Extension Digest

Vol.3 No.1 June 2019

Ecologically Sustainable Strategies for Pest Management




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National Institute of Agricultural Extension Management (MANAGE)
(An Organisation of Ministry of Agriculture & Farmers Welfare, Govt. of India)
Rajendranagar, Hyderabad – 500 030, T.S, India
www.manage.gov.in

Published by Director General on behalf of the National Institute of Agricultural Extension Management (MANAGE), Rajendranagar, Hyderabad – 500030, Telangana

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About the Publication: Extension Digest is a publication from the National Institute of Agricultural Extension Management (MANAGE). The purpose is to disseminate information on extension systems and practices, research on extension methods, efficient organisation of technology transfer and current concerns in the area of agriculture.

June 2019

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Foreword

Insect pests and diseases cause considerable damage to crops. Reliance on chemical pesticides can have a negative effect on health and the environment. There is growing awareness on the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a strategy for promoting sustainable agriculture which is accepted globally. IPM combines different management strategies viz., cultural, mechanical, physical, biological and chemical methods for pest management along with practices to control pests.

There is a shift towards ecologically sustainable strategies viz., Agro-Eco System Analysis (AESA) based IPM and Ecological Engineering for Pest Management in order to address the adverse impacts of chemical pesticides on agro-ecosystems. AESA is a process in which farmers observe the crop, analyze the field situation and take decisions for crop management based on field observations. Ecological Engineering for pest management focuses on the use of cultural techniques to bring about habitat manipulation and enhance biological control.

This issue of the Extension Digest focuses on some of these strategies for pest management and their use at the farmer level. It is hoped that this would help agricultural officers guide farmers in taking decisions for pest management and thus plant health management.

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Ecologically Sustainable Strategies for Pest Management

Introduction

The management of insect pests is necessary to ensure food security. The yield loss caused by both field and storage insect pests is estimated to be 20 to 30%. Indiscriminate use of chemical pesticides has resulted in environmental pollution and ecological imbalance causing insecticide resistance, pest resurgence and pesticide residue in food and environment.

Integrated Pest Management (IPM) is an environmentally friendly approach that integrates different practices and strategies for control of pests. IPM aims to suppress pest populations below the economic injury level (EIL). EIL is the lowest pest population density that will cause economic damage. IPM is a method for analysis of the agro-ecosystem and the management of its different elements to control pests and keep them at an acceptable level with respect to the economic, health and environmental requirements (FAO).

There has been a shift to more ecologically sustainable strategies and Bio-intensive IPM *viz*., Agro-Eco System Analysis (AESA) based IPM and Ecological Engineering for Pest Management. Agro-Eco System Analysis (AESA) is a process in which farmers observe the crop, analyze the field situation and take crop management decisions based on field observations. Ecological Engineering for pest management is a new paradigm to enhance the natural enemies of pests in an agro ecosystem and relies on use of cultural techniques to bring about habitat manipulation and enhance natural enemies of pests in the crop micro and macro environment.

IPM combines cultural, mechanical, physical, biological and chemical methods for pest control. Cultural methods rely on a strategy to make the crop unacceptable to pests through practices like mixed cropping, crop rotation, management of trap crops to divert insects away from the main crop. Mechanical methods on the principle of soil management include tillage, mowing, cutting, mulching and organic soil coverage provide unhealthy environment for weeds and disrupt pest life cycle, and physical methods include use of pheromone traps, light traps, sticky traps etc. Biological method is a strategy of controlling insect pests and diseases using other organisms like predators, parasitoids and pathogens. Chemical methods involve use of pesticides in pest management and are used when other measures are not enough.

Bio intensive IPM is an approach that considers the farm as part of an agro ecosystem and relies on diagnosis and field observation, combined with ecologically based solutions to pest problems. Bio intensive IPM is “a systems approach for management of crop pests based on an understanding of pest ecology. It begins with steps to accurately diagnose the nature and source of pest problems, and then relies on preventive tactics and biological control to keep pest population within acceptable limits” (Benbrook, 1996). The emphasis of Bio intensive IPM is on proactive measures to redesign the agricultural ecosystem to the disadvantage of a pest and to the advantage of its parasite and predator (Dufour, 2001).

Agro-Eco System Analysis (AESA) based Plant Health Management

Some crops can be grown in all zones while some crops can be grown in some zones. Decision making in pest management requires an analysis of the agro eco system. During the late 90s, FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Agro Ecosystem Analysis (AESA) is an approach, which can be employed by extension functionaries and farmers to analyze the field situations and monitor the population of pests, defenders, soil conditions, plant health and the influence of climatic factors to make informed decisions for growing a healthy crop. In AESA, farmers observe the crop, analyze the field situation and take decisions for crop management based on field observations. Focus in AESA based IPM is on pest-defender dynamics, abilities of plants to compensate for the damage caused by pests and the influence of abiotic factors on pest build up. The health of a plant is determined by its environment which includes abiotic factors (sun, rain, wind, soil nutrients etc.) and biotic factors (ie. pests, diseases, weeds etc.). These factors play a role in the balance which exists between insects and their natural enemies. Understanding these interactions can help in pest management.

The activity takes place in the farmer field. It is season-long so that it covers different developmental stages of the crop and their related management practices. The process is learner-centered and necessitates active participation of farmers and promotes decision making based on experiential learning and discovery by farmers. Experiences show that AESA has resulted in reduction in chemical pesticide usage and in cost of production, increase in yields and also conserves the agro-ecosystems (NIPHM).

Principles of AESA based Integrated Pest Management (IPM):

i. Grow a healthy crop:

Select a variety which is resistant/tolerant to major pests;

Treat the seeds/seedlings/planting material with recommended pesticides, especially bio-pesticides;

Select healthy seeds/seedlings/planting material;

Improve soil health by nutrient management especially organic manures and bio fertilizers based on soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply adequate amount for best results. Phosphate fertilizers should not be applied every season as the residual phosphate of the previous season will be available for the current season also.

Proper irrigation,

Crop rotation.

ii. Observe the field regularly:

Farmers should monitor the field situations at least once a week (soil, water, plants, pests, natural enemies, weeds, weather factors etc.); make decisions based on the field situation and Pest: Defender (P: D) ratio and take necessary action (e.g. remove infested plants etc.).

iii. Plant Compensation Ability:

Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources, for eg. from roots and remaining leaves.

iv. Understand and Conserve defenders:

Know about natural enemies to understand their role through regular observations of the agro ecosystem and avoid use of chemical pesticides.

v. Insect zoo:

Various types of insects are present in the field where some are beneficial some may be harmful. Generally farmers are not aware about this. The concept of Insect zoo can help in enhancing farmers 'skill to identify beneficial and harmful insects. In this method, unknown predators are collected in plastic containers from the field. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed to determine whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

vi. Pest: Defender ratio (P: D ratio):

The natural enemies of crop pests include parasitoids, predators and pathogens. Identifying the pests and beneficial insects helps farmers make appropriate pest management decisions. Sweep net, visual count etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest.

The general rule to be adopted for management decisions relying on the P: D ratio is 2:1. However, some of the parasitoids and predators can control more than 2 pests. Whenever the P: D ratio is found to be favorable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavorable, the farmers can be advised to resort to release of parasitoids/predators depending upon the type of pest. In addition, bio pesticides such as insect growth regulators, botanicals etc. can be used before resorting to chemical pesticides.

