp. @ 2.5 kg of *Trichoderma* mixed with 50 kg of FYM/ha of area
- Avoidance of narrow spacing / heavy seed rate for *Sclerotinia* rot management

At Seedling and Vegetative stages

- Judicious use of irrigation depending upon the stage of crop growth, soil type, rainfall, etc. Early irrigation provides tolerance against painted bug
- Application of methyl parathion 2% @ 25 kg/ha after 10 days of sowing when painted bug incidence occurred
- Management of mustard sawfly on early collateral host crops like radish and turnip
- Maintain optimum population with recommended spacing
- Clean cultivation and elimination of broad leaf weed bathu (*Chenopodium album*) which act as a collateral host of *S. sclerotiorum*
- Hand picking of aphid-infested twigs in the initial attack. Spray application of micronutrients like boron and zinc are useful in pest management
- Removal of heavily diseased plants from the field and need based spray of mancozeb (0.2% a.i.) or freshly prepared aqueous garlic bulb extract (2% w/v)

At Flowering and Pod stages

- Regular monitoring of crops and spray of appropriate pesticides
- Plucking of infested inflorescence at initial stage of aphid infestation
- Need-based spray of dimethoate 30 EC or oxydemeton methyl 25 EC @ 1ml/l of water when aphids cross ETL (25 aphids/10 cm central twig)
- Rogue out of disease infected/insect infested plants
- Foliar spray with *Trichoderma* spp. or aqueous garlic bulb extract @ 2% (w/v) at early bloom stage *i.e.* at 50 DAS and second spray after 20 days
- Need-based spray of metalaxyl 4% + mancozeb 68% @ 2.5 g/l of water when there is more severity of white rust
- Foliar spray of carbendazim @ 2 g/l of water at first appearance of powdery mildew or *Sclerotinia* rot
- Based on symptoms of early ripening of *Sclerotinia* infected plants, rogue out infected plants from fields before formation of sclerotia
- Collection and burning on the spot of all the infected stems, stubbles to reduce sclerotial inoculum load in the soil
- Need-based sprays of aureomycin @ 200 mg/ml for effective management of bacterial rot

IPM IMPLEMENTATION

IPM validation was initiated at village Bhora khurd of Gurgaon district of Haryana in farmers' participatory mode in 2000-2001 in an area of 40 ha (28 ha of IPM and 12 ha of non-IPM) with variety Varuna. It was revalidated for the second consecutive year during 2001-02. During 2002-03 validation was done in a nearby village Wajirpur over an area of 32 ha (26 ha of IPM and 6 ha non-IPM) with variety Pusa Jaikisan. After the success of IPM validation at Bhora Khurd and Wajirpur in Gurgaon, Haryana, the synthesis IPM was undertaken for the flood prone eastern plain zone III b of Rajasthan (2004-08) in collaboration with SKRAU, Agricultural Research Station, Navgaon, Alwar. The key biotic stresses of mustard were identified as *Sclerotinia* rot and white rust among diseases, painted bug among insects and *Orobanche* amongst weeds. Large scale validation of of IPM was done in an area of 118.9 ha in villages near to of Navgaon of Alwar (Rajasthan) during 2008-09 and 2009-10.

Multi-locational validations of IPM was conducted in Rajasthan and Haryana in farmers' participatory mode in 18 ha on farmers' field in Alwar, Sriganganagar and Hanumangarh in Rajasthan and Gurgaon in Haryana during 2008-09 to 2010-11. Subsequently large scale validation of IPM was conducted in Haryana and Rajasthan in 120 ha in farmers' participatory mode in collaboration of *KVK*, Navgaon Alwar of SKNAU, Jobner and *KVK* Mohindergarh of CCSHAU, Hisar during 2010-11 to 2013-14.

"IPM school" for mustard

Field view of IPM demonstration at Navgaon (Alwar, Rajasthan)

Recently in 2014-15, need based regular updating of IPM in mustard was undertaken and crop stage based IPM interventions are being validated in 20 ha in farmers' participatory mode on farmers' fields in the district of Alwar (Rajasthan) and Mohindergarh

(Haryana) in collaboration of *KVK*, Navgaon Alwar of SKNAU, Jobner and *KVK* Mohindergarh of CCSHAU, Hisar, respectively.

IMPACT OF IPM FOR MUSTARD

Implementation of IPM for mustard resulted in significant reduction in the severity of pest and increase in yield. Benefit–cost ratio remained higher in IPM as compared to farmers' practices. The validation of IPM at village Bhora Khurd (District Gurgaon, Haryana) revealed that the bio-control (*Trichoderma*) applied through seed and soil application resulted in trace incidence of white rust during the two cropping seasons (2000-02) as against low severity in most of the fields of non-IPM. During 2002-03, the incidence of white rust was 1.6 to 19.7 per cent in IPM fields compared to 12.5-22.2 per cent in non-IPM fields at Wajirpur with variety Pusa Jaikisan. The yield of mustard was higher in IPM in comparison to non-IPM fields during all the three seasons (2000-2003). The benefit cost ratio was also higher (2.56, 1.78, 2.0) in IPM in comparison to non-IPM (2.56; 1.78; 1.93) fields during the three cropping seasons. IPM for mustard validated at Navgaon, Alwar research farm (2004-08) in Rajasthan has been included in package of practices of Zone IIIb (Bharatpur zone) by Zonal Research and Extension Advisory Committee (ZREAC). Alwar district of Rajasthan had 25 per cent plant mortality due to the painted bug in fields of non IPM. In IPM fields, the crop was saved by applying methyl parathion 2 per cent dust @ 25kg/ha. Average *Alternaria* leaf blight incidence was 12.2 per cent in IPM as against 14.7 per cent in non-IPM fields. The mean incidence of white rust on leaf was 10.8 and 13 per cent in IPM and non-IPM, respectively. Average *Sclerotinia* stem rot incidence was 3.3 per cent and 5.9 per cent, respectively, in IPM and non-IPM fields. IPM package was validated on larger area of 118.9 ha under irrigated conditions of Bharatpur zone for two year in Alwar (Rajasthan) and average yield was 2182 kg/ha in IPM and 1896 kg/ha in non-IPM, respectively and net profit was ₹ 29908/ha in IPM in comparison to ₹ 24061/ha in non-IPM during 2008-09 and 2009-10.

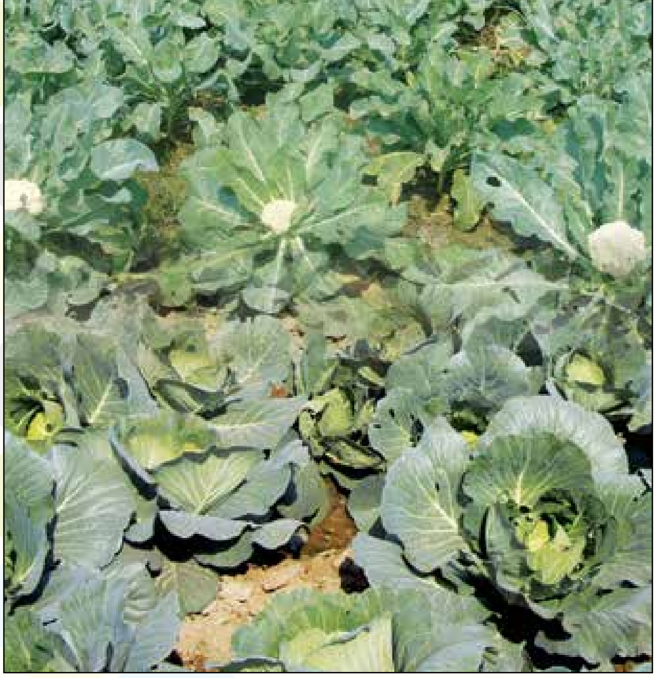
Large scale multi locational field demonstrations was started in Haryana and Rajasthan in collaboration with *KVK*s at Mewat, Mohindergarh and Navgaon, Alwar of respective States. The bio-intensive integrated management along with farmers' practices (FP) was compared in 40 hectares at cultivators' fields in Mewat and Mohindergarh district of South Western Haryana. Bio-intensive IPM interventions included improved cultural practices such as burying of diseased crop residues, deep summer ploughing, crop rotation with non-host crops, use of clean and sclerotia free certified seeds, timely sowing of mustard (from Oct.15-31), recommended dose of fertilizers @ N: P: K: S: - 60: 40: 40: 40 kg/ha, maintenance of optimum plant population, need based irrigation and rogueing of infected plants. IPM intervention also includes soil incorporation of 50 kg of farm yard manure (FYM) pre-incubated with *Trichoderma harzianum* ($2x10^6$ cfu/g) @ 2.5 kg per hectare followed by seed treatment with *T. harzianum* @ 10g/kg seed and need based foliar spray (1-2) of *T. harzianum* @ 0.2 per cent soon after disease appearance and after 21 days. At all the three locations, bio-intensive IPM interventions were found effective in reducing the diseases and increasing the seed yield. Increased benefit cost ratio resulted in better monetary returns to the farmers in IPM interventions adopted practices as compared to farmers' practices.

In 2011, desperate mustard growing farmers of Siyali Khurd (District Alwar of Rajasthan) approached NCIPM because of severe incidence of *Sclerotinia* rot. Siyali Khurd village (27° 54' 23.2'' N longitude 76° 36' 27.7'' E) is about 150 km away from IARI campus, Pusa, New Delhi. Baseline information of village indicated that the farmers of the area, prior to IPM implementation were taking monoculture of mustard without crop rotation and deep summer ploughing and no seed treatment with *Trichoderma* was undertaken. In addition to this, recommended dosage of fertilizers along with gypsum @ 250 kg/ha and Potash @ 40 kg/ha, soil incorporation of *Trichoderma* @ 2.5 kg/ha pre-incubated in 50 kg well rotten FYM and seed treatment with *Trichoderma* @ 10g/kg seed were followed. By destroying the previous crop residue in IPM, crop escaped from painted bug infestation and loss due to disease causing soil-borne pathogens. In IPM, appropriate seed rate of 4 kg/ha was followed along with regional specific optimum sowing time, which escaped the infestation of aphids, *Alternaria* blight, white rust and *Sclerotinia* rot. Farmers were not aware of IPM concept and were not able to identify insect-pests, diseases and beneficial insects. Baseline information was collected at Siyali Khurd in 2011. The IPM module was fine-tuned and implemented in 40 ha in 2011-12 in Rajasthan and Haryana, which was subsequently also implemented in 40 ha during 2012-13 and 2013-14, as more and more farmers became part of IPM programme. The endemics of *Sclerotinia* rot in Siyali Khurd farmers' field was eradicated by implementing IPM technologies. IPM has been successfully demonstrated at village level in Haryana and Rajasthan in farmers' participatory mode.

In both the oilseed crops *viz.,* groundnut and mustard, the adoption of IPM strategies have not only increased the productivity of the respective crops, but also enhanced the quality of produce resulting in betterment of socio-economic status of the farmers.





DEVELOPMENT AND VALIDATION OF IPM FOR CAULIFLOWER AND CABBAGE

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Different types of vegetables are grown in India. Cabbage and cauliflower are cultivated mainly in Uttar Pradesh, Odisha, Bihar, Jharkhand, Assam, Andhra Pradesh, West Bengal, Maharashtra, Karnataka, Haryana and Himachal Pradesh. Cabbage is grown in an area of about 0.40 m ha in India with a production of 9.04 mt amounting to 5.5% share in production ranking 5th in vegetable production. Cauliflower cultivation is in 0.43 m ha with a production of 8.6 mt, amounting to production share of 5.3%, making it 7th important vegetable. India ranks first in the world production of cauliflower. Generally, vegetables are grown both extensively and intensively in areas near to the major towns which facilitate the grower to sell their produce at a competitive price. In addition, some branded outlets purchase the harvested produce from farmers directly providing instant cash inflow. Palri (Sonipat, Haryana) and Anantpura (Jaipur, Rajasthan) are two such villages situated at a distance of 50 km away from New Delhi and Jaipur, respectively, which were selected for pilot study on development and validation of IPM for cauliflower and cabbage. The pilot study was based on previous research conducted on the management of major insect-pests and diseases using soil solarization, raised bed sowing, neem cake application, seed, seedling and soil treatments with *Trichoderma harzianum* and need-based application of pesticides, management of insect-pests of cauliflower/cabbage through seed treatment with imidacloprid, pest monitoring through sex pheromone traps, use of mustard as a trap crop, mechanical methods, selective use of new greener risk insecticides to conserve the natural enemies and the use of an action threshold-based on the percentage of plants infested to determine the need for pest management actions. A key aspect of this approach was to use reduced-risk insecticides early in the season to provide additional biological control through conservation of beneficial natural enemies (predators and parasites). Base line information before implementation of IPM revealed that there are about 150 farm families in both the villages. Cauliflower and cabbage are cultivated throughout the year in both the villages as early (September and October harvest), mid early (November harvest), mid late (December and January harvest) and late snow ball (January–March harvest). Introduction of high yielding, short-duration varieties/hybrids, cultivation round the year, due to tender and supple nature and damage from pest attack even after harvest had higher risk and manifold infestation of pest problems. A conservative estimate reports 20-25% losses in yields of these two crops. Farmers apply 10-12, 2-3 and 6-7 chemical sprays for early, mid and late maturing group of cauliflower and cabbage. Farmers had no knowledge of the IPM concept for crop protection from pests and follow the advice of local pesticide vendors. Uses of mixture of pesticides have accentuated the pest problems. The harvested produce is prone to contain high level of chemical pesticide residues. Therefore, attempt was made to develop location and season specific pest management strategies for cauliflower/cabbage to address the above problems.

Studies on the pest incidence throughout the year revealed differing pest problems from season to season necessitating different integrated pest management strategies to be formulated. The pest problems observed in early and mid-early maturing groups are cabbage head borer (*Hellula undallis*) and tobacco caterpillar (*Spodoptera litura*), damping off (*Pythium debaryanum*) and *Alternaria* leaf spot in Palri village. In addition to these pests, cauliflower in Anantpura village experiences the attack of painted bug, *Bagrada hilaris*. Nursery was prepared either in the month of June or July and transplanted in the month of July or August. *H. undalis* caused damage to the crop in the month of June, July and August. It feeds on the growing point of the seedlings and developing leaves. Severe injury occurs when they tunnel into the main stem. Damage resulted in stunting and death of young plants. More often, damage to the growing point results in deformed plants and the formation of multiple growing points or heads. On older plants, the larvae feed on leaves and by tunneling into leaf petioles. Painted bugs damage the crop by sucking the sap from the seedlings, resulting in seedling mortality and patchy growth in the nursery.

S. litura damage the crop from early-August till harvest in October. Male moth catches in sex pheromone traps started from June, with the crop damage from August. Egg laying was recorded in last week of August. Each egg mass covered with scales occur as small light greenish patch. Egg hatched within 3-5 days and neonate larvae remained in groups and started damaging leaves by nibbling epidermis. As the larvae grew, they started chewing the leaves and formed small cuts. Older larvae migrated to other leaves and plants and completely damaged the leaves, newly formed heads and curds. Leaves are damaged to the point that they are not recognizable as those of cauliflower/cabbage. In severe infestations, leaves are completely eaten away causing the plants to die. The older larva remained hidden inside the curd/head and damage even after harvest.

Damping off in the nursery and *Alternaria* leaf spot in the later part of the season among the diseases seriously affected the cauliflower/cabbage cultivation. Damping off appeared on the emerging seedlings as well as after the emergence in the nursery causing reduction to plant stand. *Alternaria* leaf spot appeared in August. Infected leaves showed black spot with concentric rings.

Pest problems observed in the mid *rabi* and late *rabi* snow ball cauliflower and cabbage are different in comparison to early and mid-early cultivation of these crops. Aphids (*Lipaphis erysimi* and *Myzus persicae*) are the major insect-pests and cause damage to the crop from December to March by sucking sap from the plant parts, thus reducing the vigour and causing yellowing. In Anantpura village the crop was also damaged by the diamond back moth, *Plutella xylostella*. *Sclerotinia* rot appear in the late *rabi* season crop on cauliflower curd and cabbage head as wet soft lesions, and as scars on stump region of the cabbage. These lesions get converted into rotten mass of tissues that gives white silvery appearance. Downy mildew infestation is also observed at a few locations.