Conducting AESA : The activity is carried out on a weekly basis

a) **Field Observations**: Farmers may go to the field in groups (about 5 farmers per group) at least 5 ft. away from the bund, walk across the field and choose 20 plants/acre randomly. Then each of these plants is observed and observations are recorded.

b) **What to observe:** Observations are recorded relating to the plant (height, branches, leaves, deficiency symptoms etc.); Insect pests; Defenders (natural enemies); Diseases; Weeds; water situation of the field; weather condition; rodent burrows. One may also manually collect insects in a plastic bag; and collect parts of the plant which have disease symptoms.

c) **Drawing and Discussion:** After observation, the group would sit together for discussion. Each group identifies the pests, defenders and diseases collected and then analyze the field situation and present their observations in a drawing. The drawing (on a chart) shows a plant representing the field situation, disease symptoms, etc., pests, Defenders, the plant part where the pests and defenders were found, soil condition, weed population, rodent damage etc. Each group then discusses the situation and makes a crop management recommendation. The facilitator facilitates the discussion and ensures that all are actively involved in this process. The group comes to a consensus on the field / pest management practice required in the AESA plot and make sure the required activities (based on the decision) are carried out. The drawing is kept for comparison in subsequent weeks.

AESA by Extension Functionaries :

The extension functionaries, during their regular visit to the village, can mobilize the farmers, conduct AESA, based on which they may also take the decision, as to which IPM components like release of defenders, application of safe pesticides are to be used for a specific situation.

Thus AESA helps farmers learn to make crop management decisions based on observations and analysis. They can then practice AESA in their own field. Experiences of trained farmers can be utilized in training other farmers in their own villages. However, farmers need to continue improving their skills and knowledge with changing field conditions and availability of new technologies.

AESA through Farmers Field Schools:

Studies have shown that adoption of AESA based IPM through Farmers Field School (FFS) programs encouraged reliance on biological control agents as well as substantial reduction in use of chemical fertilizers and pesticides and consequently reduction in cost.

The National Institute of Plant Health Management (NIPHM) and Directorate of Plant Protection, Quarantine & Storage (DPPQ&S) have revised IPM packages for different crops by incorporating agro-ecosystem analysis, ecological engineering and other IPM options in association with State Agricultural Universities and ICAR institutions. These booklets are accessible on the NIPHM website at https://niphm.gov.in/IPMPackages.html/ https://niphm.gov.in/IPMPackages/Tomato.pdf (NIPHM).

Ecological Engineering for Pest Management

Ecological Engineering (EE) for pest management is a new paradigm to enhance the natural enemies of pests in an agro ecosystem and is being considered an important strategy for promoting Bio intensive Integrated Pest Management (BIPM). This approach relies on use of cultural techniques to bring about habitat manipulation and enhance biological control.

Ecological Engineering emerged as a paradigm for considering pest management approaches that are based on cultural practices and informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops. (Gurr, et al 2004).

The primary objective in Ecological engineering is to make environment of the Agro-ecosystem suitable for the better survival of natural enemies of pests. Habitat manipulation aims to provide natural enemies of pests with nectar, pollen, physical refuge, alternate prey, alternate hosts and living sites. This can be through plantation of appropriate *companion plants* like floral trap crops and repellent crops, through which the population of pollinators, predators and parasitoids can be enhanced to manage the herbivorous insect pests.

Ecological Engineering (EE) strategies focus on pest management both below ground and above ground. The main emphasis is to improve the soil health below ground by developing soils rich in organic matter and microbial activity and above ground plant health by habitat manipulation to increase the biodiversity of beneficial natural enemies.

EE for Pest Management – Above Ground

- Focus is on making the habitat less suitable for pests and more attractive to natural enemies.
- Raising flowering plants along the border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Inter-cropping, border-cropping and mix cropping of the flowering plants provide nectar/ pollen as food for various bio-control agents. Trap crops and repelling crops for pests are also grown as intercrop along with the main crop.
- Not uprooting weed plants which are growing naturally like *Tridax procumbens*, *Ageratum sp, Alternanthera sp* etc. as they act as a nectar source for natural enemies,
- Not applying chemical pesticides, when the P: D ratio is favorable. The compensation ability of the plant should also be considered before applying chemical pesticides.

Different types of Plants used in Ecological Engineering: These can be classified into 4 categories.

1. Attractant Plants - Attract the Natural Enemies of pests
2. Trap plants - Trap the crop pests
3. Repellent plants - Repel the crop pests
4. Barrier/Border plants - Prevent the entry of pests

1. Plants which attract Natural Enemies of Pests:

These include Mustard, sunflower, buckwheat, carrot, marigold, French bean, maize/corn, cowpea, spearmint. The actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types.

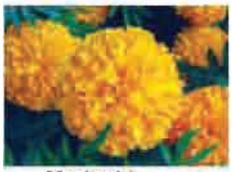

Mustard


Sunflower


Buckwheat


Carrot


Alfalfa


Marigold


French bean


Maize/Corn


Cowpea


Spearmint

Due to enhancement of biodiversity by the flowering plants, the number of parasitoids and predators (natural enemies) also increase due to availability of nectar, pollen, fruits, insects, etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, *Chrysoperla*, earwigs, etc.

Management of aphid in Cole crops through ecological engineering During a demonstration of ecological engineering in Cole crops conducted by the Directorate of Plant Protection, Quarantine & Storage, Cole crops were bordered by Sunflower, Mustard, Marigold and Coriander crops. The Sunflower was the tallest crop to attract the *Helicoverpa* pest; it was surrounded by two rows of mustard to attract *Chrysoperla* and Lady Bird Beetle. Coriander crop attracts different natural enemies of main crop pests. Marigold was the preferable crop for egg laying of *Helicoverpa*. It was observed that the cabbage and cauliflower crops found affected with aphid and the aphid population on Cole crops was found parasitized by Aphidius, a potential parasite of aphid. This parasite was able to manage the aphid population on Cole crops.

2. Trap Plants :

A trap crop is a crop that is planted *to lure insect pests away from the main crop*.

- Basil and marigold as a border crop (main crop- Garlic) controls Thrips
- Castor plant as a border crop in Cotton and chilli field, controls Tobacco caterpillar
- Legume as inter / alternate crops in sugarcane enhances the population of fungal and bacterial BCA for the management of nematodes & other soil borne diseases.
- Inter crop rows of *Tridax procumbens* in paddy crop enhances the natural parasite and predator populations.

3. Repellant Plants which repel harmful insect-pests:

Grown either as border crop or main crop, these *repel the pests away from the crop mainly due to the release of volatile repellent plant chemicals*.

- Basil repels flies, mosquito, tomato borer
- Garlic repels beetles, aphids, weevils, spider mites, carrot fly
- Radish deter cucumber beetle
- Mint repel cabbage moth
- Marigold repels beetles, cucumber beetles, nematodes

4. Barrier/ Border plants which attract insect-pests and reduce pest population on main crop :

These protect the main crop against small soft bodied flying insects which migrate from one field to other field such as whiteflies, hoppers, aphids, mealybugs, thrips etc. Eg. Maize, Sorghum, Bajra, Redgram etc. as barrier crops.

EE for Pest Management – Below Ground:

This focuses on improvement of soil health

- Keeping soils covered round the year with living vegetation and/or crop residue.
- Adding organic matter in the form of farm yard manure (FYM), Vermicompost, crop residue which enhance below ground biodiversity.
- Reducing tillage intensity so that hibernating natural enemies can be saved.
- Applying balanced dose of nutrients using biofertilizers.
- Applying mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Applying *Trichoderma spp*. and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application.

These practices strengthen the ability of crops to withstand pests and also help improve soil fertility and crop productivity.

Thus Biodiversity is crucial to crop defenses: the more diverse the plants, animals and soil-borne organisms in a farming system, the more diverse are the pest fighting beneficial organisms on the farm.

Integrating AESA based IPM and Principles of Ecological Engineering

There is a need to integrate AESA based IPM and principles of ecological engineering for pest management to help farmers maintain biodiversity and keep pests under control while at the same time maintain the eco-system.

Ecological Engineering in Pest Management - Cases

Some of the Successes achieved with Ecological Engineering may be seen below.

Ecological Engineering in Cabbage ecosystem

A study by NIPHM demonstrated that cabbage crop grown by farmers with intensive use of chemical pesticides could be successfully grown by adopting AESA based IPM in conjunction with Ecological Engineering for Pest Management. This was by continuous monitoring of the crop, increasing biodiversity in the crop ecosystem by Ecological Engineering with special focus on mustard as a trap crop which attracted leaf webber and to some extent aphid population onto it. The combination of these practices resulted in reducing pest density upto 60 days after transplanting which helped in maintaining favorable P:D ratio. Whenever unfavorable P:D ratios were observed during mid-crop growth stage, appropriate bio intensive management tactics were adopted such as release of natural enemies, as well as application of botanical pesticides. The study showed that Bio intensive approaches in cabbage crop ecosystem not only reduce cost of cultivation but also minimize pesticide residues in crop produce, conserve and increase natural enemies and protect the environment. (*Plant Health Newsletter July-Sept 2014*). There is need to popularize these concepts among farmers.

Ecological Engineering in Paddy ecosystem

The National Institute of Plant Health Management (NIPHM), Hyderabad introduced Ecological engineering for pest management to help farmers maintain the biodiversity and keep pests under control while maintaining the paddy eco-system in Erode district. Mr. Karthikeyan, a paddy farmer who adopted this technology in his field in Singiripalayam village, found the technology encouraging, since there is a 45 to 50 per cent reduction in pest population. "*I have also observed that natural predators on pests, like damsel fly, praying mantis and spider population, have increased in my field*", says the farmer. Analysis showed that natural enemies were able to maintain the pest population infesting the paddy crop. Adoption of this technology not only suppresses the pest population but also enhances soil health. (Prabhu, 2015).

Rice Pest Management by Ecological Engineering in China

Five years' of experimentation at Jinhua, Zhejiang Province in eastern China involved habitat manipulation based on growing nectar producing flowering plants (preferably sesame) combined with trap plants on the rice bunds, reducing the intensity of pesticide use and nitrogenous fertilizers, and managing the vegetation in non-rice habitats including during the rice-free season. These practices increased biodiversity in the ecosystem, increased biological control of rice pests and provided biological stability in the ecosystem. Seeing the benefits and utility of ecological engineering, the National Agriculture Technology Extension and Service Centre (NATESC) of Ministry of Agriculture has recommended it as the national rice pest management strategy in China. *(*Lu, Zhongxian et al, 2015*).*

PES or Payment for Environmental Services Policy in rice – Vietnam

Ecological engineering is being promoted in Vietnam. After five years of supporting ecological engineering demo fields in rice in Vietnam, the provincial government has become convinced that ecological engineering for pest management is effective, economically and environmentally sound. From January 2015 the provincial Government decided to adopt ecological engineering as a provincial agricultural policy and funds are now allocated to "pay farmers" to perform ecological engineering activities. The activities include growing of nectar flowers and other crop plants on the bunds and refraining from insecticide spraying in the first 40 days after crop establishment. All insecticide subsidies for plant protection activities in the province have been abolished. This experience illustrates the importance of engaging with policy makers in activities and constant dialogue to facilitate change.Women farmers are planting flowers around their rice fields and saving 42% on insect control costs. The "friendly" insects and other organisms that live in this diverse vegetation around the rice fields helped them to control rice pests such as the brown planthopper. (Heong et al).

Push-pull strategy for managing stem borers in Africa

A push-pull strategy for managing cereal stem borers in Africa was developed by scientists of the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya and Rothamsted Research in the United Kingdom, in collaboration with other research organizations in eastern Africa. Push-Pull uses a combination of legume repellent plants to deter the pest from the main crop ("push") and trap crops to attract the repelled pest ("pull"). Plants that have been identified as effective in the push-pull tactics include Napier grass, Sudan grass, molasses grass, and desmodium. Napier grass and Sudan grass are trap plants, whereas molasses grass and desmodium produce chemical compounds which repel stem borers. On the other hand, during dusk Napier grass produces other chemical substances that evaporate easily, some of which are good attractants for stemborers to lay eggs. Fortunately, Napier grass produces a gummy substance which traps the resulting stemborer larvae, and only few survive to adulthood, thus reducing their population. Push-Pull has increased maize yields of farmers in Kenya by an average of 20 - 30 percent in areas with only stemborers, and by more than 100 percent in areas with both stemborers and Striga. (Amudavi David et al., 2007)

Ecological engineering in rice production brings benefits for farmers in Philipines

A project on Ecological engineering approaches to restore and conserve ecosystem services for pest management was launched in 2013 by the International Rice Research Institute (IRRI). The goal of the project was to reduce the environmental impact of rice farming and promote sustainable rice production. It was reported that ecological engineering increased the diversity of natural enemies at their research sites at IRRI and Tanay, Rizal. The technology also promoted the natural control of pests, including brown planthopper and yellow stemborer. It was reported that their engineered sites had a higher diversity of birds without any increase in rodent damage. More native stingless bees pollinating sunflowers were also observed. Results from this study indicated higher fruit yields at sites with healthier bee populations. The engineered sites produced a range of fruits and vegetables that augmented farm production.

Recommendations were made for the optimal design of rice paddies with vegetation patches consisting of robust crops based on data collected by the researchers. These recommendations include appropriate rice varieties for high yields and low susceptibility to common pests, effective chemical-free management of apple snails, and the incorporation of biological control into rice field management (Horgan, Finbarr, 2015).

Experiences with Bio-intensive IPM in Cotton at ICAR - National Centre for Integrated Pest Management (NCIPM)

A bio-intensive IPM module focusing on conservation and promotion of naturally occurring bio agents, bio pesticides and botanicals for sustainable production of cotton was validated over 200 hectares under farmers' field conditions at Ashta village, in Nanded district of Maharashtra State. The village was found to be vulnerable to recurrent pest attacks due to multiplicity of cotton cultivars; staggered sowing; imbalance in use of fertilizers; continuous availability of *Helicoverpa* hosts in the cropping system; sanitation and rationing. Four IPM modules were synthesized *viz*., bio-intensive, bio control + insecticides, bio control + intercrop and chemical modules. The successfully tested module comprised use of bio agents, bio pesticides 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 included planting of maize as a border crop interspersed with cowpea for buildup of coccinellid (lady bird beetles) predators and their migration to cotton; planting a row of Setaria between every 9 or 10 rows of cotton to enhance the activity of predatory birds by serving as a food source and acting as a live perch; release of *Trichogramma chilonis* @ 1,50,000/ha in cotton fields when 2-8 adult moths of *H. armigera* per pheromone trap were captured continuously for 3-4 days in a week; spraying of Neem seed kernel extract (NSKE) 5% (w/v) a week after release of T. chilonis etc. (Sharma *et al.)*

Biological Control

An integral part of Integrated Pest Management is **Biological control**, i.e. Control of insect pests and diseases through biological means. Biological control deals with the use of natural enemies or biological control agents like **predators**, **parasitoids** and **pathogens** for the management of insect pests.