IPM FOR RAINY SEASON CAULIFLOWER

Field experiments were carried out during rainy season in the villages from 2006 to 2009. Cauliflower was transplanted in first week of July and harvested during September-October. The experiments used paired treatment comparisons to compare the IPM with the conventional system (designated as non-IPM). Initially there were a few farmers willing to quickly adopt the new IPM approach (1-2 ha covering 3 and 5 farm families in year 2006 and 2007, respectively), but as the confidence started building up in the village, number of farm families as well as area under IPM increased (10 ha under IPM covering 25 farm families in year 2008 and 2009). The treatments tested were: (a) IPM module synthesized on the basis of available information from literature; (b) conventional system *vis á vis* farmers' practice (FP), using application of agronomic factors and pest management commonly practiced by the local farmers. IPM components were applied in three stages *i.e.* at the nursery, during and after transplanting. IPM trials were conducted on a cauliflower variety belonging to September maturity. All the growers in the locality were persuaded to raise nursery and to undertake transplanting simultaneously. Farmers selected under IPM practice and the conventional practices were the ones who had transplanted their crop in the first week of July. Crop was raised following similar agronomic schedule in both IPM and non IPM fields.

IPM INTERVENTIONS IN NURSERY

For sowing of seeds, raised beds of 15 cm height were prepared in a well-drained area so that excess water could be drained in case of heavy rains. Depending upon the requirement for 0.4 ha, nursery beds of size 10 sq.m area was prepared. These beds were solarized by covering with transparent polythene sheet of 250 gauge thickness for 15-20 days for protection against soil borne pathogens. 2.5 kg talc-based formulation of *Trichoderma harzianum* adapted for local conditions was amended with 100 kg of farm yard manure. It was moistened with water and kept for 15-20 days for enrichment with *T. harzianum*. Neem cake and the enriched FYM were broadcast on raised beds at 50 g/m^2 and mixed in the soil at the time of sowing. Seeds of cauliflower variety early *kuary* marketed by Doctor Seeds (Pvt.) Ltd., Ludhiana were treated with paste prepared by mixing 5g talc formulation of *T. harzianum* (10^8 conidia/g) in 10-15 ml of water. Seeds were sown in the first fortnight of June for preparation of seedlings. Seeds were treated with Imidacloprid at 3-5 g/kg for protection against painted bug.

IPM INTERVENTIONS AT TRANSPLANTING

Raised beds of 35 cm heights were prepared with the help of tractor driven harrow in fields selected for transplanting the seedlings of cauliflower. Such beds were placed at a distance of 45 cm. Seedlings were planted on such beds at a distance of 30 cm. Space between the beds were used as irrigating channel for watering the crop. Raised bed method of transplanting the seedlings helped in avoiding the accumulation of excess moisture and thus prevented the proliferation of pathogens. Before transplanting roots of the seedlings were dipped for 10-15 minutes in the suspension prepared by dissolving 10 g of talc based formulation of *T. harzianum* per liter of water. Funnel shaped pheromone traps with lures of 200 mg (Z)-11-Hexadecenal (97%) and (Z)-9-Hexadecenal (3%) were erected @ 10/ha to monitor the population of *S. litura*. The lures were changed at intervals of 30 days. The height of the trap maintained was 30 cm above the plant canopy.

IPM INTERVENTIONS AFTER TRANSPLANTING

Major pest of cauliflower after transplanting is *S. litura*. Farmers were advised to initiate spraying of *Sl*NPV at the time of appearance of egg masses as well as when number of 8-10 male moth catches/ trap/night followed by application of azadirachtin at the rate of 30ppm/liter of water to conserve the natural enemies of the pest. Need-based spray of green molecules of chemical insecticides, against which the development of resistance has not been reported such as Indoxacarb, Spinosad and Novaluron was undertaken. Mancozeb (2 g/l) was applied for management for *Alternaria* leaf spot at its appearance. Plucking of leaves infested with neonate larvae, hand picking of egg masses and older larvae of *S. litura* was advised at curd formation stages when the canopy of the crop became dense as application of pesticides then was not feasible.

IPM implementation was initiated through organizing farmers' field schools based on the principle of learning by doing for adding to farmers' knowledge and skill. Therefore, the most important component in the first year of the project was training of the farmers for development of technical skills which led to the transfer of IPM technologies to them for development of technical skills such as reinforcement of FYM with *T. harzianum*, seed treatment and seedling dip with *T. harzianum*. The participatory learning sessions resulted in the increased awareness of participants on action threshold concept, importance of soil-borne diseases, recognition of symptoms, scouting for the damage due to *H. undalis, S. litura* and *Alternaria* leaf spot (ALS), installation of sex pheromone trap for monitoring of population of *S. litura.* Farmers' participatory training (FPT) also enabled the farmers to recognize the life stages of insect pests such as egg stages of *S. litura*, and scout for the presence of cocoons of natural enemies such as *C. glomeratus* in the field. FPTs had greater success in achieving IPM implementation.

Pest incidence

During the period under study (2006-2009), per cent plants infested with *H. undalis* ranged 1.36-5.03% in IPM and 1.7-14.7%, in non-IPM fields, per cent plants infested by the neonate larvae of *S. litura* was also lower in IPM (1.5- 5.0%) than the non-IPM fields (5.4-13.5%). Maximum male moth catches of *S. litura* and its damage was recorded in August and early September; thereafter both damage and population declined. Incidence of damping off in the nursery with IPM practices ranged 3-6% and that of *Alternaria* leaf spot 2-5% in IPM main fields. In nursery with farmers conventional practices, 5-11% damping off incidence was observed whereas 4-10% incidence of *Alternaria* leaf spot diseases was recorded in main plots with farmers' practice.

Natural enemies

In the present study, major natural enemies recorded were egg/larval parasitoid (*Telenomus* sp.) and larval parasitoid (*Cotesia glomeratus*) of *S. litura*, *Chrysoperla carnea* (Stephans) predating neonate larvae of *S. litura*. During rainy season, extent of parasitization by *C. glomeratus* was seen in both IPM and farmers' field, but was higher in the former. Though no parasitization was recorded in the first year, buildup of population of natural enemies was observed from second year due to the use of bio-pesticides and green molecules of chemical insecticides.

Curd yield and economic analysis

On an average, the IPM program increased marketable yield by 15.7% and decreased the number of chemical pesticide applications by 50-60%. In cauliflower, cost of production including plant protection (₹/ha) was less in IPM fields than in farmers' practice. Economic analysis of the data also showed higher economic returns and benefit-cost ratio in IPM practice (₹ 179738/ha, 4.79) as compared to farmers practice (₹ 152574 /ha, 3.26). Higher benefits were primarily due to decrease in cost of inputs for plant protection in IPM fields as compared to farmers' practice. Mean cost of plant protection in IPM field was ₹ 6247/ha as compared to ₹ 11488/ha, indicating 45 per cent reduction in cost of plant protection. The reduction in cost of plant protection has taken place due to replacement of Cyclidiene, Organophosphates, Carbamates and Synthetic pyrethroid, with newly introduced insecticides such as Spinosad, Indoxacarb, *Sl*NPV, Rimon with proven efficacy against *S. litura* and low residual effect with shorter waiting period for harvest of the produce. The results in the present study established that IPM had the economic potential to substitute chemical pesticides without demanding any enhancement in cost of cultivation. Over and above it also ensured higher economic returns as well as higher curd yield with added advantage of no adverse effect on environment, natural enemies and human health.

Implementation of IPM in irrigated cauliflower (*Brassica oleracea* L var *botrytis* subvar *cauliflora*) at Anantpura, Rajasthan also led to reduction in number of chemical pesticide sprays by 50-60% and their replacement with safer pesticides. Lower insect-pest and disease incidence with higher curd production was observed in the IPM fields as compared to farmers' practice. IPM module was able to cut the cost of crop protection resulting in higher benefit-cost ratio.

IPM FOR LATE *RABI* CAULIFLOWER

Field experiments were carried out in the late winter season (November to March). The IPM module comprising soil solarization of nursery beds of height 35 cm for three weeks prior to sowing, soil application of *T. harzianum* augmented in farm yard manure @ 250 g/100 kg, neem cake application @ 50 g/m^2, seed treatment with *T. harzianum* @ 4 g/kg seed and Imidacloprid 70 WS @ 5 g/kg seed (nursery stage), raised bed transplanting (25-35 cm height), seedling dip in *T. harzianum* @ 4 g/l, mustard as trap crop after every 25 rows of cauliflower (before transplanting), need-based application of azadirachtin 3000 ppm @ 5 ml/l, two applications of Imidacloprid 17.8 EC, at action threshold level of visual damage (05-20 aphids per plant) and one spray of Mancozeb @ 2 g/l (after transplanting). Mustard was sown in the space between two rows of cauliflower transplanted on the edges of the raised beds on the same day after every 25 rows of cauliflower. In conventional plots, farmers solely depend upon on 6-7 applications of pesticides for protection against pests involving Chlorpyriphos, Endosulfan, Cypermethrin, Carbendazim and Mancozeb. No seed treatment of bio-control agents or Imidacloprid @ 70 WS or mustard as a trap was adopted and nursery was prepared on flat beds. An average of 0.3 - 0.4 kg /ha seed was used for sowing and the seedlings were ready for transplanting after 4-5 weeks. Aphids colonizing mustard crop were prevented from infesting cauliflower plants by spraying with Methyl demeton 25 EC. Fields were prepared by 3-4 ploughings. IPM components were applied in three stages *i.e.* at the nursery, during and after transplanting of seedlings. IPM trials were conducted on a cauliflower hybrid belonging to March maturity. All the growers in the locality were persuaded to raise nursery and to undertake transplanting simultaneously to minimize the error that may occur due to difference in timing of the sowing of the crop and ultimately may be reflected while estimating the curd yield between IPM trials and conventional practice. Crop was raised under similar agronomic schedule in both IPM and non-IPM fields. Harvesting of the crop started in the beginning of February and continued till first week of March. Initially (2006-07 and 2007-08) five farmers' families each for IPM and non-IPM in the village were adopted for validation. Later (2008-09 and 2009-10), number of farmers rose to 25 for both IPM and non-IPM covering 10 ha. At Anantpura (Jaipur, Rajasthan) field experiments were conducted during late winter (*rabi)* seasons (2007-08 and 2008-09). Nursery of cabbage was prepared in mid-December and transplanted in mid-January. Harvesting of the crop started in last week of February and continued till mid-April. There were 10 locations covering ten farmers and at each location 0.4 ha was covered for implementing IPM technology.

Pest incidence

Observations on pest Incidence at Palri village showed that damping off in nursery and *Alternaria* leaf spot among the diseases were the major pests after transplanting. In nursery with farmers' practices 6.8-10.7% damping off incidence was observed that was 1.5-4.51% in IPM fields. *L. erysimi* was the major insect-pest with its infestation from January and till harvest of the crop. IPM farmers adopted seed treatment with Imidacloprid 70 WS followed by application of azadirachtin 3000 ppm and Imidacloprid 17.8 SL in January and February, respectively for protection against the aphids appearing on cauliflower. Also mustard was used as a trap crop that attracted the migrating winged aphids more than the maturing cauliflower curds and therefore reduced aphid infestation was observed in IPM fields. The crop was sprayed once with Imidacloprid 17.8 SL during entire span of the curd picking in IPM fields and it prevented the application of chemical pesticides in January and later. However, farmers in non-IPM fields protected their crop with 5-6 sprays of synthetic insecticides such as Cypermethrin, Chlorpyriphos or Endosulfan during January and February. Implementation of IPM components, proper pest scouting and advice to IPM farmers helped in reducing aphid population more effectively as was evident from over all low mean aphid population in the IPM as compared to non-IPM fields during the four years of study. Higher number of *Coccinella septempunctata* was observed in IPM as compared to non-IPM cauliflower fields.

Observations on pest incidence at Anantpura village, showed the incidence of diamond back moth *Plutella xylostella,* aphid *Lipaphis erysimi*, painted bug *Bagrada hilaris* and cabbage web worm *Crocidolomia binotalis* among the insect-pests; damping off (*Pythium debaryanum*, *Alternaria* leaf spot (*Alternaria brassicicola*) and downy mildew (*Peronospora parasitica*) among the diseases were recorded. Population of *L. erysimi* and *P. xylostella* tended to rise above economic threshold (ETL) and needed management interventions. Appearance of aphids was noticed in the first week of January that however remained low. It started increasing at the end of January due to rise in temperature and migration of winged aphids from adjoining mustard fields till last week of February. Male moths caught in sex pheromone traps for *P. xyllostella* were also recorded from first week of February. Larval damage due to *P. xylostella* was recorded from mid-February to mid-April. Data showed that number of aphids/ plant (5.7) and that of mean larvae of *P. xylostella* (0.4) in IPM fields were low compared to those [11.5 and 1.1/plant] in farmers' practice (FP). Among the diseases, damping off incidence was merely 3.1% in nursery stage and 1.5% due to *Alternaria* leaf spot during fruiting stage in IPM fields as compared to 6.5 and 3.1%, respectively in farmers' practice.

ECONOMIC IMPACT

The data on curd yield, cost of production and economic returns for all the four years at Palari village indicated that implementation of IPM module resulted increase in curd yield, gross returns, net returns as well as reduction in the cost of production compared to non-IPM practice adopted by farmers. Mean curd yield was 2.26 and 2.06 tons in IPM and non-IPM fields, respectively and was higher by 9%. Mean cost of production (₹/ha) was lower in IPM (25167) as compared to non-IPM fields (28736). It resulted in significantly higher mean gross and net returns (₹/ha) for cauliflower for IPM (154132 and 128965) as compared to non-IPM (140492 and 111756) fields.

The yields of cabbage at Anantpura revealed higher mean head yield in IPM fields (437 q/ha) as compared to farmers' practice (393 q/ha) by 11.11%. Mean number of sprays of insecticides and fungicides were 3.0 in IPM as compared to 5.6 in FP resulting in 60% reduction in number of sprays in IPM. Net returns for cabbage in winter season were ₹ 1,75,489 in IPM as compared to ₹ 1,04,676 in farmers' practice. Benefit cost ratio was 3.61 and 2.82, respectively in fields of IPM and farmers' practice. Thus, the economic analysis demonstrated that IPM technology has the potential to protect the crop from pests in more profitable manner as compared to use of toxic chemical pesticides.

Further, growers have learnt to pay attention to what is going on in their fields and realize that not all insects are pests, and that just having a few insects does not mean that a prophylactic intervention is necessary. Growers understood the importance of scouting, proper choice of pesticides and timing of their applications. Use of mustard as a trap crop, raised bed sowing in both nurseries as well as after transplanting, knowledge about the beneficial insects, green molecules of chemical pesticides and bio-pesticide such as *T. harzianum* are the IPM practices that found adoption among farmers.

IPM IN KINNOW AND *KHASI* MANDARINS

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Report of the joint inspection team of the National Horticulture Mission *(http://nhm.nic.in/JIT_Reports/JIT-Punjab-FEB%202013.pdf)* revealed the use of highly toxic chemical pesticides in Kinnow and the need to practice IPM in Punjab. Kinnow growers of the region were also anxious to know about non-chemical management practices to prevent the pest damage in an eco-friendly way. Hence, an IPM for validation was initiated in Panjkosi village of Abohar, Fazilika. Simultaneously, IPM practices for *khasi* mandarin cultivated in North Eastern Region of India were taken up with a view to validate combination of different IPM components for a sustainable and effective pest management. Only the actionable IPM practices, which are economically viable were validated. Base line information collected at Panjkosi village about the kinnow mandarin by the farmers indicated gummosis to be the major disease prevalent in the area. It is known by various names as *Phytophthora* foot rot, crown-rot, root-rot, fruit-rot and leaf fall. Foot rot is caused by *Phytophthora parasitica, P. nicotianae* var. *parasitica* in tropical condition and *P. citrophthora* in sub-tropical/temperate situation. It occurs in citrus nursery resulting in toppling of the seedlings and causing more than 20% seedling mortality. Foot rot occurs in orchards where phyto-sanitary conditions are not met properly. The infection occurs through bark near the ground level at the scion which extends down to the bud union, producing lesions on the trunk or crown roots that can girdle and kill the tree. While the primary spread is through infested nursery stock, the flood irrigation system causes secondary spread of the foot rot. When fruits are infected by *Phytophthora*, it produces a decay in which the affected area is light brown, leathery and not sunken compared to the adjacent rind. Infested fruits may not show symptoms until these have been kept in storage for a few days.

The diseases such as citrus greening, *Candidatus Liberibacter asiaticus*, Citrus ring spot virus (CRSV), citrus canker (*Xanthomonas campestris* pv. citri), citrus dieback or citrus decline and scab, *Elsinoe fawcettii* have also been reported in kinnow, but are not as prevalent as foot rot.