Predators are natural enemies that feed on crop pests and play a major role in the reduction of insect population.

Parasitoids lay eggs in or on the bodies of their insect host, and complete their life cycles on host bodies ultimately killing the host.

Pathogens are disease causing micro-organisms including bacteria, fungi, viruses and some nematodes which kill or debilitate their own host.

Biological control involves protecting and encouraging natural enemies; introduction, artificial increase and colonization of specific parasitoids and predators; and propagation and dissemination of specific bacterial, viral, fungal and protozoan diseases.

Biological Control Agents

Predators

Predators like Coccinellid beetles in vegetable ecosystem, Spiders in rice ecosystem, dragon flies, damsel flies, lady bird beetles, lacewings, birds etc., have proved helpful in protecting crops.

- **Ladybird beetle:** Ladybird beetles - grubs and adults feed on aphids and other soft bodied insect pests.


Coccinella septumpuncta – a common lady bird beetle adult and grub eating aphids

- **Mealy bug Ladybird:** *Cryptolaemus montrouzieri* feeds on mealy bugs on citrus, guava, grapes, coffee, mango, custard apple and green shield scale on mango, guava.

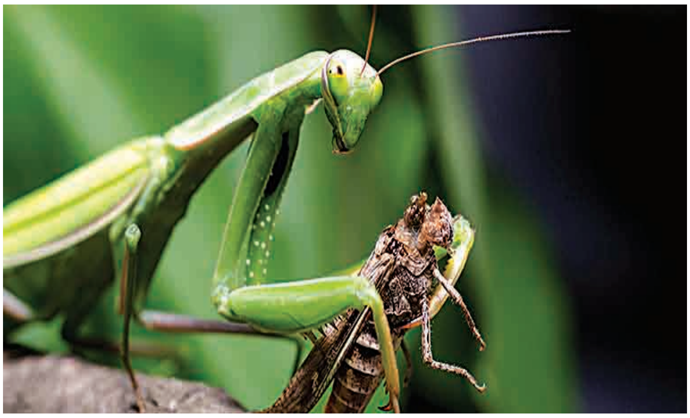

Cryptolaemus montrouzieri (lady bird beetle adult and grub) eating mealy bugs

- **Ground beetles** target Coconut black headed caterpillar and rice brown plant hopper
- **Green lace wing:** The larvae of Green lace wing **(***Chrysoperla carnea)* feed on soft bodied insects like aphids, jassids, white flies, mealybug etc.


Larva of Green Lace Wing eating soft bodied aphids


Chrysoperla carnea adult

- **Praying mantis**: Both Nymphs & Adults feed on Caterpillars & grasshoppers



Praying mantis eating grass hopper and larva

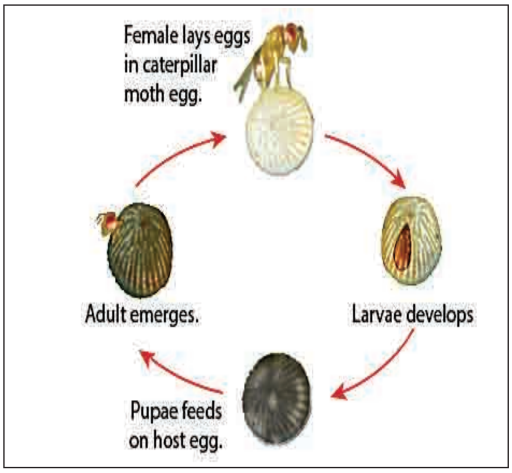
Predatory insects can be mass multiplied in the laboratory and released in the field. However, for effective management of insect pests, farmers must be conscious with respect to the time of release of predators and the stage of crop at which release has to be made.

Parasitoids

Parasitoids include a number of species of wasps, fly etc. which lay eggs in or on the bodies of their insect host, and complete their life cycles on host bodies ultimately killing the host. Parasitoids may be of different types viz., egg, egg-larval, larval, pupal, adult depending on the developmental stage of the host in/on which it completes its life cycle. Examples are different species of *Trichogramma, Bracon, Chelonus,* etc.

Egg parasitoids: These deposit their eggs in the eggs of the host and whose progeny emerge from the host eggs. Eg *Trichogramma chilonis* is used against sugarcane borer pests, rice leaf folder.

Trichogramma chilonis laying eggs inside eggs of pest



Llife cycle of Trichogramma egg parasitoid

Egg-larval parasitoid: These parasitoids deposit eggs in the host eggs but development and emergence are not completed until the host larval stage is reached. Eg. *Chelonus blackburni* is Egg-larval parasitoid of several lepidopterous pests like potato tuber moth, *Phthorimaea operculella,* cotton bollworms, *Hellula undalis, Plutella xylostella,* etc. It has been used for the biological suppression of *P. operculella* in Maharashtra, *Earias vittella* (Fabricius) in Karnataka, *E. insulana* Stoll. *(=E. fabia)* in Maharashtra, *Pecinophora gossypiella* (Saunders) in Maharashtra and *Helicoverpa armigera* (Huebner) on cotton and other host plants in many states. It is becoming an important component of IPM systems on potato, cotton, etc.

Chelonis blackburni laying eggs inside eggs of host

Larval parasitoid: These deposit egg on the larvae and their progeny complete their development and emerge from the host larvae. For eg. *Bracon brevicornis (a wasp),* an extremely polyphagous ectoparasitoid, attacking Crambidae and Pyralidae in stored products and in the field; in the field other lepidopterous families may also be attacked. Important hosts include coconut black headed caterpillar (*Opisina arenosella*), Maize stem borer (*Chilo partellus*), cotton pink bollworm (*Pectinophora gossypiella*).

Bracon brevicornis parasitizing coconut black headed caterpillar larva, and development of early instar larvae of *Bracon* inside black headed cater pillar

Pupal parasitoid: These parasitoids deposit their eggs in the host pupae and emerge from the host pupae. For eg *Trichospilus pupivora,* a gregarious pupal parasite of several lepidopterous pests like *Opisina arenosella* Walker on coconut, *Spodoptera mauritia* (Boisduval), *Syllepte derogata* (F.), *Tirathaba* spp., *S. litura* (F.), etc. Mostly primary or hyperparasitic through tachinids.

Adult *Diadromus collaris* a pupal parasitoid laying eggs inside pupa of cabbage diamond backed moth

Adult parasitoid: This parasitoid deposits larva on its host while in flight and the mature maggot emerges from the dead adult host. Eg. *Epiricania melanoleuca* parasitizes adults of sugarcane leaf hopper.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
Lady bird beetle	One adult lady bird beetle eats 50 aphids per day
Reduviid bug	1st & 2nd nymphal instars can consume 1 small larva/day 3rd & 4th nymphal instars can consume 2 to 3 medium larvae/day 5th nymphal instar & adult can consume 3 to 4 big larvae/day In total life cycle they can consume approx. 250 to 300 larvae
Green Lace wing	Each larva can consume 100 aphids, 329 pupa of whitefly and 288 nymphs of jassids during the entire larval period
Spider	5 big larvae/adults/day
Bracon hebetor	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva
Trichogramma sp	Egg laying capacity is 20-200 eggs/female
Predatory mite	Predatory rate of adult is 20-35 phytophagous mites/female/day

Pathogens for Disease Management

Biological control is the inhibition of growth, infection or reproduction of one organism using another organism (Baker, 1987). *Trichoderma*, a fungal antagonist produces a range of enzymes that are directed against cell walls of pathogenic fungi. Many microbes produce and secrete one or more compounds with antibiotic activity, or other metabolites, or compete for food, controlling the disease causing microbe.