Survey for the prevalence of insect-pests indicated that sap feeders form the major threat. Citrus leaf miner: *Phyllocnistis citrella* Stainton, citrus psylla, *Diaphorina citri* Kuwayama, citrus whitefly: *Dialeurodes citri* (Ashmead), citrus blackly: *Aleurocanthus woglumi* Ashby, citrus aphid, *Toxoptera aurantii*, *Myzus persicae* Sulzer, *Aphis gossypii* Glove and citrus mite: *Eutetranychus orientalis* Klein and *Brevipalpus rugulosus* are the key sap feeders. Sap sucking insects generally feed on the under surface of the leaves. The nymphs and adults suck the plant sap and excrete honeydew due to which sooty mould develops on the leaves. Severe infestation results in manifestation of black layer covering entire plant parts including fruits due to which photosynthesis is affected. A few sap feeders like psylla transmit greening virus disease and aphid *T. aurantii* and *A. gossypii* transmit *Tristeza* virus (CTV). Leaf miner forms silvery serpentine mines usually on the under surface of the leaves. This mining of the leaves causes them to curl up, distort thereby reducing the photosynthetic area of the young foliage. Damage by this pest predisposes the plant for development of canker disease. Citrus mite damage results in speckled appearance of the leaves and mite damaged fruits develop a dark brown patch particularly those fruits exposed to sun. Thrips were also found damaging both leaves and fruits. Affected leaves become leathery and curl upward while fruits show characteristic white silvery ring around the neck at the stem end.

Trunk borer, *Anoplophora versteegi* and bark eating caterpillar, *Indarbela quadrinotata* are common on *khasi* mandarin in North Eastern region of India. The former lays eggs on the base of the trunk. Upon hatching the caterpillar bores into the trunk. As a result trees start drying. The adult beetle population is high till June and declines with the onset of monsoon. The bark eating caterpillar damages the bark of the trees and found mostly in neglected orchards.

Available management options recommended by the regional research institutions/universities (Punjab Agricultural University, Regional Research Station, Abohar; Swami Keshwanand Rajasthan Agricultural University, Agricultural Research Station, Sriganganagar; Central Institute of Post Harvest Engineering and Technology, Abohar; Assam Agricultural University, Citrus Research Station, Tinsukia and concerned crop-based ICAR institutes (ICAR-Central Citrus Research Institute, Nagpur) were referred. These management options were put together and amended based on the recent innovations made and a comprehensive IPM module was prepared. It was implemented at farmers' orchards in Panjkosi village of Abohar tehsil in Fazilika district of Punjab from 2013-2014 to 2015-2016.

IPM OPTIONS FOR KINNOW MANDARIN

Spring season (February – March)

- Occurrence of citrus psylla should be checked on the border trees. It starts after harvesting of fruit at bud swelling stage towards the end of February or beginning of March. If found infested, spraying of *Lecanicillium lecanii* ($1x10^7$ conidia/ml) or Dimethoate 30 EC @ 25 ml/10 l of water needs to be done, for the management of early (1st and 2nd) instar nymphs of citrus psylla.
- In the month of March, if the occurrence of the pest is still observed above ETL, spray of Imidacloprid 17.8 SL (4 ml/10 l water), for the management of citrus psylla, leaf miner and aphids, may be considered. If required, spray of Thiamethoxam 25 WG @ 3 g/10 l water, 10 days after application of Imidacloprid should be done.
- *Phytophthora* affected bark portions of the tree trunk, branches and limbs along with some healthy green bark should be scrapped with the help of sharp knife or khurpa. Proper destruction of the diseased bark is advocated by burning. Apply the fungicidal paint of Metalaxyl (2 g in 100 ml Linseed oil) or *Trichoderma harzianum* ($1x10^8$ cfu/g @ 100 g/l) and paint linseed oil after 5 days with the help of painting brush. Drenching the root zone area of the infected tree with Metalaxyl (25 g / tree in 10 litres of water) should also be done.
- Farmers adopted the trunk method of irrigation by flooding of orchards through use of tractor driven raised bed planter which created a depression between the row of trees, for preventing the passage of water around the bud scion.
- Prune the trees and spray Bordeaux mixture.

Summer season (April- June)

- Erection of yellow sticky traps @ 10 per ha could be useful. If whitefly population is more than 5-10/ trap/week (ETL), spray of Triazophos 40 EC @ 25 ml/10 l of water coinciding with 50 per cent of egg hatching or first nymphal stage could be done, which would also take care of leaf miner and/ or psylla. Spray of Ethion 50 EC @ 20 ml/10 l water, 8-10 days after Triazophos application needs consideration if whitefly reappears beyond ETL. Spray mixture of Aureofungin/Carbendazim + 2, 4-D @ 0.4 g/10 g + 0.1 g/10 l water for the management of fruit drop. Use GA_3 instead of 2, 4-D when cotton or other broad leaved crop is cultivated in or around the orchard could be useful. If infestation of *Phytophthora* is observed, spray fosetyl-Al 80 WP @ 25 g/10 l water could be undertaken.
- Foliar application of fosetyl- Al 80 WP (2.5 g/l) may be made during April for the effective *Phytophthora* management. The spray application will check the lesions on the tree parts as well as regeneration of feeder roots. Fosetyl- Al spray can be combined with drenching of root zone area with Metalaxyl.
- If whitefly still persists beyone ETL, spray Triazophos 40 EC @ 25 ml/10 l water. Carbendazim 50 WP could be applied @ 10 ml/ 10 l for the management of fruit drop, if needed.

Monsoon season (July-September)

- Scrap the affected bark portions of the tree trunk, branches and limbs along with some healthy green bark with the help of sharp knife or khurpa. Properly collect and destroy the diseased bark by burning and do not allow it to fall on the ground. Apply the fungicidal paint of Metalaxyl (2 g in 100 ml Linseed oil) or *Trichoderma harzianum* @ 100 g/l and paint linseed oil after 5 days with the help of painting brush. Drenching the root zone area of the infected tree with Metalaxyl (25 g/tree in 10 litres of water).

- Spray Fosetyl- Al 80 WP (2.5 g/l) for the effective *Phytophthora* control. The spray application will check the lesions on the tree parts as well as regeneration of feeder roots. Fosetyl- Al spray can be combined with drenching of root zone area with Metalaxyl.
- During this period, psylla or leaf miner or white fly starts reinfesting the trees. Spray Thiamethoxam 25 WG @ 3 g/10 l of water or Triazophos 40 EC @ 25 ml/10 l of water.
- Spray mixture of 2,4-D at 0.1g + Tilt Propiconazole 25 EC 10 ml/10 l water for the management of fruit drop. Spray Carbendazim 50 WP @ 10 g/10 l water, 2 weeks after application of 2,4-D, if needed.
- If the whitefly damage still persists beyond ETL and sooty mould is observed, spray mixture of Triazophos 40 EC at 25 ml + Ziram 80 WP at 25 g /10 l water could be useful.
- Clearing the infested branches of the fross, faeces and injection of 5-10 ml of Dichlorvos (0.1%) in to the tunnel and covering it with cotton swap reduces infestation of bark eating caterpillar.
- Spray Fosetyl- Al 80 WP @ 25 g/10 l water to manage *Phytophthora*. Need-based spray of Thiophanate methyl 70 WP @ 10 g/10 l water for the management of fruit drop at end of September.

Post-monsoon season (October-December)

- If the spraying of Triazophos was done in September, citrus psylla is still observed beyond ETL, spray of Thiamethoxam 25 WG @ 3 g/10 l water could be useful. There is need to destroy the fallen fruits by burying.
- Generation of smoke in the late evening hours and foliar application of neem oil (1%) or Malathion 50 EC @ 2 ml/l reduces infestation of fruit sucking moth.
- For the effective management of canker/ scab, spray mixture of Streptocycline + Copper oxy chloride @ 1 g + 25 g/10 l water.

IPM OPTIONS *KHASI* MANDARIN

IPM practices for *khasi* mandarin (North Eastern Region of India).

Spring season (February-March)

- Application of Petroleum spray oil (2%) for citrus butterfly and citrus psylla.
- Application of Bordeaux mixture (1%) for most of the diseases.
- Soil application of *Paecilomyces lilacinus* ($2x10^7$ spores/g) infested grain 30 g/tree for managing citrus nematodes (*www.nrccitrus.nic.in*).
- Smearing the tree trunk up to 1m from the ground level by the mixture of 50 ml Dimethoate + 2 kg lime in 10 litres of water along with gum in March to prevent early infestation of trunk borer and bark eating caterpillars.
- Soil drenching and spraying of tree trunk with Metalaxyl 8%+ Mancozeb 64% @ 0.2% in February to manage *Phytophthora* foot rot.

Summer season (April-June)

- Installation of yellow sticky trap at 10/ha for soft bodied insect-pests and methyl eugenol trap @ 10/ha for fruit fly.
- Application of biorational insecticide, spinosad 45 SC @ 1% for managing leaf miner.
- Spraying of Aliette 80 WP (2 g/litre) during May for management of *Phytophthora.*
- Application of Bactronol 1000 ppm for management of citrus greening.
- ITK (Paddy straw is tied at a height of 1m around the tree trunk during April to prevent insect from crawling upward).

Monsoon season (July-September)

- Smearing the tree trunk up to 1m from the ground level by the mixture of 50 ml Dimethoate + 2 kg lime in 10 litres of water along with gum in March to prevent early infestation of trunk borer and bark eating caterpillar.

- Soil application of *Paecilomyces lilacinus* infested grain 30 g/tree for managing citrus nematodes.
- Need-based spray of Thiophanate methyl 70 WP @ 10 g/10 l water for the management of fruit drop at end of September.

Post-monsoon season (October-December)

- For the effective management of canker/scab, spray mixture of Streptocycline + Copper oxychloride @ 1 g + 25 g/ 10 l water.
- Application of Petroleum spray oil (2%) for citrus psylla.

MANAGEMENT OF GREENING DISEASE

- The management of greening disease involves removal of affected unproductive trees and their replacement by disease-free budded plants developed on improved rootstock through proper indexing programme (*www.nrccitrus.nic.in*).
- Regulatory (quarantine) measures should be strengthened to limit movement, sale and use of infected bud wood or nursery stock.
- Strict management of nurseries through registered disease-free certification scheme is essential to prevent the spread of disease.
- Since the disease also spreads through the vector citrus psylla, recommended insecticides should be applied to manage the disease spread.

GENERAL MANAGEMENT PRACTICES

- As a precautionary measure first spray may be applied as soon as the new flush emerged.
- Destroy the ant colonies in the orchards as they are the carriers of certain pests to their feeding sites.
- Close spacing and water logging conditions should be avoided in the orchards which help in creating micro-niche favouring the pest population.
- Avoid pruning during active growth periods as it induces irregular and frequent flushes which lead to the perpetuation of pest. If necessary, prune only the infested dry shoots after fruit harvest.
- Apply nitrogenous fertilizers as per need only as excessive and frequent applications promote new flushes which provide favourable conditions for insect-pest infestation.
- Modify canopy structure in such a way that light interception is maximum. Preparations of spray solution, spraying operations, insecticide residue and compatibility in mixtures are important aspects to keep in mind before undertaking the sprays.
- The time of insecticide application should be decided after monitoring the pest incidence *viz*., only young and vulnerable life stages of the pest should be sprayed upon.
- The spray should be targeted on the lower surface of the leaves and the new flush. Canopy should be covered till the run-off stage.
- Avoid repeat application of a particular chemical pesticide and do not use pesticide beyond date of expiry.
- Prepare spray solution first in small quantity and then increase the volume to desired level by adding water. In case of wettable powder take required quantity of pesticide, add a little quantity of water, mix it thoroughly to prepare the paste and then add remaining quantity of water to this paste with constant stirring.
- Avoid spraying during strong winds, cloudy days and drizzling.

IMPACT OF IMPLEMENTATION OF IPM

Need-based implementation of IPM options in North Western region resulted in reduced pest incidence and increased *Coccinellids* and spiders in the IPM as compared to non-IPM orchards. Fruit yield (t/ha) was higher from IPM orchards. Number of applications and amount of chemical pesticides also reduced as a result of implementation of IPM along with the replacement of hazardous molecules by greener pesticides. At North Eastern Region of India, with different pests scenario *viz*. citrus trunk borer, bark eating caterpillar, citrus Psylla, leaf miner, lemon butterfly and *Phytophthora* foot rot, twig blight, citrus greening, citrus scab, pre-harvest fruit drop, the location specific IPM strategy also resulted in decreased incidence of the pests as well as higher economic benefits.

LIGHT TRAP MODELS FOR USE IN IPM

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ICAR: National Research Centre for Integrated Pest Management, New Delhi

INTRODUCTION

Complete crop failures occur in case of serious attacks by insect-pests. Annual crop loss due to pests in India was estimated at ₹ 60 thousand millions in 1983 which at today's prices could easily exceed ₹ 200 billion. In general, the losses caused by pests range 10-30% per year depending on the crop and the environment. Spectrum of pests are different across agro-ecological regions and they need to be tackled in an eco-friendly manner. Sole reliance on the application of chemical pesticides has led to several side effects like insect resurgence, resistance to chemical pesticides and outbreak of secondary pests coupled with problems of environmental pollution. To overcome these problems integrated pest management (IPM) technology has been advocated. Improved insect light trap is one of the important tools of plant protection. Insect light traps are the most widely used visual traps for the agricultural insect pests, and have been particularly important in surveillance and monitoring of the seasonal appearance of many species of moths, hoppers, beetles, etc. It is an electrically operated tool having a light source designed to attract and trap insect-pests. Light traps are mechanical devices and are most widely used as insect traps for relative estimates of population, and at times claimed for mass trapping.

ADVANTAGES OF LIGHT TRAPS

(i) Insect-pest monitoring to document seasonal dynamics of their populations in the agro-eco-systems for timely pest management.

(ii) Mass trapping of selective phototrophic insect-pests like macro-lepidopteran insects *viz.,* hairy caterpillar, semilooper, etc. Several insects belonging to orders *viz*., Hymenoptera, Coleoptera, Dermaptera, Diptera escape from the filter chamber of light trap.

(iii) The non-target insect fauna are saved from unnecessary trapping and mortality. Although the device cannot restore all beneficial insects to environment, the dimensions are good enough to enable escape of several non-target and beneficial insect fauna including micro-hymenopteran (Ichneumonidae, Formicidae, unknown hymenopteran insects), micro-coleopteran (Staphylinidae), micro-dipteran (Ephydridae), micro-dermapteran (Forficulidae) and several other unidentified insect fauna.

(iv) The application of chemical pesticides may be reduced significantly thus reducing the cost of plant protection.

(v) Durable and may be used year after year. The life of the insect light trap is almost of the duration of 3-4 years as it is made up of plastic of high quality.

(ix) Non-target effect of chemical pesticides on beneficial insects can be overcome.

(x) As there is plurality in regulation of pore sizes of the filter chamber, there is scope to increase its use in diverse agro-eco-systems.

(xi) Cost-effective method of insect-pest management. The cost of economic models of insect light trap are below ₹ 1801 / piece, which is quite reasonable in comparison to the labour cost engaged in applying of the chemical pesticides on the crops.

(xii) During rains, the insecticides are vulnerable to run off loss. On the hand, the light traps operate irrespective of weather conditions although effectiveness may very.

DESCRIPTION OF THE LIGHT TRAP

ICAR-NCIPM, New Delhi has developed and improved the insect light trap for mass trapping of selective phototrophic macro-lepidopteran insect-pests like hairy caterpillars, boll worms, pod borer, semilooper, tobacco caterpillar and macro-coleopteran like white grubs. Improved light traps can be used to trap all these major pests that are prevalent in almost all agro-ecological regions of country on majority of crops including field and commercial crops, pulses, oilseeds, cereals and vegetable crops.

It comprises of a light source as an attractant and a funnel to direct lured insects into the insect collecting chamber. Funnel supports three baffles which are joined at the top. A hook has been provided at the top portion to install the light trap in the crop fields. The funnel accommodates an insect collecting chamber. The chamber contains a cap in the bottom required for opening and closing the chamber. The funnel at the rear end also accommodates an outer protective covering. Inside the protective covering there are sub light sources.

The height of the light trap can be kept in such a way that it remains 60 cm above that of the crop. The main light source attracts the phototrophic insects such as moths, flies and beetles towards it. These insects fall in the funnel kept below it and get collected into the insect collecting chamber. The sub light sources provided inside the protective cover attract the trapped insects towards it from the insect collection chamber. The porous walls of the insect collection chamber allow smaller sized insects to escape. The trap may be installed in the field wherever one would like to monitor or trap the insects. The insect collection chamber can be removed from the delivery end of the funnel. The harmful insects trapped in the insect collecting chamber can be removed out of it or killed there itself. Mass trapping of adults of both sexes of insect-pests by light traps help in minimizing their infestation in the crop fields. On the other side, the facility of escape of non-target/beneficial insects from the insect collecting chamber is a desirable attribute. It is a proven important eco-friendly tool against crop pests.

SPECIFICATIONS OF THE LIGHT TRAP

Light source	Bulb 125 W mercury vapour lamp having hard glass cover
Funnel	It is made of high quality plastic (to avoid electric shocks in the field)
	Upper diameter: 12"
	Lower diameter: 2"
	Weight: 300 g
Baffle	No. of baffles: 3
	Length: 12.5"
	Width: 4"
	Angle: 120^0
Insect collection chamber/ filter	1. Light trap safer to beneficial insects: It contains single filter chamber having pore size 3 mm approx.
	2. Light trap for managing insects: It contains double-walled filter chamber having pore size 0-7 mm.
	Features of the filter chamber:
	1. Filter fitted with two 5 W watt bulbs 15 W transparent glass bulbs to attract non-target insects trapped within the filter chamber.
	2. Filter is covered with cloth expanded with the help of rings.
	3. In this light trap, for trapping most of the phototrophic macro-lepidopteran insects, there is need to maintain pore size of 3 mm. The size may, however, be regulated by rotating the wall as per the requirement (based on specific non-target insects desired to be released).
	Length of filter chamber: 12"
	Breadth of filter chamber: 9"
Although the device cannot restore all beneficial insects the dimensions are good enough to enable escape of several non-target and beneficial insect fauna including micro-hymenopteran (Ichneumonidae, Formicidae, other hymenopteran insects), micro-coleopterans (Staphylinidae), micro-dipterans (Ephydridae), micro-dermapterans (Forficulidae) and several other insect fauna. During outbreak of pests of size smaller than the pore dimensions *viz.*, brown plant hopper, white backed plant hopper of paddy and other similar small insects, the pores can be completely blocked by sliding over the chamber.	

** The dimensions and other features are approximate. Measurements are dynamic in nature and vary as per the light trap model and other requirements.*

ICAR-NCIPM, New Delhi had already filed the patent applications for the inventions.

Light trap safer to beneficial insects (Inventors: Surender Kumar Singh and OM Bambawale)	2010	Patent application No. 1822/DEL/2010. FILING DATE: 02 Aug 2010
Light trap for managing insects (Inventors: Surender Kumar Singh and OM Bambawale)*	2011	Indian Patent application No. 94/DEL/2011 FILING DATE: 17 Jan 2011

*The international patent applications have also been filed in three countries *viz.,* Australia, Vietnam and Indonesia. The application was also filed in International Bureau of the World Intellectual Property Organization (Application No.: PCT/IB2012/050168, Date of filing: 13 January 2012), to protect IPR rights of innovative insect light trap developed, ICAR-NCIPM had designed and filed the application for its trademark (TERA®) in the patent office, New Delhi.

INSTALLATION PROCEDURE

1) Install light trap 60 cm above the crop canopy.
2) Switch on the light trap just after sunset for 2-3 hours for good insect catch.
3) Check the trapped insects in the insect collection chamber, remove or kill them by exposing them to DDVP soaked in a swab.

INSTRUCTIONS AND PRECAUTIONS

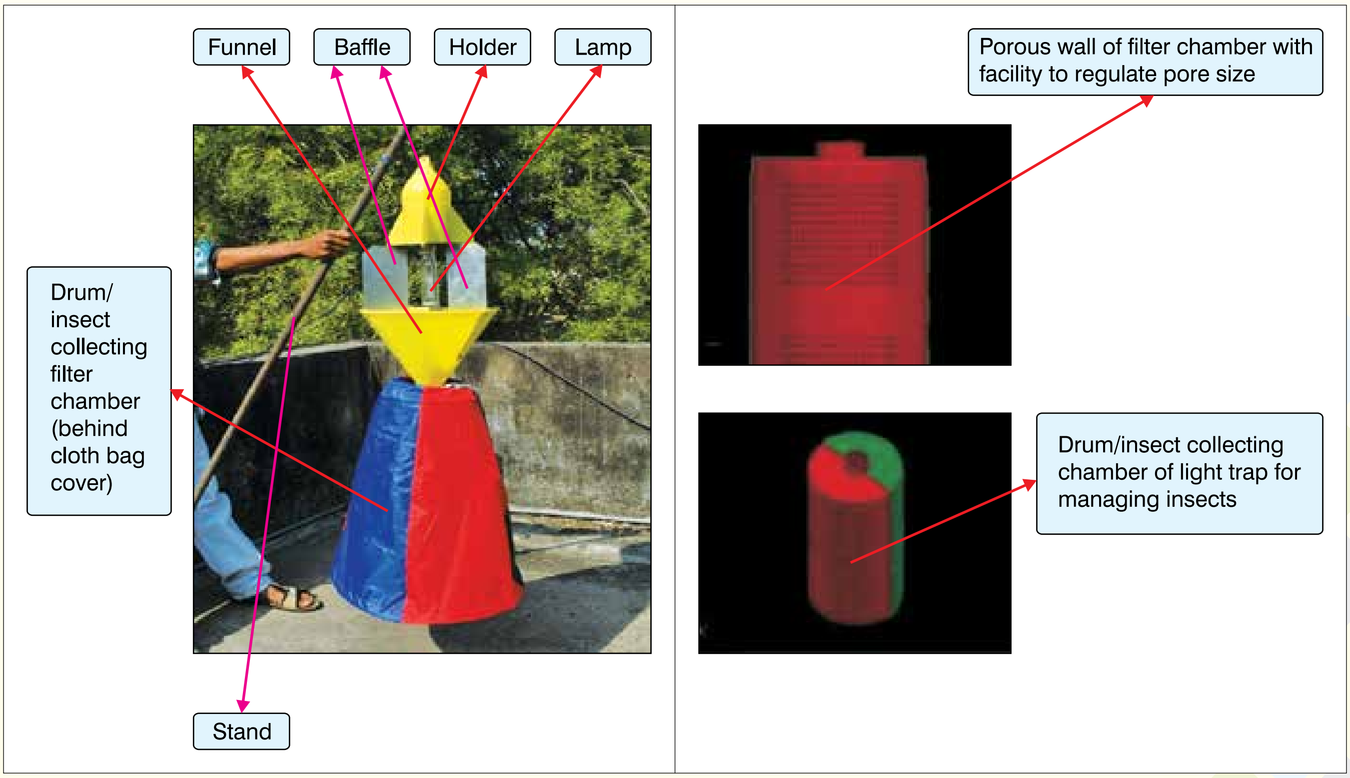
1) One trap is adequate for 1 hectare.
2) Clean the light source, funnel and filter chamber regularly to maintain good insect catch.
3) Clean the filter thoroughly.
4) Do not stare at light source for long.

These light traps can be operated by (i) direct electricity supply (ii) battery (iii) solar energy and (iv) generators as per the requirement and situation.

LIMITATIONS

1. Availability of electricity in villages may be a limiting factor.
2. The migration of the insects from the neighbouring areas may be a limitation for the success of the tool.

LIGHT TRAP SAFER TO BENEFICIAL INSECTS



SCOPE OF LIGHT TRAP

Crops

Cereals, pulses, oilseeds, fibers, fodders, sugarcanes, vegetables and fruits, floriculture, spices, medicinal and aromatic and other such as tea, coffee, tobacco, forests nurseries/plantations, etc.

Farming situations

Organic cultivation, protected cultivation, paddy fish farming and other areas for managing those phototropic insects that have developed resistance to chemical insecticides.

VALIDATION OF LIGHT TRAPS

White grubs

Three insect light traps developed by ICAR-NCIPM, New Delhi were installed in the month of June, 2011 at three different locations, two at farmers' fields of Bagas, Bagru and one at Research farm, ARS, Durgapura, Jaipur, Rajasthan. The attraction of different scarabaeid beetles towards these light traps was observed daily from the date of installation.

Among the various species of *scarabaeid, Holotrichia consanguinea, Maladera sp., Anomala dimidiate,* and *Anomala bengalensis* were found in abundance at all the locations.

The emergence of *H. consanguinea* was observed during third week of June with peak emergence between 29th June and 4th July; thereafter, emergence; declined and ended in the first week of August 2011. In case of *Maladera,* there were two peaks of emergence, first was observed in the end of (4th week) of June to first week of July whereas second was in the end of July (4th week). Bagru Ravan and Bagas is the hot spot for *Holotrichia consanguinea* and has relatively higher population of *Maladera* sp.

Tea insect pests

The light traps developed by ICAR-NCIPM were installed in October, 2011 in tea ecosystem in collaboration of Andrew Yule Company Limited, Hoolungooree Tea Estate, to trap the insect-pests of tea in Assam. The numbers of moths trapped/month/light trap were higher for looper in November and slug in December.

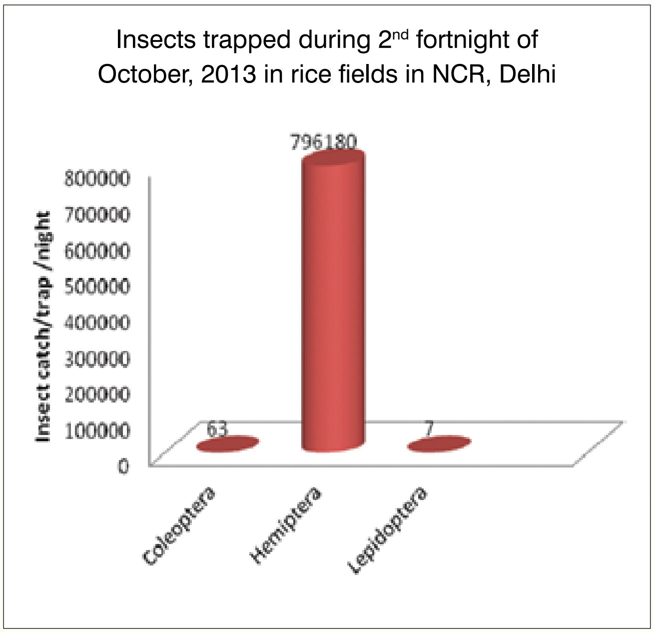
DEMONSTRATION OF LIGHT TRAP

Rice

A demonstration of improved insect light trap developed by ICAR-NCIPM was laid out in *KVK*, Sakoli, Maharashtra near the paddy fields in mid-July, 2011. Yellow stem borer of paddy (400 moths/night/light trap) were found trapped in the light trap and on the other hand the beneficial and non-target insects (12,955 insects/night/trap) escaped through the pores of the filtered chambered.

Validation of insect light trap against white grubs in Jaipur, Rajasthan

Month	Location	*Holotrichia consanguinea*	*Maladera* sp.	*Anomala dimidiate*	*Anomala bengalensis*
June, 2011	Bagas	820	108	0	0
	Bagru Ravan	2065	70	0	0
	ARS farm, Durgapura, Jaipur	77	158	0	0
July, 2011	Bagas	595	266	18	12
	Bagru Ravan	1987	118	7	0
	ARS farm, Durgapura, Jaipur	57	789	0	0
August, 2011	Bagas	6	14	7	0
	Bagru Ravan	3	17	7	0
	ARS farm, Durgapura, Jaipur	0	64	0	0
September, 2011	Bagas	0	0	0	0
	Bagru Ravan	0	0	0	0
	ARS farm, Durgapura, Jaipur	0	19	0	0



The demonstrations of the newly developed light trap of ICAR-NCIPM were laid out in rice fields at NCR Delhi and Hyderabad, Medak, A.P., during the *Kharif* seasons of 2011-13.

Percentage escape of insects from light trap pores installed in paddy (cv. Pusa *Basmati* 1121) fields during *kharif* season 2013

Period	% insects escaped/night/ trap (pore size 5mm)	% insects escaped/night from the pores (pore size 3mm)
38 SMW	52.43	52.10
39 SMW	72.01	39.74

Maize

There was severe outbreak of red hairy caterpillar on the crops in M.P. in *Kharif* season, 2011. Awareness creation among the farmers and demonstration of insect light traps of ICAR-NCIPM were done. Pithampur, Badnavat, Gunavad, Aamkheda, Magod, Sardarpur, Rajgarh, Bhag block (Jali village), Ringnod, Samelia, Aamba, Dhuled, Chhoti Machhliya, Machhliya, Bhura Dhabra, Rama, Kalidevi, Chapri villages of M.P. were during 1st fortnight of August, 2011 and information about insect light trap was disseminated.

Tomato

Insects trapped and filtered out in tomato

SMW	Total Insects trapped	Total Insects filtered	% insects saved
14	376	1254	77
15	377	18227	98
16	7359	2933	29
17	557	5013	90
18	1428	7319	84
19	1970	2463	56
20	772	2281	75
21	460	2653	85
22	21	2197	99
Mean	1480	4927	77

Display of insect light traps

Catches of rice yellow stem borer moths at *KVK*, Sakoli, Maharashtra

FACTORS AFFECTING INSECT CATCHES IN LIGHT TRAPS

Population of adults

- Season (*kharif*, *rabi,* summer season) and weather (rains, drought, hailing, dust storm, wind speed conditions).
- Application of chemical pesticides in the crop fields.
- Nature of crop(s) grown, varieties sown, vegetation of the area and host availability.
- Geography of the area.
- Moon light, presence/absence of surrounding lights near the insect light trap.
- Installation height and location of the trap.

BENEFITS

As the insect collecting chamber has been improved and made porous with a provision to regulate the pore sizes, the insect fauna having small and narrow body size escape through these pores and are saved from unnecessary mortality inside the trapping system.

The starting price of the insect light trap is below ₹ 1,000/- which is less than the cost of the labour applying chemical pesticides in the fields. Insect light trap can be used over seasons. As the body is made of plastic, it is durable and easily portable. It can be used for insect monitoring and mass trapping of phototrophic insect fauna.

INFORMATION AND COMMUNICATION TECHNOLOGY BASED PEST SURVEILLANCE AND ADVISORY FOR IPM

S Vennila, N Singh, RK Tanwar, OP Sharma and DB Ahuja

ICAR: National Research Centre for Integrated Pest Management, New Delhi

1. INTRODUCTION

Welfare of a nation and its citizens is dependent on thought processes led actions executed at policy and implementation levels. In an era driven by advancements in the field of information and communication technology (ICT) for livelihood and lifestyle privileges, vistas of its application are ubiquitous. Approach to use of ICT evolves from a specific vision of improvising the existing practices accounting the drawbacks associated with them. More often than not the advantageous features of ICT transform the structure and function of the organizations for their mandated services. Leveraging individual and integrated services of agriculture to the farmers ensuring their efficiency, transparency and reliability at affordable costs is possible through use of ICT. In agricultural research and development, the role of ICT is enormous from down to earth to the limit of the sky, and localized to global scales of space and time offering information with security along with the value addition of data preservation for a single to manifold components of any given subject.

Integrated pest management (IPM) like ICT has many components of crop protection. Levels of IPM could be for a given crop or for a cropping and production system. However, based on the status of harmful organisms (be it insect-pests, pathogens, nematodes, weeds, mites and rodents) that need a continuous watch kept over them. Realizing the scope of ICT in plant protection with multifold possibilities of centralization and decentralization, considering the roles and responsibilities of the stakeholders involved, the National Research Centre for Integrated Pest Management (NCIPM) with its mandate of eliciting national pest scenario across crops *vis-á-vis* dissemination of IPM practices to the growers revolutionized the ICT-driven pest surveillance, often referred as e-pest surveillance, and incorporated into various programmes operational across India.

2. PRE-REQUISITES FOR PEST SURVEILLANCE

An elaborate preparation is necessary for an effective and efficient pest surveillance. An organized sampling plan is needed based on the distribution of cropped area under the target crop for village and field selections. Scientifically-based sampling methodology including selection of spots/plants in a field and pests to be observed (incidence or the damage) need finalization. Information such as crop variety, date of sowing, other agronomic practices and pesticides applied add value when recorded. Regular schedule is must for recording pest observations during the cropping season. Guidelines for field selection, tools, global positioing system (GPS), traps and lures for insect-pests and data sheets (books) for recording field details and pest observations and training of personnel (pest scouts and monitors) on identification cum sampling of insect-pests and diseases of the target crops are the essential components. Additionally, infrastructure including computers, customized software and internet connectivity besides trained manpower (data entry operators) makes the best possible implementation of e-pest surveillance. There is need to be continuous co-ordination among the stakeholders right from programme formulation to field level implementation in terms of knowing the pests status, recommendation of pest management advisories and their dissemination to farmers.