- *Trichoderma harzianum* is a green color fungus that is also used as a fungicide. It is used for foliar application, seed treatment and soil treatment for suppression of various disease causing fungal pathogens.

- *Trichoderma viridae, typically white or light cream color* biofungicide used for seed and soil treatment for suppression of various diseases caused by fungal diseases.
- *Pseudomonas fluorescens*, useful bacteria, have bio control properties, protecting the roots of some plant species against parasitic fungi such as *Fusarium*, *Pythium*, as well as some phytophagous nematodes. The bacteria induce systemic resistance in the host plant, so it can better resist attack by a true pathogen, the bacteria out compete other (pathogenic) soil microbes, giving a competitive advantage at scavenging for iron, and the bacteria produce compounds antagonistic to other soil microbes.

Pathogens for Insect Pest Management

Entomopathogenic Bacteria. These are parasitic organisms that grow on/in insects, often killing them in the process. Pathogenic bacteria of insects which have potential for use in biological pesticides include *Bacillus thuringiensis*, *B. sphaericus* and *B. papillae.*

Looper killed by *bacillus*

Entomopathogenic Virus. The infected insects stop feeding and the larvae turns into pinkish white on the ventral side. If the infection continues, larva become flaccid, skin becomes fragile and finally ruptures. The diseased larvae in the field crawl to the tip of the plant and from that position it hangs upside down. This symptom is called tree top disease. Eg. Ha NPV against *Helicoverpa armigera,* SL NPV against *Spodoptera litura.*

NPV infected caterpillars

Entomopathogenic Fungi. Entomopathogenic fungi directly penetrate the outer protective covering/ layer. Once it attaches to the host, fungus penetrates the insect body wall. The cause of the insect's death is extensive fungal growth and poisoning by fungal toxin. *Metarrhizum anisoplae* develops disease (green color fungal growth) in root grubs and rhinocerous beetles.

Metarhizium anisopliae infected Spodoptea litura larva, adult grasshoppers, and root grub

Entomopathogenic Nematodes. Entomopathogenic nematodes (EPNs) cause disease within an insect and have the ability to kill insects. EPNs have the ability to search the target insect in the soil, plant surface, partly embedded insects in plant tissues. EPNs are being used for management of soil borne grubs that have adverse impact on crops particularly sugarcane, groundnut and cardamom and to a limited extent in greenhouse, nursery, and small fruit operations to better manage insect pests.

Entomopathogenic nematodes killing root grubs

Biological control Strategies

There are three types of strategies in Biological control:

a. **Classical biological control:** This involves the introduction of natural enemies to a new locality by importing, and releasing natural enemies to control an insect pest. For example *Acerophagus papayae,* a parasitic wasp was imported for controlling papaya mealybug in India.

Acerophagus papayae, laying eggs on papaya mealybug (*Paracoccus marginatus*)

b. **Augmentation:** Thus includes all activities to increase numbers of locally-occurring natural enemies. This is done through Inoculative release or Inundative or Mass release.

   i) **Inoculative release** involves releasing small numbers of a natural enemy into a crop cycle with the expectation that they will reproduce in the crop and continue to provide pest control for an extended period of time.

ii) **Mass release** involves mass culture and release of natural enemies to suppress the pest population. For Eg: Mass release of Trichogramma egg parasitoids, predators like green lace wing, and lady bird beetles*.* The cropping system may also be modified to favor or augment the natural enemies.


Mass Release of Biocontrol agents - Placing *Trichogramma* egg cards in the fields

c. **Conservation:** preserving and increasing natural enemies by protecting them from being killed and using measures to increase their longevity and reproduction. This can be done by

i. **Preservation of Inactive Stages:** For example: Pupae of Epipyrops (parasite moth) found in the trash of sugarcane leaves at the time of harvesting are left around harvested fields to augment the supply of natural enemies in the pre-monsoon season against pyrilla.

ii. **Maintaining Diversity:** Providing alternate hosts as source of food, shelter etc.

iii. **Protection from Pesticides:** Selective use of pesticides.

These biological control strategies may not be always effective individually, however, when they are used in an integrated manner, they can be a powerful tool in IPM.

Advantages of biocontrol agents:

1. Biocontrol agents are target specific and generally do not impact non-target organisms.
2. Cost effective
3. Self-perpetuating
4. Safe for the environment and safe to use.
5. Nontoxic to plants.
6. Unlike chemical pesticides problem of resistance does not arise.

Limitations of Biological Control

A few limitations of Biological Control are that it is slow to achieve results, there may be partial success and it can be complex sometimes.

Mass production of Biocontrol Agents

Biological control agents can be mass multiplied in the laboratory at a low cost. The National Institute of Plant Health Management (NIPHM) has developed simple and low cost technologies for mass production of biocontrol agents and microbial pesticides which can be easily adopted at the farm level. (NIPHM Plant Health Newsletter April-June 2014). These are being popularized among extension functionaries and progressive farmers so that farmers are equipped with skills to produce natural enemies and to manage pests. NIPHM is organizing Training on on-farm production of Biological Control Agents for Extension workers and Farmers. The trainees are provided hands on experience on mass production of different parasitoids, predators and microbial bio pesticides. Methods for mass production of some of the biological agents which could be adopted at farm level are detailed on the website of NIPHM.

The following biocontrol agents can be mass multiplied and released:

Trichogramma egg cards (egg parasitoid)

Trichogramma is an egg parasitoid which primarily parasitizes eggs of Lepidoptera. It is important for plant protection because of its wide spread natural occurrence and its success as a biological control agent by mass release. This parasitoid kills the pest in the egg stage itself, before the pest can cause any damage to the crop.

Precautions to be taken

- Emergence date should be specified on cards.
- Tricho cards should be stapled on the inner-side of the leaf to avoid direct sunlight.
- Card should be stapled in morning hours and just before emergence to avoid predation.
- Farmers should not use pesticides in the field where *Trichogramma* are released. If necessary, selective / safer pesticides can be used and ensure that pesticides are used 15 days before or after release of *Trichogramma*.

Field release

- *Trichogramma chilonis*: @ 50,000/ha on sugarcane and vegetables; @ 100,000/ha on maize and @ 1,50,000/ha on cotton; Number of releases: Sugarcane @ 4 to 6 releases at 10 days intervals for early shoot borer; 8 to 10 releases for stalk, internode and Gurdaspur borers; Cotton (Non Bt) & Vegetables @ 6 weekly releases; Maize @ 3 releases at five days intervals
- *Trichogramma japonicum*: in Sugarcane & Paddy @ 50,000/ha, number of releases @ 4 to 6 releases at 10 days intervals on observing pest or from 60th day in sugar cane, 6 releases on appearance of pest or from 30th day after transplantation in paddy.

Bracon Pupal cards (*Bracon hebetor*, *Bracon brevicornis*.) (Larval Parasitoid)

Bracon spp (a Wasp) are Parasitoids of several species of Lepidopteran larvae, such as rice moth, angoumois grain moth, wax moth, Indian meal moth, castor shoot and capsule borer, castor semi looper, cabbage head borer, gram pod borer, spotted pod borer, spotted bollworm, tobacco caterpillar, cabbage leaf webber, sorghum/maize stem borer, pink bollworm and coconut black headed cater pillar

Bracon spp. attacks the larval stage of the insect host and lays eggs on the surface of the host insect. Larvae upon hatching start feeding on host body fluids. From each host larvae 2 or more parasitoid larvae develop and pupate.

Release rates @ 4000-5000 pupae cocoons ha^{-1} or 2000-5000 adults ha^{-1} will effectively control the pests. Depending upon the need, weekly releases need to be made. *Release methods include* Stapling Bracon card with pupae; releasing adults collected from sandwich or tub method. *Recommended dose* @ 10 adult/tree for coconut black headed caterpillar, and 20000 adults/ha for cotton bollworm

Chelonus Blackburnii (Egg-larval parasitoid)

Chelonus blackburnii is an egg-larval parasitoid, used for biological suppression of *Phthorimaea operculella*, *Earias vitella*, *Pectinophora gossypiella* and *Helicoverpa armigera* on cotton, potato and other host plants.

Recommended Dose @ 50,000 adults /ha in the field (2 releases at weekly intervals); 2 adults per kg of potatoes in godowns (3 to 4 releases at fortnightly intervals).

Goniozus Pupal cards (Larval parasitoid)

Goniozus nephantidis, a larval or prepupal ectoparasitoid is an effective and widely used parasitoid of coconut black headed caterpillar, one of the major pests of coconut palm. The host larvae are parasitized and the parasitoid feeds on host body fluid. The parasitoid can suppress the population by stinging and paralyzing 1st - 2nd instar larvae. The parasitoid is being mass multiplied and released in Karnataka, Kerala and several other states.

Field release

- The adults are released either in the crown region of coconut palms or on the trunk, preferably early in the season before the buildup of coconut black headed caterpillar.
- 10 adults per palm (4 releases) are recommended to get good control.

Chrysoperla Carnea - Green Lacewing (Predator)

This predator is important for management of aphids in cotton and tobacco and several sucking pests in fruit crops.

*Recommended dose:*10,000 first instar larvae/ha (Twice during the season with an interval of 15 days ; On fruit crops, 10 – 20 larvae per infested tree)

Reduviid Adults (Predator)

Reduviid Bugs are predators of insect pests in a number of agro-ecosystems (soybean, groundnut, pigeonpea, cotton, castor, rice, cabbage, tobacco, pumpkin, okra, citrus, sugarcane, sesbania, apple etc). They reduce the pest population by killing the host quickly.

Reduviids feed on a range of soft-bodied insects mainly caterpillars and can be reared on natural or alternative laboratory hosts. In the laboratory, Reduviids are mass reared using rice moth larvae (*Corcyra cephalonica)* as host.

NIPHM has developed simple on-farm production technology for this predator where it can be multiplied easily under laboratory conditions and used for effective pest management.

Recommended Dose: 5000/hectare (One or more releases based on pest intensity)

Entomopathogenic Nematodes (EPN)

EPNs can be formulated as dust, sprays, capsules, granules, etc. and applied through spraying suspension or through irrigation system. In spite of their benefits in managing insect pests, utilization of EPN in India is low due to lack of awareness and non-availability of EPN at reasonable cost.

NIPHM has developed simple low cost technologies for mass multiplication of EPN that can be adopted by farmers as well as by commercial establishments and is popularizing EPN through capacity building programmes for scientists, extension officers and interested progressive farmers. This low cost method requires less space; host larvae are infected much earlier and is a quicker method for mass production of EPNs; does not require periodic inspection; results in higher yield; there is no need of harvesting on a daily basis; can be learned by farmers easily; easy to scale up; ensures 100% infection of insect larvae; easy to mass produce, highly effective, durable bio-control formulation.

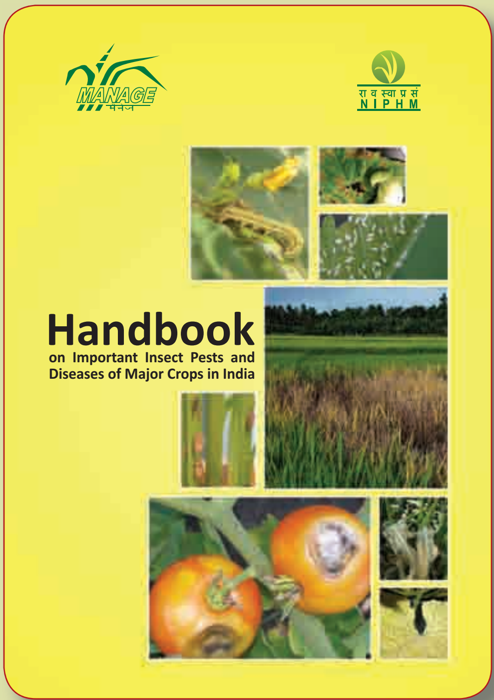
Microbial Biopesticides

Microbial biopesticides are produced, formulated and applied in the field to control target pests. They are target specific/host specific and are eco friendly. To ensure availability of quality biopesticides at farmer's level, various organizations including NIPHM are popularizing easy, low cost and simple on-farm production technology for mass production of bio pesticides for easy adoption by farmers.

Trichoderma and Pseudomonas are important bio control agents for protecting crops against several soil and air borne plant pathogens and can be produced at the farm level. They also stimulate plant growth, enhance germination, plant survival rate and growth of roots and shoots. NIPHM has prepared special media for mass production of fungal and bacterial bio agents. For more details please visit NIPHM website http://niphm.gov.in/phment.html; https://niphm.gov.in/mothercultures.html.

Handbook on important insect pests and diseases of major crops of India

This Handbook has been brought out by MANAGE as a ready reckoner and covers important insect pests and diseases of major crops of India. The technical inputs are contributed by the scientists of NIPHM. This Handbook covers one hundred important insect pests and diseases. Information is furnished in this handbook for each pest along with ecological tips for their management for food security and environmental safety. In order to manage the pest, the recommended pesticides as per the Insecticide Act 1968, are also given for the benefit of users.



Some Success Stories in Biological Control

Control of papaya mealybug through importing Parasitoids

Papaya mealy bug infested Papaya plants in Tamil Nadu, Kerala, Karnataka, during 2008-09 resulting in a loss of 60 – 80 per cent. This bug also attacked other crops like tapioca, pigeonpea, cotton, okra, tomato, brinjal etc.Chemical pesticides gave only temporary relief and available natural enemies were not able to keep the pest population under check.

The National Bureau of Agriculturally Important Insects (NBAIR), Bangalore in collaboration with CIPMC, Bangalore of Directorate of Plant Protection Quarantine and Storage imported three species of papaya mealy bug parasitoids - *Acerophagus papayae, Pseudleptomastix mexicana and Anagyrus loecki* with the help of United States Department of Agriculture (USDA) from their facility at Puerto Rico during July, 2010 and completed the mandatory safety and specificity tests.