3. PROGRAMMES OF ICT-BASED PEST SURVEILLANCE OF NCIPM AT A GLANCE

3.1. Crop Pest Surveillance and Advisory Project (CROPSAP) of Maharashtra

Severe pest attack on soybean during 2008-09 in Marathwada and Vidarbha regions of Maharashtra, and the reasons for the outbreak implicating the lack of scientific and systematic pest monitoring and management led to the innovative use of ICT in the field of plant protection for implementation of IPM on an area-wide basis in India. It was strongly felt that pre-emptive actions are a must for averting pest outbreaks given the changing pest scenario associated with diversifying cropping systems, cultivation practices and the felt effects of high variability in seasonal weather. Considering the increased area under soybean on equivalent scale with cotton at Maharashtra, and the common pest status of *Spodoptera litura* on cotton as well as soybean, the program was initiated for both the crops followed by inclusion of pigeonpea and the *Rabi* crop of chickpea since 2009. Rice grown as *Kharif* crop was also included under the surveillance crop-based pest management advisory from 2011. Creation of awareness among farmers of Maharashtra across all target crops under pest surveillance was continuously aimed *vis-á-vis* issuing of real time pest management advisories through tools of ICT. The Department of Agriculture (DA), Maharashtra is the CROPSAP implementation authority with the funding through *Rashtriya Krishi Vikas Yojana (RKVY)* by Central Government till 2012 followed by Government of Maharashtra from 2013 till date.

3.1.1. Objectives

- Implementation ICT-based pest surveillance and advisory
- Awareness creation among farmers on IPM
- Integrated pest management by issuing appropriate advisories and ensuring timely availability of critical inputs

3.1.2. Stakeholders

State Agricultural Universities (SAU) of Maharashtra *viz.,* Mahatma Phule Krishi Vidyapeeth, Rahuri, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Marathwada Agricultural University, Parbhani, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and ICAR institutes *viz*., the National Research Centre for Integrated Pest Management, New Delhi, Directorate of Soybean Research, Indore, Madhya Pradesh, Central Institute for Cotton Research, Nagpur, Maharashtra, Directorate of Rice Research, Hyderabad, Telangana (2012 and 2013 seasons), National Rice Research Institute, Cuttack, Odisha (from 2013), Central Research Institute for Dryland Agriculture, Hyderabad, Telangana, Indian Institute of Pulses Research, Kanpur, Uttar Pradesh, National Institute of Plant Health Management, Hyderabad (from 2013) and the implementing authority of State Department of Agriculture, Maharashtra with its farmers constitute the participants.

3.1.3. Target crops and area of operation

Nearly 43000 villages across 348 talukas of 33 districts from among seven divisions of Maharashtra are being covered under the programme. The area under each crop fluctuates with seasons. Soybean among *Kharif* crops and chickpea of *Rabi* has shown marked increase in area under cultivation during 2014-15.

Area of cultivation (m ha) of the target crops in Maharashtra

Crop	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Soybean	30.19	27.29	30.10	30.64	32.18	39.17
Cotton	33.92	39.42	41.67	41.87	41.50	38.72
Rice	14.50	14.86	15.16	15.28	15.92	15.14
Pigeonpea	10.93	13.02	12.33	12.14	11.60	10.93

3.1.4. Framework of pest surveillance implementation

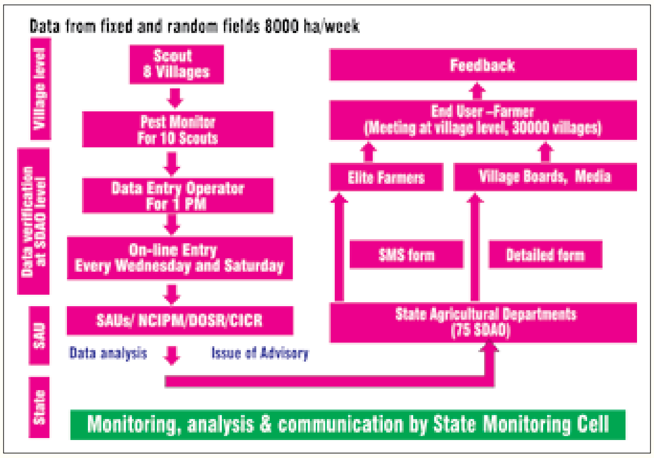
Establishment of pest monitoring units (PMU) covering blocks based on cropped area, manpower deployment in terms of pest scouts (covering around 8 villages/week), pest monitors (one for every 10 scouts), one data entry operator per PMU and server supporters across the State, and engagement of contractual staff such as research associates and computer operators at the ICAR and SAUs formed the platform for implementation of CROPSAP. The villages were clustered into 8000 ha of target crops and those having highest area under each target crop were selected for pest surveillance. For every 1000 ha under the target crop two fixed (observations recorded from start to end of crop season from same fields) and two random fields were selected for pest scouting.

Fixed and random fields were selected from different directions of the village. During this process of field selection it was ensured that the selected villages represent the cluster of villages. In each block, the villages not covered for pest scouting were considered for roving surveys done twice a week by pest monitors wherein 10-15 fields spread across 10 villages were observed in a single day. The unit of field observations was 0.4 ha. In roving survey, qualitative pest status was recorded from randomly selected fields of villages other than those selected for quantitative surveillance by pest monitors.

For each of target crops *viz.,* soybean, cotton, rice, pigeonpea and chickpea, two types of data sheets were prepared *viz.,* proforma for use by scouts (to record the quantitative data for the pests of surveillance from fixed and random fields) and pest monitor proforma (to record the qualitative information on the target and additional pests of importance). Guidelines to record each of the information and data are provided in the data books for pest scouts and monitors.

ICT tools *viz.* laptop, internet modems and GPS devices formed essential part of the program under custody of the PMUs. Functionality of data entry, upload and online reporting software applications are maintained by ICAR-NCIPM, New Delhi.

3.1.5. Scheme of CROPSAP implementation process



3.1.6. Pests under surveillance

Crop	Quantitative	Qualitative surveillance
Soybean	*Spodoptera*, Semilooper (*Chrysodeixis acuta*), *Helicoverpa armigera*, Girdle beetle (*Obereopsis brevis*)	Hairy caterpillar, Stem fly *(Melanogromyza sojae)*, Whitefly *(Bemisia tabaci)* , Yellow mosaic virus, Rust *(Phakopsora pachyrhizi)* and Pod blight *(Colletorictum truncatum)*
Cotton	*Spodoptera*, Jassids (*Amrasca devestans*), Whiteflies (*Bemisia tabaci*), Thrips (*Thrips tabaci*), Mealybug (*Phenacoccus solenopsis*) and Leaf reddening	Aphids *(Aphis gossypii)*, *H. armigera*, *Earias* spp., Pink bollworm *(Pectinophora gossipiella)*, Grey mildew *(Ramularia areola)* and Parawilt
Rice	Yellow stem borer (*Scirpophaga incertulas*), Gall midge (*Orseolia oryzae*), Swarming caterpillar (*Spodoptera mauritia*), Leaf folder (*Cnaphalocrosis medinalis*), Plant hoppers – White blacked plant hopper (*Sogatella furcifera*) & Brown plant hopper (*Nilaparvata lugens*), Blue beetle (*Leptisma pygmaea*), Bacterial leaf blight (*Xanthomonas campestris pv oryzae*), Sheath blight (*Rhizoctonia solani*) and Blast – (*Pyricularia oryzae*)	Caseworm *(Nymphula depunctalis)*, Brown spot *(Helminthosporium oryzae)*, *Hispa*
Pigeonpea	Pod borer (*Helicoverpa armigera*), Pod fly *(Melanagromyza obtusa)*	Mealybug, Cowbug, Pod bugs, Termites, Stem weevil, Blister beetle and Sterility mosaic
Chickpea	*Helicoverpa armigera*, Wilt disease (*Fusarium*)	-

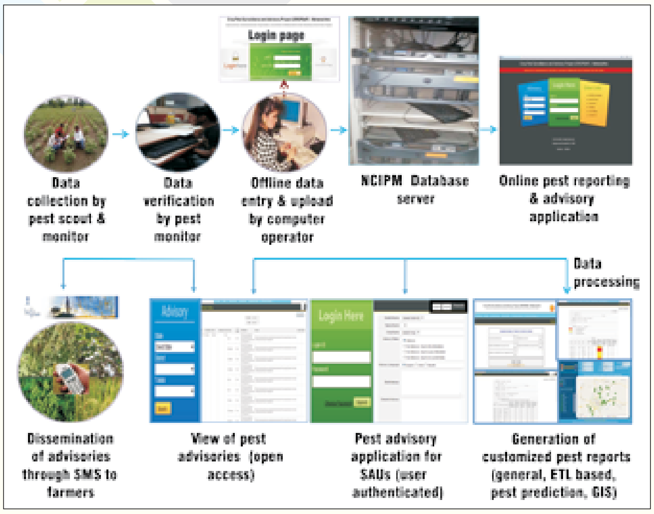
Quantitative surveillance are done by the pest scouts; Qualitative surveillance (Low/ Moderate/High) done by pest monitors

3.1.7. Schedule of pest surveillance and management advisories

Data collection	Data entry and uploads	Data analysis & issue of advisories (SAUs)	Dissemination of advisories by DA
Monday & Tuesday	Wednesday	Thursday	Thursday
Thursday & Friday	Saturday	Monday	Monday

3.1.8. Architecture of e-pest surveillance and advisory

The architecture is a three-tier system designed for pest surveillance that consists of offline data management facility, online pest reporting application and centralised database. Database having various tables for information storage were developed using SQL 2000. Offline data management and online pest reporting applications were developed using ASP.net 2.0 technology. XML format was used for data transfer from offline application to database.

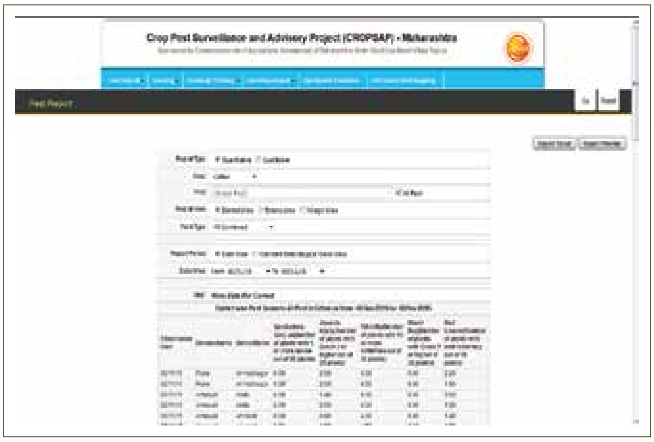


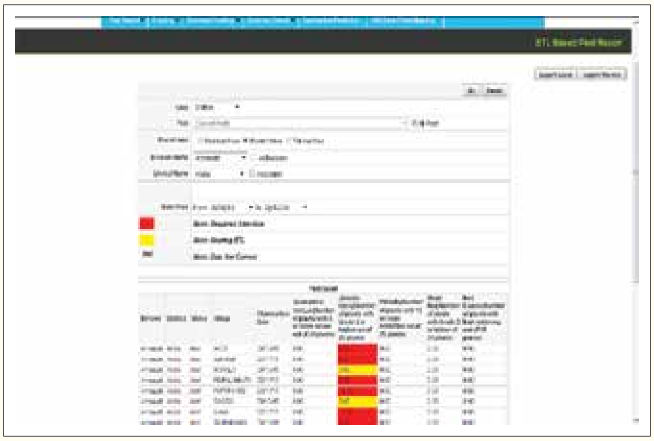
3.1.9. Features of off-line client application

Client application is user-authenticated for application by the pest monitoring units to enter and upload the collected data in respect of the fields from villages of selected talukas of districts of the State. The quantitative and qualitative data collected from fields by pest scouts and pest monitors, respectively in respect of crops (soybean, cotton, rice, pigeonpea and chickpea) could be entered offline and stored. While viewing and editing of field details data can be scrutinised for their correctness before uploads. The upload option compiles and synchronizes the data base and connects to the server through internet.

3.1.10. Features of online reporting application

The technical inputs *viz.,* the economic threshold levels (ETL) and the pest management advisories formulated in detailed and brief formats for the selected pests of target crops by the SAUs and ICAR institutes formed the basis for developing reporting applications. The online reporting and analysis application accessible for authenticated users were assigned to the stakeholders through *http://www.ncipm.org.in/cropsap2015/login.aspx* that produces general and ETL based pest reports with additional options for tracking pest scout, monitor and advisory



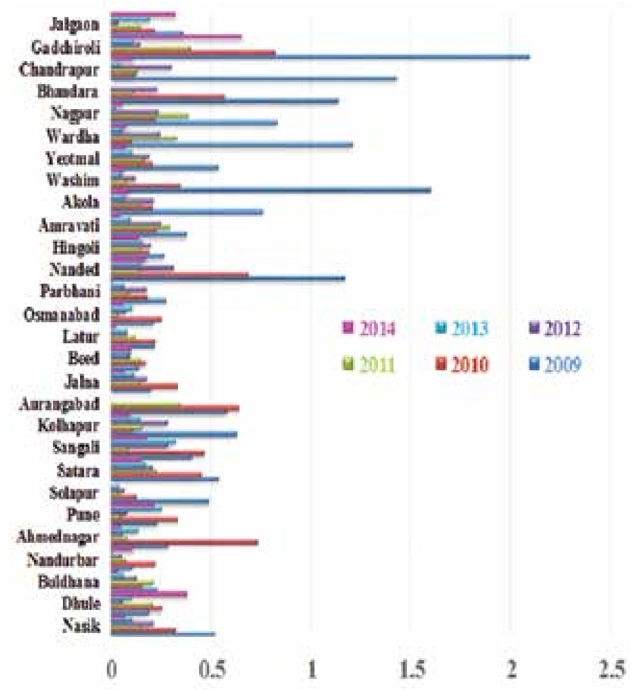


uploads, besides geographic information system (GIS) mapping indicating the hotspots of any pest of the target crop across the State. Prediction of *Spodoptera litura* severity on soybean, data reporting for different combinations based on user selections and data display in the form of tables that can also be exported to MS Excel for further analysis are the additional features. The advisories in brief and detailed forms relevant to the crop(s) pertaining to the current period are also accessible to any user at taluk level through *http://www.ncipm.org.in/cropsap2015/login.aspx.*

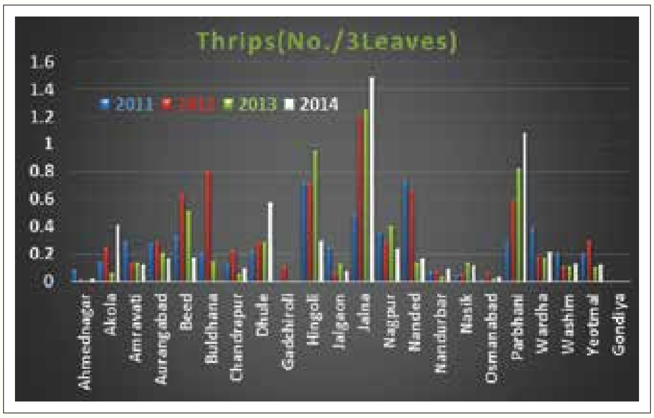
3.1.11.1. Pest status

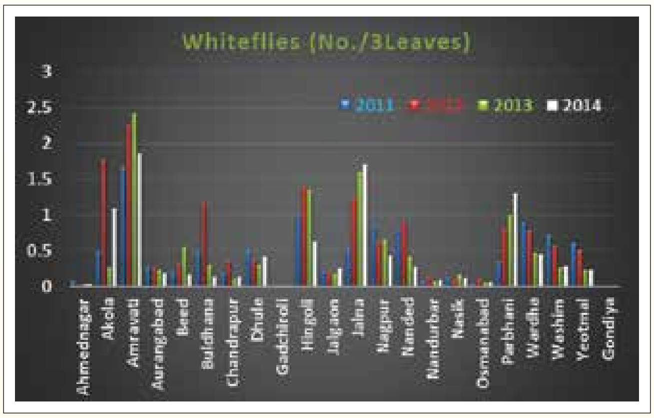
Soybean: The semilooper, *Chrysodeixis acuta* and *Spodoptera litura* had been relatively lower across all districts during 2014 over the past five years of soybean cultivation. During 2014-15 *S. litura* assumed pest status often at Gadchiroli followed by Jalgaon, Jalna and Chandrapur districts. Semilooper *C. acuta* incidence too was low during 2014 throughout Maharashtra with above ETL population only in the districts of Jalna, Satara, Sangli and Amravati. Girdle Beetle (*Oberea brevis*) damage was greater than ETL (3%) only at Agekhed village of Patur taluka. Neipingah of Chandur bazar, and Amdapur of Varud taluk of Amravati, Sunegaon and Navki of Parbhani district of Latur division besides Kelzar village of Satana (Baglan) taluka of Nasik.