These parasitoids were multiplied in the laboratory and released into the farmers' fields and proved successful in control of papaya mealy bug not only on papaya, but also on other crops. A nationwide network of stakeholders has been established for production, release and conservation of the parasitoid. (*Shylesha et al., 2010)*

Biological Control of sugarcane wooly aphid

Outbreak of sugarcane wooly aphid became a serious problem in sugarcane in Maharashtra and Karnataka and spread to Andhra Pradesh, Tamil Nadu, Kerala, Uttaranchal and Bihar in 2002. As natural enemies like *Micromus Egorotus* – a neuropteran predator and *Dipha Aphidivore* – a lepidopteran predator were found to rapidly colonize the wooly aphid infested sugarcane fields and reduce the pest population, a simple method of mass production of *Dipha* and *Micromus* on aphids grown in shade nets was developed. Experiments in farmers' fields showed that release of either 1000 larvae of Dipha or 2500 larvae of Micromus per hectare controlled the pest in 40-60 days. The Project Directorate of Biological Control, ICAR, developed bio control strategies using predators. The Project Directorate in collaboration with entomologists of UAS, Dharwad, MPKV Pune, TNAU, Sugarcane Breeding Institute popularized biological control of wooly aphids through demonstrations and training to farmers and extension officers and his resulted in successful management of the aphid. *(Rabindra et al.)*

Biological Control of Spiralling Whitefly

Spiralling whitefly, *Aleurodicus dispersus*, a native of Carribbean region and Central America was introduced into India in 1995. First reported from Kerala, it spread to southern states causing serious damage to avocado, banana, cassava, guava, papaya and mango, besides several ornamental and avenue trees. Severe infestations cause yellowing, crinkling and curling, and premature fall of leaves. Exotic aphelinid parasitoids, *Encarsia guadeloupae* and *E. sp. nr. meritoria* (Origin: Carribbean region/ Central America) collected from Minicoy Island of Lakshadweep caused reduction in pest population (singh, 2014).

Coccinellid Predator for Control of Subabul Psyllid

Leucaena psyllid *Heteropsylla cubana*, a native of South America invaded subabul in 1988 and devastated plantations in Karnataka, Kerala, Tamil Nadu and Andhra Pradesh and spread all over the country. Adults and nymphs of the psyllid attack tender shoots and severe infestations caused complete defoliation.

The coccinellid predator, *Curinus coeruleus* (origin: South America) was obtained from Thailand in 1988 for the biological suppression of *H. cubana. C. coeruleus* was produced on bouquets of *H. cubana* infested twigs; the eggs were deposited by the females on small strips of cardboard cartons. *C. coeruleus* was successfuly colonized on subabul around Bangalore. The grubs consume 10,630 eggs and 3,500 nymphs during their lifetime. In the field at Bangalore the predator population started building up. In about two years after release, the population of the psyllid was drastically reduced and the predator firmly established in the release sites. The beetles have since then been released in many other parts of Karnataka, Kerala, Andhra Pradesh, Tamil Nadu and Manipur where they are providing efficient, cost effective and environmentally safe control of the pest on a sustainable basis (Singh, 2014).

Transfer of Parasitoids within the Country for Biological Control of Sugarcane Pests

Epiricania melanoleuca an important parasitoid of Pyrilla perpusilla was introduced into Gujarat, in 1982, from Maharashtra and Haryana, for the control of Pyrilla on sugarcane. Even after 15 years, it suppresses the population and provides 72% parasitism. The pyrilla population starts declining and within 30 days a balance is struck when the population becomes less injurious (i.e. below ETL level). Similarly, the ichneumonid, *Isotima javensis* is a key parasitoid of sugarcane top borer, *Scirpophaga excerptalis* in northern India. It has been successfuly colonized in southern India and plays an important role in the suppression of this pest *(Singh, 2004).*

Use of Biological Control Agents from India in other countries - Some Success Stories

- Braconid parasitoid *Aphidius smithi* introduced into USA in 1958 successfully controlled the pea aphid *Acyrthosiphon pisum* in pea and alfalfa fields.
- The braconid larval parasitoid, *Cotesia flavipes* introduced in 1966 and 1967 in Barbados completely suppressed the sugarcane tissue borer.
- Release of *Cotesia flavipes* in 1966 in Mauritius against *Etiella zinckenella* infesting pigeon pea provided complete suppression of this pest.
- In 1969, the parasitoid *Encarsia lahorensis* was introduced in California (USA) where it successfully established on citrus white fly.
- Coccinellid predator *Chilocorus nigrita* introduced to Seychelles in 1938, successfully suppressed citrus black scale *Chrysomphalus aonidum* in citrus orchard areas, and also controlled the scale insect *Ischnaspis longirostris* on coconut palm.

(Singh, 2004).

New Technology in Plant Health Management

Mobile app for pest and disease management of crops

Plantix https://play.google.com/store/apps/details?id=com.peat.GartenBank&hl=en Developed by: PEAT, Germany

Plantix, a mobile app for plant disease diagnostics and monitoring provides users with customized information concerning best practices and information on preventive measures. The app can help in detecting pests, diseases and also identify nutrient deficiencies. One can send pictures of affected plants directly via smartphone and the app guides through an identification process to determine the plant disease and appropriate treatment. All pictures sent via the Mobile App are tagged with coordinates, which enables real time monitoring of pest and diseases. The resulting metadata provides an insight into the spatial distribution of cultivated crops and most significant plant diseases e.g. in the form of high resolution maps. Furthermore Plantix aims to get a deeper understanding of the relations between plant diseases and geofactors by the intersection of the gathered information.

Features

- Real-time diagnosis: Uploaded crop photos are analyzed using image-recognition technology that uses a database of half a million pictures covering 30 crops and offers prescriptions for over 120 crop diseases
- Weather information system
- Community feature facilitates interactions.
- Smallholder farmers as end-users: Free of cost, with an easy-to-use dashboard in local languages.

Plantix app developed by PEAT was cutomised in collaboration with ICRISAT and State Agricultural University for local crop needs and was launched in Telugu. This has been demonstrated successfully with farmers in Andhra Pradesh and Telangana.

Groundnut – IPM Mobile App

GIPM, a mobile App on Groundnut pest management developed by NCIPM is useful for various stakeholders, extension functionaries, pesticide dealers and farmers.

Features:

1. Provides images of damaging stages of insect pests and symptoms of diseases.
2. Methodology of sampling for each insect pest and disease.
3. Allows access to management options both directly and individual insect/disease wise along the tools of IPM.
4. Provides selection of management options based on crop stage (crop calendar based).
5. Chemical options has link to insecticide and fungicide calculator to facilitate selection of insecticide/ fungicide along with calculation of quantity for a required area and application technology.

   Similar apps have been developed by NCIPM for pigeonpea, rice and tomato.

Insecticide and Fungicide calculators

ICAR- National Research Centre for Integrated Pest Management (NCIPM), New Delhi has developed insecticide and fungicide calculators (IFCs) on web and mobile platforms for 12 major crops *viz.,* Rice, Cotton, Pigeonpea, Groundnut, Tomato, Soybean, Chickpea, Chillies, Okra, Cabbage, Cauliflower and Brinjal (available at: http://www.ncipm.org.in/cropsapifc; http://www.ncipm org.in/nicra2015/ Softwaretools.aspx and http://www.ncipm.org.in/technologies.htm). IFCs provide information on pesticides with label claims, quantity calculations based on recommended dosages, methods of application and application technology against target insect pests and diseases to aid in judicious selection, sale and use on target crops (https:www.ncipm.org.in-cropsapifc).

PestPredict

Forewarning is an essential component of Integrated Pest Management (IPM). PestPredict, an android mobile application from ICAR-NICPM for pest forewarning assists researchers, extension personnel of agriculture and farmers in getting location specific forecasts of selected insect pest(s) or disease(s) for their effective management on target crops. The app makes weather based pest forewarning as a component of Integrated Pest Management in the area of crop protection. Approaches to forewarning – Rule based prediction system (RBS) – Empirical model based system (EMS) validated forecast models of insect pests and diseases are built in 'PestPredict'. In the Pest Prediction Empirical Model Based System (PestPredict) user can get predictions of insects, diseases and beneficials for locations by providing inputs of weather associated with model equations of kharif. Rule Based System (RBS) predicting largely rice insect pests, *Spodoptera litura* of groundnut and early blight of tomato have also been integrated. Currently this application is aimed for field use to predict incidence of pests of four target crops – rice, pigeonpea, groundnut and tomato- for purposes of issuing 'pest alerts' at times of high severity or above economic threshold levels. Accordingly pest control measures can be planned and preparedness of farmers will improve to tackle pest problems. (Vennila, S. et al, 2016). This is accessible on google play.

Crop Pest Surveillance and Advisory Project (CROPSAP)

The State Department of Agriculture, Maharashtra piloted State level e-pest surveillance through 'Crop Pest Surveillance and Advisory Project (CROPSAP)" involving extension functionaries and farmers. The Project was undertaken by Commissionerate of Agriculture, Government of Maharashtra with ICAR-NCIPM and other agricultural research institutes and State Agricultural Universities of Maharashtra in the backdrop of severe pest outbreak on soybean crop during 2008-09 in Maharashtra that resulted in crop losses. This initiative reduced the lead time between surveillance and pest management interventions.

Use of ICT in pest monitoring helped in providing prompt and reliable pest reports to the concerned agencies on real time basis so as to provide timely and correct advisory to the farmers and thus confirmed the operation of effective monitoring.

CROPSAP resulted in monetary dividends to the growers of cotton, soybean rice, pigeonpea and chickpea. Since inception of the project there has been no outbreak of any major pest in the mandated crops in the State. The number of farmers enrolled for SMS service doubled, advisories issued increased by 4.63 times, SMSs sent increased by 11.30 times and shift towards use of bio-pesticides increased 1.57 times.

The project was conferred the `Prime Minister's Award for Excellence in Public Administration' (2012–13).

There is also M-Cropsap - mobile based data entry application used for crop-pest surveillance and advisory project (CROPSAP). This application is designed to record surveillance data of crops, their respective pests and diseases and location. https://icar.org.in/node/6140. For more details please see http://www.ncipm.res.in/NCIPMPDFs/FOLDERS/CROPSAP%20Book%20for%20WEB.pdf

References

Amudavi David, Zeyaur Khan and John Pickett (2007). Enhancing the Push Pull Strategy. LEISA Vol 33 (4) December 2007. https://www. ileia.org/wp-content/uploads/2017/08/2007-12-20-LEISA_23_04.pdf

Baker, K.F. (1987). Evolving concepts of biological control of plant pathogens. Annual Review of Phytopathology, 25: 67-85

Benbrook, Charles M. et al (1996). Pest Management at the Crossroads. Consumers Union, Yonkers, NY. 272

Dufour, Rex (2001). Biointensive Integrated Pest Management, ATTRA, USDA.

FAO (2019). Integrated pest management. Retreived from http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/managing-ecosystems/integrated-pest-management/en/ (Accessed on 15th April 2019).

Gurr GM, Wratten SD and Altieri MA (2004). Ecological Engineering: a new direction for agricultural pest management. Australia Farm Business Management Journal 1 (1): 28-35.

Heong K.L., Escalada, Monina and Van Chien, Ho (2015). PES – Payment for Environmental Services to farmers now a policy in Tien Giang province, Vietnam. Retreived from https://ricehopper.wordpress.com/category/ecological-engineering/ (Accessed on April 20th 2019).

Horgan, Finbarr (2015). Philippines: Ecological engineering in rice production proven to bring tangible benefits for farmers. IRRI News Sept 11, 2015 http://news.irri.org/2015/09/philippines-ecological-engineering-in.html

Khan, Zeyaur R. and John A. Pickett. Push-Pull Strategy for Insect Pest Management. http://entomology.ifas.ufl.edu/capinera/eny5236/pest2/content/14/29_push_pull_strategy.pdf

Lu, Zhongxian & Zhu, Pingyang & Gurr, Geoff & Zheng, Xusong & Chen, Guihua & Heong, KL. (2015). Rice Pest Management by Ecological Engineering: A Pioneering Attempt in China.Pp 163-180. Chapter 8. In Heong, KL, Cheng, JA and Escalada, MM. (eds) "Rice Planthoppers: Ecology, Management,Socio Economics and Policy" Zhejiang University Press, Hangzhou and Springer Science+Business Media Dordrecht. DOI 10.1007/978-94-017-9535-7.)

NCIPM (2018). Insecticide and Fungicide Calculators. Retrieved from http://www.ncipm.res.in/cropsapifc/index.html

NIPHM (2014). AESA based IPM Packages - Tomato. AESA BASED IPM Package No. 18. Retrieved from https://niphm.gov.in/IPMPackages/Tomato.pdf (Accessed on 16th February 2019).

NIPHM (2014). Plant Health Newsletter April – June 2014. Hyderabad.

NIPHM (2014). Plant Health Newsletter July – September 2014. Hyderabad

Prabhu, MJ, (2015). A new concept called ecological engineering to reduce pests. The Hindu 7th May 2015. Retrieved from https://www.thehindu.com/sci-tech/a-new-concept-called-ecological-engineering-to-reduce-pests/article7177418.ece. (Accessed on 20th January 2019).

Rabindra, R.J., Joshi, Sunil and Mohanraj, Prashant (n.d.). Biological Control of the sugarcane wooly aphid: a success story. ICAR, Project Directorate of Biological Control, Bangalore. Retrieved from http://www.nbair.res.in/e-Learning/SWA%20English.pdf.

Sharma, O.P., Murthy, K.S., Puri, S.N., Lavekar, R.C. and Mayee, C.D. (2016). Integrated pest management in cotton at Ashta village In S. Vennila, Ajanta Birah, Vikas Kanwar, C. Chattopadhyay. Success stories of Integrated Pest Management in India. NCIPM, New Delhi. Retrieved from http://www.ncipm.res.in/NCIPMPDFs/folders/Success%20stories.pdf. (Accessed on 20th April 2019).

Shylesha AN., Joshi, Sunil, Rabindra, R.J. and Bhumannavar, B.S. (2011). Classical Biological Control of the papaya mealybug. Bangalore, NBAII. Retrieved from http://www.nbair.res.in/e-Learning/PM%20English.pdf.

Singh SP, (2004). Some Success stories in Classical Biological control of Agricultural Pests in India. Bangkok, APAARI. Retrieved from http://www.apaari.org/wp-content/uploads/2009/05/ss_2004_02.pdf. (Accessed on 18th April 2019).

Vennila S., et al. (2016). User Manual on PESTPREDICT : An Android Application. ICAR-National Research Centre for Integrated Pest Management, New Delhi, India. 12 pp. Retrieved from http://www.nicra-icar.in/nicrarevised/images/ publications/Manual_NCIPM%20PESTPREDICT%20User%20Manual.pdf. Accessed on 18th April 2019).

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