***S.litura* solitary larva (no. per metre)**



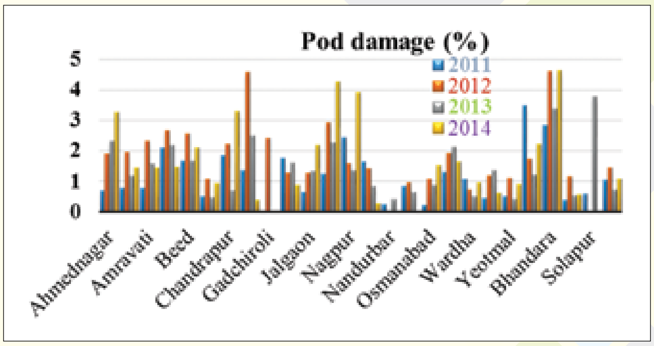
Cotton: The importance of sap feeders was Jassids (*A. devastans*) > Whiteflies (*B. tabaci*) >Thrips (*T. tabaci*). Increasing whiteflies at Jalna and Parbhani, and thirps at Akola, Dhule, Jalna and Parbhani in 2014 over 2011-2013 seasons was obvious.





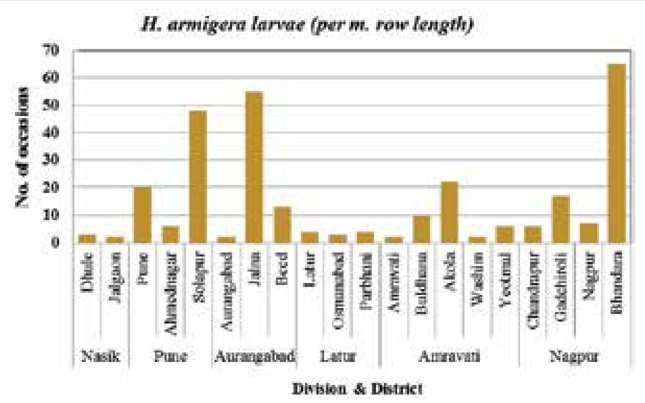
Pigeonpea: Pod damage due to the pod borer complex was higher at Jalna, Nagpur and Nandurbar, and moderate at Chandrapur, Nanded, Gondiya and Aurangabad districts. Pune, Parbhani, Buldhana and Washim had *Helicoverpa armigera* as well as pod damage above ETL, however on a lesser number of occasions. Increasing pod damage due to pod borer complex was observed during 2014 at Ahmednagar,

Comparative scenario of pod damage across districts of Maharashtra

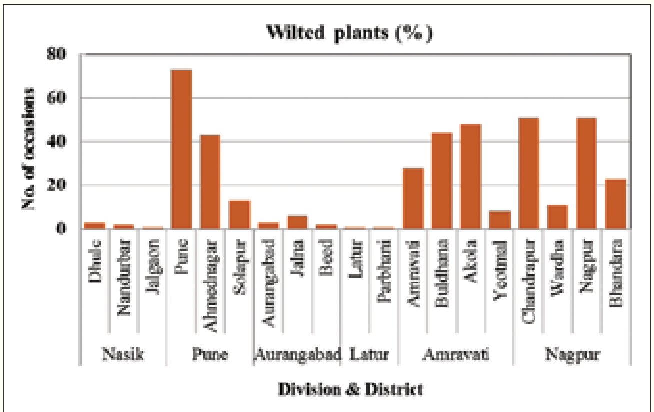


Chandrapur, Jalna, Nagpur, Wardha and Bhandara districts over the previous three seasons. Reduced pod damage was noticed at Dhule and Hingoli during 2014.

Chickpea: *Helicoverpa armigera* on chickpea attained pest status to a higher frequency at Bhandara>Jalna>Solapur>Akola>Pune. Most other districts had lower level of *H. armigera* incidence. Wilt due to *Fusarium* was greater at Pune division followed by Amravati and Nagpur. Nasik, Aurangabad and Latur divisions had the lowest wilt incidence.



Pest status of *Helicoverpa armigera*



Status of *Fusarium* wilt

3.1.11.2. Yield levels

Considering 2008-09 as the problematic year in terms of two dry spells of two weeks in June-July that had delayed the crop sowing followed by three weeks of dry spell in August resulting in severe pest infestation on Soybean, the observed productivity was less in soybean, cotton and pigeonpea crops. Although seasons of 2009-10 to 2011-12 witnessed 2-3 dry spells, despite timely onset of monsoon, and pest incidences were there after dry spells they were detected in time and corrective measures were taken appropriately through supply of critical pest management inputs. Since 2010-11, productivity of crops never declined to the level of (pest outbreak season) 2008-09 due to continuous vigil kept through e-pest surveillance.

3.1.11.3. ICT-based dissemination of pest management advisories

The participatory response of farmers for short message services (SMSs) enrolment, advisories issued by SAUs, sent by DA demonstrates the growing subscribers, and awareness on pest management generated under the programme during *Kharif* and *Rabi* seasons across five crops.

Area and productivity of target crops of pest surveillance during project period

Crop	Particulars	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Soybean	A	30.63	30.19	27.29	25.3	30.64	39.17	38.01
	P	601	728	1581	1312	1531	1302	499
Cotton	A	31.46	33.91	39.42	43.5	41.87	38.72	41.92
	P	257	256	322	280	276	343	163
Rice	A	14.99	14.5	14.86	15	15.28	15.13	15.00
	P	1496	1474	1766	1816	1964	1799	1875
Pigeonpea	A	10.08	10.93	13.02	12	12.17	10.96	10.37
	P	600	841	750	704	829	874	313
Chickpea	A	11.43	12.91	14.23	10.51	11.35	13.2	13.48
	P	677	863	914	775	826	932	615

(A=Area in 1 x 10^5 ha, P=Productivity in kg/ha)

Dissemination of pest management advisories through SMSs across the crops of soybean, cotton, rice, pigeonpea and chickpea based on ETLs of different pests since the inception of CROPSAP indicate the need-based and effective functioning of plant protection extension across the state of Maharashtra.

ICT-based pest management advisory dissemination

Year	No. of subscribers (lakhs)	No. of SMSs sent (lakhs)
2009-10	1.63	31.93
2010-11	2.40	112.00
2011-12	3.11	199.06
2012-13	3.40	360.83
2013-14	3.90	265.80
2014-15	15.00	550.27

Number of advisories issued

Season	Soy-bean	Cotton	Rice	Pigeon-pea	Chick-pea	Total
2014-15	9310	14171	15193	8097	10594	57365
2013-14	15170	24846	20959	13364	10759	85098
2012-13	10043	17177	13720	13120	16017	70077
2011-12	11935	16668	15528	11502	8537	64170
2010-11	12077	17289	**	15768	10996	56130
2009-10	2583	2212	**	3061	5661	13517

*** Rice crop was included for pest surveillance from 2012 season*

Since the inception of CROPSAP till date there has been no outbreak of any major pest on the targeted crops due to the consistent pest monitoring, timely guidance received by farmers through SMSs and adoption of appropriate pest management strategies.

On the side-lines of CROPSAP considered as one of the path-breaking initiatives with the possibility and success of the programme demonstrated, many other ICT initiatives have been brought into operation in plant protection. The highlights of the programmes are furnished in brief.

3.2. National information System for Pest Management (NISPM-*Bt* cotton) and On-line Pest Monitoring and Advisory Services (OPMAS) (cotton)

Introduction of *Bt* cotton in India from 2002 for the management of bollworms resulted in changing pest scenario with the sap feeders (mirids, mealybugs, aphids, thrips and whiteflies) acquiring the status of major pests in addition to emergence of grey mildew, leaf spot and rust diseases and the disorder of leaf reddening. There was an urgent need to monitor the insect-pests and diseases regularly for issue of advisories to take up remedial measures before epidemic situations arise. Department of Agriculture and Cooperation, Ministry of Agriculture operated the National Information System of Pest Management (NISPM) in *Bt* cotton under Technology Mission on Cotton Mini Mission II between 2008 and 2013. From 2014, programme has been renamed as “On-line Pest Monitoring and Advisory Services (OPMAS)” and covered under the National Food Security Mission (NFSM) - Commercial Crops with the aim to expand the web-based pest monitoring and advisory services across the country in major cotton growing districts with ICAR-NCIPM as a coordinating centre. While NISPM covered 1120 fields spread over 280 villages in 14 intensive cotton growing districts of nine states, presently OPMAS is being implemented in ten major cotton growing States with the help of 16 cooperating centres of SAUs, ICAR and *Krishi Vigyan Kendras* to cover 21000 farmers of 26 districts. OPMAS has been implemented in 23134 ha of cotton involving 19956 farmers of 216 villages during 2014-15.

3.2.1. Implementing centers of OPMAS

State	Participating centre	Implementing district	No. of farmers
1. Haryana	1. ICAR-Central Institute for Cotton Research, Sirsa	1. Sirsa	750
		2. Fatehabad	750
2. Punjab	2. Regional Research Station, Faridkot	3. Faridkot	1000
		4. Shri Muktsar Saheb	1000
3. Rajasthan	3. Agricultural Research Station, Banswara	5. Banswara	750
		6. Pratapgarh	750
4. Gujarat	4. Anand Agricultural University, Anand	7. Varodara	750
		8. Kheda	750
5. Madhya Pradesh	5. Cotton Research Station, Khandwa	9. Khandwa	1000
		10. Khargone	1000
6. Maharashtra	6. Cotton Section, Akola	11. Akola	1000
		12. Buldana	1000
	7. *KVK*, Kharpudi, Jalna	13. Jalna	1000
		14. Parbhani	1000
	8. *KVK*, Ahmednagar	15. Ahmednagar	1000
		16. Aurangabad	1000
7. Telangana	9. *KVK*, Jamnikunta, Karimnagar	17. Karimnagar	625
		18. Warangal	625
8. Andhra Pradesh	10. Regional Research Station, Guntur	19. Guntur	625
		20. Prakasam	625
9. Karnataka	11. *KVK*, Tukaratti, Belgaum	21. Belgaum	625
		22. Dharwad	625
	12. *KVK*, Mysore	23. Mysore	625
		24. Chamarajanagar	625
10. Tamil Nadu	13. *KVK*, Perambalur	25. Perambalaur	750
		26. Salem	750

Additionally, ICAR-Central Research Institute for Dryland Agricultural, Hyderabad and ICAR-Indian Agricultural Research Institute are serving as specialised centres involved in pest-weather correlation studies and hot spot identification.

3.2.2. Surveillance plan under NISPM and OPMAS

Formulation of data sheets along with guidelines for recording the pest observations formed the basic step of pest surveillance. Collection of pest data was done by pest scouts from two fixed and two random fields per village at weekly intervals following the prescribed method of sampling using the developed data sheets.

3.2.3. Pests under surveillance

Pest category	Insect/Disease/Beneficial/Disorder
Sap feeders	Jassids *(A. devastans)*
	Aphids *(A. gossypil)*
	Whiteflies *(B. tabaci)*
	Thrips *(T. tabaci)*
	Mirid bugs *(Creontiodes biseratense)*
	Mealy bugs *(Phenacocus solenopsis)*
Bollworms	American bollworm (egg larvae) *(H. armigera)*
	Spotted bollworm (larvae) *(Earias spp)*
	Pink bollworm (larvae)
	Spodoptera (Egg mass & larvae)
	Fruiting structures (Squares and green bolls)
	Bollworm damage-(Square bolls)
Beneficials	Coccinellids *(Coccinella, Scynmus)*
	Chrysoperla eggs
	Spiders
Diseases	Cotton Leaf Curl Disease
	Grey mildew *(Ramularia aureola)*
	Para wilt
Disorder	Leaf reddening

3.2.4. Features of the ICT in OPMAS

Both NISPM and OPMAS involve the online data feeding and uploads by the cooperating centres. Exclusive launching of home page has been made at NCIPM website. While erstwhile NISPM operated on the URL of *www.ncipm.org.in/NISPM* between 2008 and 2014, the present web-based system under OPMAS was re-designed and hosted on *www.ncipm.org.in/OPMAS/2015/* for cotton pest monitoring and issuing pest management advisories to the farmers through SMS. OPMAS involving ICT was developed using SQL server 2008 and asp. net 4.0 technologies. Other than pest data entry

and reporting, OPMAS web-based application has additional salient features such as farmer registration for receiving pest advisories, pest image library and news section. While images of pests are helping the project workers in pest identification, news section provides recent happenings across areas of cotton pest management. Pest image library has both static as well as video recorded images.

3.2.5. Highlights of NISPM & OPMAS

3.2.5.1. Pest status on Bt cotton (NISPM): 2009-2013

Sucking pests, especially jassids, thrips and whiteflies showed increasing trend up to 2011-12 with a decline in the following two seasons. Jassids>thrips>whiteflies was the order of importance at the national level. Leaf reddening emerged as a serious physiological disorder in *Bt* among 14 districts during 2010-11 with its decline in the later years due to effective management interventions.

ETL-based pest scenario on *Bt* cotton under NISPM

Pest	No. of districts (No. of occasions above ETL)				
	2009-10	2010-11	2011-12	2012-13	2013-14
Jassid	8 (109)	8 (210)	12 (582)	9 (112)	12 (218)
Whiteflies	6 (61)	-	7 (282)	8 (61)	10 (57)
Thrips	6 (68)	1 (1)	8 (131)	7 (116)	10 (59)
Mealybugs	5 (12)	3 (178)	8 (445)	5 (25)	6(42)
Mirid bug	2 (5)	3 (21)	2 (31)	1 (41)	2 (7)
American bollworm	1 (4)	3 (4)	6	-	-
Spotted boll-worm	1 (5)	-	-	-	-
Spodoptera	3 (8)	-	-	2 (5)	2 (7)
CLCuD	1 (2)	1 (2)	-	-	1 (6)
Wilt	2 (13)	12 (290)	5 (22)	-	5 (22)
Leaf reddening	-	14 (1964)	10 (349)	5 (193)	11 (266)

Experiments undertaken at selected centres of NISPM *viz*., Akola, Patur, Kanheri Saraf and Bhaurad on the management of leaf reddening brought out spray of $MgSO_4$ @ 1% (w/v) to be significantly better along with other recommended practices for *Bt* cotton.

3.2.5.2. Extension of pest management advisories

The capabilities of farmers on pest management strategies in *Bt* cotton were enhanced through village level group meetings and trainings at NISPM

Awareness creation and extension of IPM (NISPM)

Activity		2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Village group meetings	No. during season	48	740	801	1030	553	356
	No. of farmers	1051	10100	10630	13106	10758	8796
Farmer trainings	No. during season	27	60	86	80	95	72
	No. of farmers	1189	2779	2984	3453	3480	2159
Newspaper coverage	No. during season	12	176	95	87	93	127
Radio talks		NA	17	31	42	34	38

centres. Further awareness through mass media (newspapers and radio talks) was created regularly as and when situations warranted. Extension folders and technical bulletins in local vernacular languages were published by different centres to bring awareness on the emerging insect-pests and diseases besides their management using IPM.

The numbers of advisories and news items on cotton pest management issued in respect of OPMAS centres, and of farmers to whom the advisories were disseminated during 2014-15 indicate the user details of the ICT-based technology.

Extension of IPM (OPMAS): 2014-15

Centre	No. of advisories issued	No. of news items uploaded	No. of farmers involved
Sirsa	7	2	0783
Faridkot	4	3	0276
Banswara	20	11	1038
Anand	20	16	1500
Khandwa	5	2	1811
Akola	6	11	-
Jalna	12	4	1789
Ahmednagar	11	10	1795
Karimnagar	4	1	1240
Guntur	20	9	2031
Belgaum	19	9	1509
Mysore	18	10	2619
Perambalur	11	10	-
Total	*157*	*98*	*16391*

3.2.6. Impact of IPM through NISPM

The regular monitoring and dissemination of advisory helped in reducing the number of chemical pesticide sprays in fields of IPM trained farmers as compared to farmer practices (FP). The seed cotton yield recorded was also higher in IPM as compared to FP.

Pesticide use and yield levels of IPM *versus* FP

Year	Number of pesticide sprays		Cost of pesticide sprays/ha (in ₹)		Seed cotton yield (kg/ha)	
	IPM	FP	IPM	FP	IPM	FP
2008-09	4.2	6.3	2071	2924	2043	1850
2009-10	4.1	6.5	2234	3193	2040	1775
2010-11	3.9	6.0	2475	4246	2138	1841
2011-12	3.7	6.1	2685	4510	2107	1850
2012-13	4.04	6.37	2900	4725	2195	1865
2013-14	4.27	7.34	42168*	45944*	2248	1885
2014-15	3.85	5.94	34513*	37567*	2628	2356

** cost of cultivation*

Centre-wise economic analysis made in 2014 in respect of centres based on ICT-based IPM implementation across seasons of 2008-2013 through NISPM indicated reduced application of chemical pesticides in all the locations.

The use bio-pesticides including botanicals was to an extent of 23.5% of total pesticidal sprays in IPM as against 6.78 in non-IPM fields. Higher net returns as well as benefit cost ratio in IPM over non-IPM was obtained across all centres.

3.3. e-National Pest Reporting and Alert System for Pulses

The domestic demand and increasing import of pulses resulting in an urgent need to increase the pulse production in the country by reducing yield losses due to pest attack led to the development of "Accelerated Pulses Production Programme (A3P)" under the National Food Security Mission (NFSM) of the Department of Agriculture & Cooperation (DAC), Government of India. Development of web-based tool towards reporting of pest situation from fields through periodical monitoring, and issuing of appropriate pest management advisories to the farmers were built in the programme. The broader objectives of A3P initiative were:

1. To detect pest build-up and monitor their progress through web-based query interface at village/taluk/district level
2. Facilitate the electronic transfer of appropriate information from National Research Centre for Integrated Pest Management (NCIPM) to State Agricultural Departments for initiating timely action.
3. To forewarn farmers through SMSs to ready themselves with preventive as well as curative pest management tools

The purpose of web-based approach was to report the real time pest infestation in the fields and to advise the farmers for applying the appropriate pest management practice so that epidemic situations can be avoided by detecting damage prior to establishment of a higher pest population. The web-based tool 'e-National Pest Reporting and Alert System for Pulses' for the crops of Pigeonpea and Chickpea was implemented initially in five states since 2009, and was extended to Jharkhand from 2010 to 2014.

Number of villages and farmers covered under e-National Pest Surveillance

State (Districts)	Pigeonpea		Chickpea	
	Villag-es	Farm-ers	Villag-es	Farm-ers
Karnataka (Gulbarga)	34	3301	23	1529
Maharashtra (Badnapur, Parbhani, Osmanabad, Nanded)	26	5017	20	3587
Andhra Pradesh (Anantapur)	25	482	12	1000
Madhya Pradesh (Chindwara & Narsimpur)	316	2967	55	1708
Uttar Pradesh (Hamirpur & Banda)	69	3000	12	557
Total	470	14767	122	8381

3.3.1. Features of e-national pest reporting & alert system

The "e-National pest reporting & alert system" for pulses could be accessed at *http://www.ncipm.org.in/A3P/UI/HOME/Login.aspx.* Its platform was independent and could be accessed from any computer connected to the internet. The only requirement at the client side is a web browser and authorization following online registration at NCIPM home page. The system was developed using three tier architecture with online data entry, reporting and advisory to farmers through SMSs in respective languages of the States. Javascript, ASP.Net 3.5 and SQL server 2005 technologies were used in the development of the application. The GIS has been used for pest reporting on map for spatial data management to facilitate easy understanding and visual interpretation.

Home page of "e-National pest reporting & alert system".

Pest reporting through Google maps

Temporal reports (graphical horizontal bars & tabular), and map-based report using Google maps depicting pest incidence and affected areas in different colors representing severity of incidence are possible. The purpose of this pest reporting through Google maps is to communicate immediate or potential danger arising from the occurrence, outbreak or spread of a pest as well as identifying the pest hotspots so as to advise the State machinery and farmers to take appropriate and timely action for pest management to minimize losses due to pest incidence. This application represents the pest population through an icon in Red, Yellow and Green colours for easy inference regarding different levels of pest intensity. These pest reports allowed them to adjust for necessary pest management requirements and actions to take into account. Pest reports also provided useful current and weekly information for operation of ongoing pest management programme in the States. e-Pest alert system also featured (a) sending SMS to single mobile phone (web2mobile), (b) broadcasting SMS to a group of mobile phones (web2mobiles). However modification was done to include forwarding of single SMS from a mobile phone to a group of mobile phones (mobile2mobiles). More specifically, the pest expert logs in the system and selects the SMS recipient(s). Then a pop-up window emerges where the SMS is written. The SMS could be written in English as well as regional languages (Hindi, Marathi, Kannada and Telugu). 'Translate' tool of Google has been used to convert messages from English into regional languages.

Options (view and send) of pest management advisories

3.3.2. Impact of A3P

Near 25000 farmers were registered for receiving SMS advisories. Total SMSs sent during 2010 were 9530. Currently, potential beneficiary of the system are 25000 farmers who were selected by NCIPM as well as 90% of the farmers that own a mobile phone.

State based A3P co-operators (UP, MP, AP, Maharashtra and Karnataka) conveyed their pest management advisories across 592 villages covering 36000 ha to 3545 and 4650 farmers through 9530 and 13245 SMSs during 2009-10 and 2010-11, respectively.

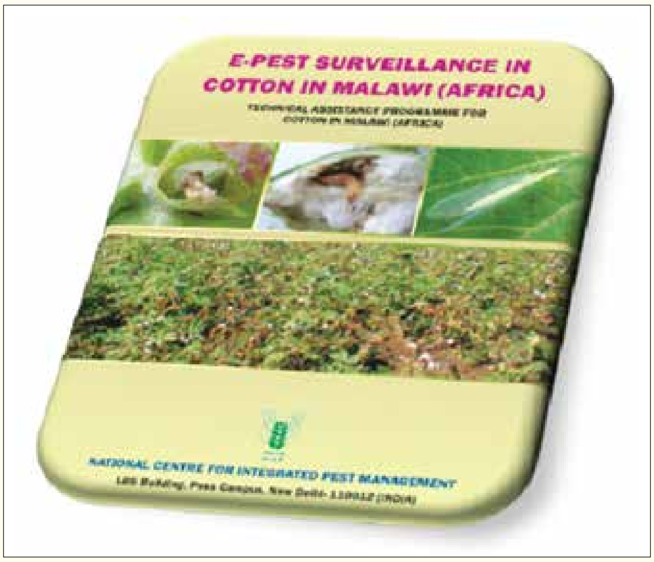
Implementation of this application not only helped in identifying the hot spots but also geared up the staff to manage the crisis situations through creation of popularity and awareness.

Yield could be increased from 10 to 12 q/ha over 2009-10 by minimizing losses caused by pests. Pest advisories sent to the farmers through SMS on the basis of pest reporting led to the reduction in number of chemical pesticide sprays from 6 to 3 in Gulbarga district. This has also proved very successful and led to 3 million tonnes additional production of pulses in comparison to previous years, despite failures in Anantapur (AP) as well as Chindwara and Narsingpur (MP).

The system has also enabled identify the potential areas wherein yield can be increased by minimizing losses caused by proliferating pests (*Maruca* and *Melanagromyza obtusa*) as well as identification of endemic areas (sterility mosaic virus & leaf spot *Cercospora*) diseases.

3.4. Implementation of ICT-based Pest Surveillance in Malawi-Technical Assistance Progamme (TAP), Africa

Expertise of ICT-based pest surveillance and advisory carried out by NCIPM under National Information System for Pest Management (*Bt* cotton) in addition to the operational success of programmes like CROPSAP and A3P facilitated the pilot scale implementation of ICT-based pest surveillance in Malawi (Africa) in cotton. ICAR-NCIPM in collaboration with Ministry of Agriculture and Food Security, Malawi and Infrastructure Leasing & Financial Services of Clusters Private Ltd. (IL&FS) took up the initiative of demonstrating the potential of ICT in agriculture for cotton pest surveillance and issuing of pest management advisories to extension personnel and farmers of Malawi. As a pre-requisite to the implementation of e-pest surveillance, the baseline information was collected on insect-pests and diseases though a visit by NCIPM scientists for finalizing the data formats for pest observations and customized software development. Software for data entry, and advisory dissemination were customized as per the infrastructure available at Malawi. ICT-based application was hosted vide. *http://www.ncipm.org.in/ICTMalawi/.* A manual on e-pest surveillance for cotton in Malawi (Africa) was also prepared. Training and workshop were conducted by NCIPM team at Balaka and Machinga districts of Malawi for extension personnel on the identification of cotton pests and implementation of the e-pest surveillance. About 500 farmers from both the districts were registered to receive the pest management advisories through SMSs. ICT-based pest surveillance was launched in Malawi in December 2014. The software has the provision to cover the entire country (28 districts) although only two districts have been covered on a pilot scale presently. Scope of the continued implementation of ICT-based pest surveillance in those two districts and further expansion to other districts of Malawi depends on further funding for deployment of man power and additional infrastructure development.



3.5. Implementation of e-Pest Surveillance and Pest Management Advisory for Fruit Crops (Maharashtra)

The thrust for rising fruit productivity through reduction of yield losses due to pests through action

threshold-based application of pesticides constitute an essential part of integrated pest management. The success of CROPSAP at Maharashtra in field crops motivated the officials of Department of Horticulture of the State to adopt ICT-based pest surveillance for horticultural crops. ICAR-NCIPM with its expertise in ICT-based pest management solutions in collaboration with multiple institutions of Indian Council of Agricultural Research *viz.,* Central Citrus Research Institute, Nagpur, National Research Centre for Pomegranate at Solapur and National Research Centre for Banana at Trichi, and State Agricultural Universities *viz.,* Mahatma Phule Krishi Vidyapeeth, Rahuri, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani with State department officials of horticulture and farmers of target fruit crops are involved in programme implementation.

Horticulture pest surveillance and advisory project (HortSAP) - Maharashtra was initiated from 2011-12 initially for Mango, Pomegranate and Banana followed by the expansion to other fruit crops *viz.,*Sapota, Orange (Nagpur Mandarin) and Sweet Orange (Mosambi) since 2014-15. The districts selected are Jalgaon for banana, Thane, Raigad, Ratnagiri and Sindhudurg for mango and Ahmednagar, Nashik, Solapur and Sangli for pomegranate covering 44032 ha, 101840 ha and 38771 ha, respectively. At present the programme spreads over five districts for banana (Jalgaon, Solapur, Hingoli, Nanded, Akola), two districts for sweet orange (Aurangabad and Jalna), seven districts for mango (Palghar, Raigarh, Ratnagiri, Sindhudurg, Osmanabad, Aurangabad, Beed), five districts for Nagpur mandarin (Akola, Amravati, Buldhana, Wardha and Nagpur), eight districts for pomegranate (Ahmednagar, Solapur, Sangli, Satara, Nashik, Dhule, Aurangabad and Pune) and one district for sapota (Palghar). The implementation profile of e-pest surveillance across fruit crops is exhaustive as given below.

Area of operation under e-pest surveillance of fruit crops

Crop	Districts	Talukas	Villages	Area covered (ha.)
Banana	4	13	462	53,881
Mango	7	45	3670	1,07,182
Pomegranate	8	32	1121	64,928
Orange/Nagpur Mandarin	6	25	944	73,381
Sweet Orange/ Mosambi	4	23	574	56,859
Sapota	1	4	42	5,416
Total	23	142	6813	3,61,647

Key insect-pests and diseases of the six fruit crops considered for surveillance are:

Insect pests and diseases of surveillance

Crop	Pests of surveillance
Santra and Sweet Orange	Bark eating caterpillar, Blackfly, *Psylla*, Fruit sucking moth, Leaf miner, Mites, *Phytophthora*, Thrips, Whitefly
Sapota	Bud Borer, *Phytophthora*, Seed borer
Banana	Leaf Spot, Thrips
Mango	Anthracnose, Hopper, Powdery mildew, Thrips, Trap catch of fruit flies
Pomegranate	Bacterial blight severity for leaf/ Stem/Fruit, Fruit borer, Fruit damage due to thrips, Thrips damage to twigs, Wilt

3.5.1. Features of HortSAP ICT application

HortSAP application also consists of data capture, pest reporting and advisory modules. The system is access rights based that only authorize users to log into the application. The application has provisions to capture information such as location, agronomic, pest details and other relevant information as envisaged in data recording formats. Reporting module generates location-specific current and temporal ETL-based pest reports. (http://www.ncipm.org.in/Horticulture15-16/Default.aspx). Wherever pest population has either reached near or crossed ETL, pest experts issue advisories using the system to the farmers of that area. One of the important feature of the system is that user can easily add crop and pest into it. This also has provision to generate tracking of reports for user activities.

3.5.2. Impact of HortSAP

Implementation of the project in the state has helped the progressive farmers in creating awareness for the correct identification of the pests, timely and ETL-based application of the IPM technologies without time lag between the occurrence of the pests and their management as envisaged from the final estimate of productivity of fruits of Maharashtra presented by National Board of Horticulture. The productivity (mt/ha) of mango, banana, pomegranate, citrus and sapota was 2.5, 58.2, 10.5, 6.4 and 6.5 during post project implementation period of 2013-14 and was higher over 2011-12 (1.0, 52.6, 5.8, 4.4 and 4.1), the startup season of e-pest surveillance and advisory, respectively.

Advisories and SMS issued to farmers

Crop	2011-12		2012-13		2013-14		2014-15	
	Advisories	SMS	Advisories	SMS	Advisories	SMS**	Advisories	SMS
Banana	3	2382	223	67923	452	-	329	78,385
Mango	772	3,63,710	1024	4,52,990	156	-	1425	4,14,611
Pomegranate	692	74,254	1444	10,90,883	452	-	857	25,43426
Sapota*	-	-	-	-	-	-	19	1,42,482
Orange* (Nagpur Mandarin)	-	-	-	-	-	-	445	5,18384
Sweet Orange* (Mosambi)	-	-	-	-	-	-	1692	4,47,263
Total	1467	4,40,346	2691	1,61,1796	2095	28,30,222	4767	41,44,551

** Orange and Sweet orange crops were added for e- pest surveillance and advisory from 2014-15, ** data not available*

3.6. ICT as a Tool for Data Base Development through Electronic Networking and Pest Forecasting

Pest risks associated with climate change requires comprehensive and long term data of crop-pest-weather over space and time, and ICT serves as a translational tool to assimilate them effectively and efficiently. National Innovations on Climate Resilient Agriculture (NICRA) provides a research platform to ICAR-National Research Centre for Integrated Pest Management (NCIPM) for studying the changes in the pest scenarios in response to climatic change across crops of rice, pigeonpea, groundnut and tomato that are important for food and livelihood security of India. Assessment of the changing pest scenarios, mapping of vulnerable regions of pest risks, and evolving curative and preventive pest management strategies towards climatic stress have been emphasized. Twenty five locations from 12 States representing 10 agro-climatic zones (3, 4, 6-13) and 12 agro-ecological regions (R2-8 & R10-11, R15 & R18) of the country were identified for study on real time pest dynamics (RTPD). The centres of project implementation across crops are: Rice: Aduthurai (TN), Mandya (KA), Raipur (CG), Ludhiana (PB), Chinsurah (WB), Karjat (MH) and Hyderabad (TS); Pigeonpea: Gulbarga (KA), Dantiwada (GJ), Warangal (TS), Vamban (TN), Jabalpur (MP), and Anantapur (AP); Tomato: Varanasi (UP), Ludhiana (PB), Rahuri (MH), Hyderabad (TS), Kalyani (WB), Raipur (CG) and Bengaluru (KA); Groundnut: Junagadh (GJ), Jalgaon (MH), Virudhachalam (TN), Anantapur (AP) and Dharwad (KA). Pest surveillance plan for experimental stations and farmer's fields was devised and the list of pests along with their sampling method and weather variables and GPS coordinates to be collected were used to design data recording formats through consultative group meetings involving experts of target crops (*http://www.ncipm.org.in/nicra/DataSheets_Manuals_Guidelines.aspxhttp://www.ncipm.org.in/nicra/index.aspx).* A web-based system consisting of four major components *viz.,* centralized database, offline client data capture, admin panel, and data reporting and analysis was designed. System consisting centralized database, offline data capture and online pest reporting cum analysis facility was developed using SQL Server 2005, ASP.net 3.5 and XML technologies, respectively. Setup files for client software installation by RTPD centres are generated using admin panel configuring software applicable for the target RTPD centre. Reporting application consisting admin panel is functional and available on website: *http://www.ncipm.org.in/nicra/.* The reporting system operates through the start page: *http://www.ncipm.org.in/nicra/NICRAAdminPanelNew/rvLogin.aspx* to log in. Staff exclusively for pest surveillance, training and involvement of subject matter team with their active participation in RTPD centres improves the ICT process and project efficiency. Data base developed through this project is accessible to all stakeholders and serves to bring out location-specific as well as national pest scenario for the present and future climatic scenarios. A web-enabled weather-based forewarning module (available at: *http://www.ncipm.org.in/nicra/ForewarningSystem/PestPrediction.aspx; http://www.ncipm.org.in/nicra/ForewarningSystem/PestPredictionEmpirical.aspx)* for *(a)* Rice yellow stem borer for five locations for *Kharif (b)* Rice leaf folder for *Kharif* (two locations) and for *Rabi* season (one location) (c) *Spodoptera litura* on groundnut for three locations has also been developed and integrated into the system. While field level impacts of climate change on pests are serving

to develop resilient pest management technologies (through further adaptive research), the pest forewarning feature of the project is directly applied at the regional (district) level to minimize the yield losses caused by the insect-pests and diseases. While the ICT accelerated data base development is leading to faster research outputs and forms repository for long-term research, the forewarning component aids in judicious and timely use of pesticides at farm level thus accruing economic and environmental benefits to the crop growers.

3.6.1. Highlights of pest dynamics in relation to climatic variability

- Twenty five real time pest dynamic (RTPD) centers from 11 states, across 11 agro-climatic zones covering 12 agro-ecological regions are being implemented with e-pest surveillance for the four target crops (rice, pigeonpea, groundnut & tomato) during *Kharif* 2011-2015. Comparative analysis of pest scenario *vis-a-vis* weather variables from climatic variability perspective was made considering the data base over three *Kharif* (2011-2013) and *Rabi* (2011-12 – 2013-14) seasons for seven, six, five and seven real time pest dynamic (RTPD) locations in respect of 34, 23, 27 and 30 parameters (including insect-pests, diseases, beneficial, light and pheromone trap catches) corresponding to Rice, Pigeonpea, Groundnut and Tomato crops.
- While outbreak of rice black bug, *Scoutinophara lurida* was seen at Aduthurai (TN) due to greater and unusual rains during 33 standard meteorological week (SMW), Ludhiana (PB) has witnessed reduced rice BPH, *Nilaparvata lugens* due to absence of rainfall and associated reduced humidity levels during the 33 and 34 SMWs.
- Heavy incidence of jassids (*Empoasca kerri*) during 2014 and 2015 as against trace population in the past years was observed at Gulbarga (KA) following higher minimum temperature of 2-5°C over normal throughout the pre- and post-monsoon periods (mid-March – September) followed by torrential rains (195 mm in 35 SMW) coupled with dry spells and intermittent rains (>10mm). Pigeonpea *Phytophthora* blight is on the rise at Gulbarga (KA) in response to the increased rainfall over normal during the late crop growth stage. *Helicoverpa armigera*, *Grapholita critica*, *Adisura atkinsoni* and *Exelastis atomosa* were at their lowest during 2014 at S.K. Nagar (GJ) when the rainfall amount during the season (June - December) had been lower over previous three seasons.
- Higher temperature during pre-monsoon period coupled with delayed rains and late sowing of Groundnut at Dharwad (KA) followed by continuous rains till October during *Kharif* 2014 saw moderate to high (40-50% leaf defoliation) damage due to *Spodoptera litura* and late leaf spot (Grade 5) with leaf miner at its low. Early and late season dry spells and comparatively high rainfall events amidst crop season during 2014 at Jalgaon (MS) had the increasing population levels of jassids *Empoasca kerri*, thrips *Scirtothrips dorsalis* and leaf miner *Aproaerema modicella*. The rare occurrence of thrips damage at maturity period of groundnut at Junagadh (GJ) in 2014 was due to the prevalence of high temperature in day time and absence of rains.
- South American tomato leaf miner, *Tuta absoluta* was documented as a new invasive pest from India during *Rabi* 2014 at Bengaluru (KA). Heavy rains of August (149 mm in 35 SMW as against normal of 21 mm) in 2014 led to *Phytophthora* rot of fruits (40-50%) at Rajendranagar (Telangana) besides early blight and *Fusarium* wilt. Rabi tomato had 40-50% severity of late blight in the 3rd week of March (12th SMW) at Patiala (PB). Increasing target leaf spot incidence with increasing maximum temperature and decreasing relative humidity of December, and decreasing early blight with increasing minimum temperature and morning relative humidity of February were noted at Kalyani (WB).
- Prediction rules based on weather criteria and pest severity levels were developed for brown plant hopper *Nilaparvata lugens* at Raipur (CG), Ludhiana (PB) and Aduthurai (TN), and for early leaf blight at Bengaluru (KA). Web-enabled weather-based predictions for four rice pests (yellow stem borer, gall midge, case worm and green leaf hopper), and *S. litura* on groundnut at weekly and fortnightly basis predicting maximum severity of *S. litura* forewarned low severity in 100% of the occasions during *Kharif* 2014.

4. WAY FORWARD

Use of ICT in plant protection has obviated the drawback of non-availability of complete data sets on pests at one or a few places that make the spatial and temporal pest scenario compilations and exchanges highly difficult for the crop. Considering that large amount of research data that gets lost in the note books of the persons who recorded the data, carefully designed ICT-based pest surveillance not only brings convergence in measuring pests essential for comparison purposes but also fastened the pest scenario known on real time basis for instant recommendations of need-based pest management through advisory notifications. It is also well known that changes in technology are continuous and the sophistication levels of surveillance/ reporting tools are dynamic. Electronic gadgets and networking make pest surveillance and monitoring a commercial enterprise however with the continuous trainings and skill development made available. ICT would continue to play a greater role in effective use of data gathered over time and space in understanding changing pest scenario, effects and efficacy of pest management methods, effects of weather/climate change on crop-pest interactions and in development of forecasts and policies of plant protection. Evolving instant feedback mechanisms from farmers for aiding alternate pest/ crop management planning is required to be attempted hereafter.

PRIME MINISTER'S AWARD FOR EXCELLENCE IN PUBLIC ADMINISTRATION 2012-13

Crop Pest Surveillance and Advisory Project (CROPSAP) - for pest management in major crops in Maharashtra was awarded 'Prime Minister's Award for Excellence in Public Administration' for the year 2012–13. Shri Prabhakar Deshmukh, then Commissioner of Agriculture, Maharashtra received the award on the Ninth Civil Services Day held on 21 Apr 2015 organized by the Department of Administrative Reforms and Public Grievances.

E GOVERNANCE GOLD MEDAL

Crop Pest Surveillance and Advisory Project (CROPSAP) – Maharashtra was an award winner for exemplary use of ICT-based solutions at the 15th National Conference on e-Governance held during 9-10 Feb 2012 at Bhubaneshwar, Odisha.

.... the cup of joy is full only when the findings find practical applications

– Louis Pasteur

AWARENESS ON IPM: KEY TO SUCCESS

Mukesh Sehgal and Ajanta Birah

ICAR: National Research Centre for Integrated Pest Management, New Delhi

IPM is a knowledge intensive sustainable approach for managing pests by combining compatible cultural, biological, chemical, and physical tools in a way that minimizes economic, health, and environmental risks. IPM does not rely on single method to solve pest problems but relies on the knowledge of crop and pest interactions to choose the best combination of locally available pest management tools. ICAR-NCIPM is engaged regularly in conducting training programmes, refresher courses and workshops for evolving master trainers at crop-based ICAR institutions, State Agricultural Universities, *Krishi Vigyan Kendras*, State Agricultural Department, Industry personnel, non-governmental organisations and crop growers involved in plant protection. The focus is on imparting training and educating with recent developments in the field of IPM so as to promote awareness for implementation of IPM. The topics covered in each of the trainings include the use of genetic plant materials, cultural practices, bio-pesticides, biotechnology, mass production of bio-control agents, safer use of chemical pesticides, pesticide residues, weed management, use of information technology and managing natural resources that are components of an effective IPM. The programmes include lectures by eminent IPM experts from NCIPM as well from other institutes. IPM field visits followed by hands-on training on mass production of bio-control agents are also part of the trainings. The centre has developed a number of location-specific IPM modules/packages for different crops across agro-climatic zones. Trainings are also grounds for inflow of information from field functionaries and IPM practitioners that guide researchers to develop need-based IPM programs with services and support facilitated continuously.

ICAR-NCIPM is proud to be a leader in training on IPM in the country. Over the 17 active years, pest management correspondence and IPM courses have been the training of choice for 813 of ICAR/SAU/*KVK*/ZARS/NGO/SDA/entrepreneurs/Industrial personnel. Thirty nine training programmes including 10 on mass production of bio-control agents were held up to 2012. Since 2013, 16 training programmes were organised that also targeted progressive farmers in addition to researchers from ICAR/SAUs. ICAR sponsored winter school on “Recent advances on IPM” (25 participants from 11 States), short course on “Mass production of bio-control agents” (25 participants from 10 States), an orientation course for field functionaries (77 extension personnel of SDA, Tripura) are notable contributions towards creation of IPM awareness and development across the country. Trainings of 56 farmers of Tripura and 20 from Bihar on IPM of important crops were organised at Tripura and New Delhi, respectively. Progressive growers of rice (Bambawad, UP), fruits (Abohar, Punjab), cotton (Jind, Haryana), vegetables (Karnal, Haryana) and oilseeds (Alwar, Rajasthan), who have successfully implemented IPM in their fields, serve as ‘IPM ambassadors’ through their interactions and sharing of their experiences. More than hundred trainings and interactions were organised for the farmers at different agro-climatic zones that created awareness on IPM in rice, cotton, oilseeds, vegetable, pulses and fruit crops covering more than one lakh farmers in the country.

Trained ‘IPM Ambassadors’ are successfully spreading the IPM across villages of Assam, Karnataka, Tripura, Haryana, Punjab, Jammu & Kashmir, Rajasthan, Uttar Pradesh, Sikkim, Meghalaya, Nagaland, Manipur, Tamil Nadu, Kerala, Puducherry, Delhi, Uttarakhand, Madhya Pradesh, Bihar, West Bengal, Chhattisgarh, Goa, and Gujarat. IPM page on ‘Facebook’ also serves to quickly spread the IPM knowledge. All course materials *viz.*, training manuals, resource or knowledge book, pest guides fortify the IPM knowledge over time amongst the trainees. IPM for the specific agricultural and horticultural crops *viz.,* rice, cotton, wheat, sugarcane, vegetable, fruit crops, oilseeds, pulses crops and pests like nematodes in addition to protected cultivation, use of information and communication technology and socio-economic issues of IPM for a given production system and climatic regions are routinely inbuilt with the human resource development (HRD).

HRD activities of NCIPM

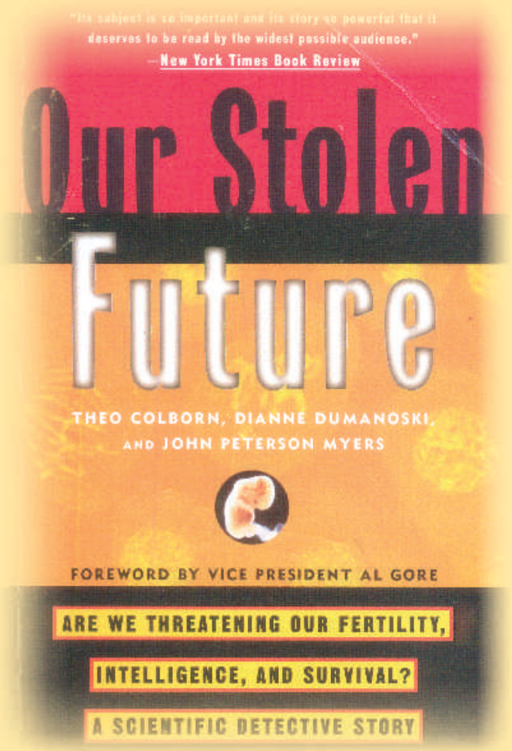
Name	Year	Venue	Participants		
			Farmers	*KVK* Personnel	Total
Orientation / Refresher / Entrepreneur course on IPM / Bio-agent mass multiplication	1995-2012	ICAR-NCIPM	56	106 ZARS + 43 *KVK*	813
IPM in Important Crops of NEH Region	2013	ICAR, Nagaland Centre, ATARI Zone III, Jharnapani, Nagaland	13	27	40
Integrated Pest Management on Major Crops of NEH Region	2013	ICAR Research Complex for NEH Region, ATARI Zone III, Umiam, Meghalaya	12	24	36
Integrated Pest Management for Progressive Farmers of Tripura	2013	ICAR Research Complex for NEH Region, Tripura Centre at Lembucherra, ATARI Zone III, Tripura	39	3	42
Integrated Pest Management for Field Functionaries of Tripura	2013	Pragyan Bhawan, Agartala, Tripura			77
Orientation Course on IPM in Important Crops of Southern India with special reference to Karnataka, Kerala, Goa and Tamil Nadu	2014	NBAIR, ATARI Zone VIII, Bengaluru, Karnataka	12	34	46
Refresher Course on IPM in Important Crops with special reference to Uttar Pradesh and Uttarakhand	2014	ATARI Zone IV, Kanpur, Uttar Pradesh	14	36	50
Orientation Course on IPM in Important Crops of Southern India with special reference to Puducherry, TN and Kerala	2014	PK *Krishi Vigyan Kendra*, ATARI Zone VIII, Puducherry	11	32	43
Training course on Integrated Pest Management in Important Corps of Bihar	2014	ICAR-NCIPM, New Delhi	20		20
Refresher Course on IPM in Important Crops of Gujarat and Rajasthan	2014	Rajasthan Agriculture Research Institute, ATARI Zone VI, Jaipur, Rajasthan		66	66
Refresher Course on IPM in Important Crops with special reference to Uttar Pradesh and Uttarakhand	2014	IIFSR, ATARI Zone IV, Modipuram, Uttar Pradesh		39	39
ICAR-sponsored winter School on 'Recent advances in IPM' (*KVK* personnel, ICAR, SAUs scientists, etc.)	2015	ICAR-NCIPM, New Delhi			25
Refresher Course on IPM in Important Crops with special reference to Madhya Pradesh, Chhattisgarh and Odisha	2015	JNKVV, ATARI Zone VI, Jabalpur, Madhya Pradesh	16	62	78

cont...

Refresher Course on IPM in Important Crops with special reference to Bihar, West Bengal, Andaman and Nicobar Island	2015	BCKV, ATARI Zone II, Kalyani, West Bengal	11	61	72
Refresher Course on IPM in Important Crops with special reference to Punjab, Haryana, Himachal Pradesh and J&K	2015	PAU, ATARI Zone I, Ludhiana Punjab	13	48	61
ICAR Sponsored Short Course on Mass Production of bio-agents (*KVK* personnel, ICAR, SAUs scientists, etc)	2015	ICAR-NCIPM, New Delhi			25
Refresher Course on IPM in Important Crops with special reference to Andhra Pradesh, Maharashtra and Telangana	2016	ICAR-CRIDA, ATARI Zone V, Hyderabad, Telangana	05	44	49

Since inception the total number of trainings conducted by ICAR-NCIPM has been 55 for 1582 participants that included 476 *KVK* personnel from all the eight ICAR-ATARI zones in the last three years and the rest from ICAR and SAU researchers, progressive farmers and field functionaries of State Agriculture Department. The feedback collected from these participants have revealed that the participants have started designing their IPM programmes for their respective zones and disseminating the IPM knowledge as per ICAR-NCIPM suggestions based on the IPM knowledge gained.

Education is the manifestation of perfection already in Man.
–Swami Vivekananda

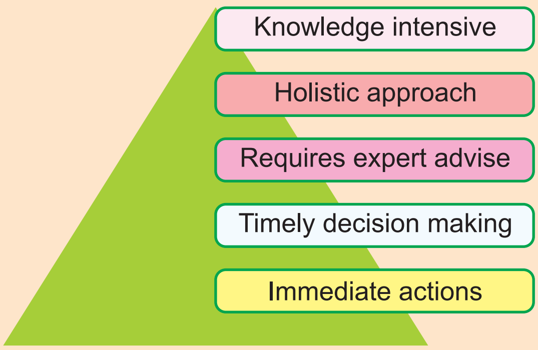


Chemical pesticides were responsible for 49% lower sperm count in men eating raw fruits (Sheiner *et al.*, 2003); chemical pesticides are among factors responsible for neurological problems (Ascherio *et al.*, 2006; Baldi *et al.*, 2010), neuro-developmental disorders (Beseler *et al.*, 2008; Jurewicz and Hanke 2008), birth defects (Winchester *et al.*, 2009); Organo-chlorine pesticides linked to pre-term deaths, reduced baby weight, ovarian cancer in North India (Sharma *et al.*, 2015; Tyagi *et al.*, 2015; Mustafa *et al.*, 2016), foetal death (Sanborn *et al.*, 2007); 2.2 m die annually of cancer related to chemical pesticide poisoning (McCauley *et al*, 2006; Gilden *et al.*, 2010), large use of chemical pesticides give way to several diseases (07 April 2015, Times of India; WHO, CSAUAT); chemical pesticides are linked to increased risk of diabetes and exposure to chemical pesticides significantly increases the risk of type 2 diabetes by nearly 60% (Fotini Kawoura *et al.*, 25 September 2015, Medscape Medical News, UK).

Basic Principles of IPM

Thorough understanding of the crop, pest, environment and their interrelationships	**Requires advanced planning**	**Balances cost/ benefits of all management practices**	**Requires routine monitoring of crop and pest conditions**

Integrated Pest Management (IPM)



Emphasis of IPM in India: 'not losing what is grown and produced' to pests is as important as 'growing more food'

- **Cluster approach for community farming (nursery onwards)**
- **Record keeping by farmers for better decisions**

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