Integrated Pest Management (IPM) - A Nature Friendly Technology for Pest Management in Crops

Bolli Venu Babu
Assistant Plant Protection Officer (Ento.), IPM HQ, Directorate of Plant Protection Quarantine & Storage, Ministry of Agriculture & Farmers Welfare, Government of India, Faridabad-121001
Corresponding Author: bolli.venubabu@gov.in, bollivenubabu@gmail.com

Integrated Pest Management is a broad ecological approach which aims at keeping the pest population below economic injury level by employing all the available methods of pest management such as cultural, mechanical, biological, Legislative and lastly the chemical methods in a compatible manner.

Why IPM?

Indiscriminate and injudicious use of chemical pesticides in agriculture has resulted in several problems such as-

- Environmental pollution
- Ecological imbalances
- Pesticides residues in fruits and vegetables, fodder, soil and water
- Pest resurgence
- Human and animal health hazards
- Destruction of biocontrol agents
- Development of resistance in pests etc

Keeping above in view Govt. of India has adopted Integrated Pest Management (IPM) plant protection measure in the overall Crop Production Programme since 1985. The IPM approach is being disseminated through various schemes/projects at national and state level.

Components of IPM

IPM includes various components which are described below

1. Cultural practices in IPM

Cultural methods of pest control consist of regular farm operations in such a way which either destroy the pests or prevent them from causing economic loss.

Cultural practices in IPM involve regular farm operations designed to destroy or prevent pests. Key methods include preparing pest-free nurseries by removing plant debris, trimming bunds, deep summer ploughing, and treating soil with chemicals or biocontrol agents. Soil testing ensures appropriate fertilizer application. Using certified seeds treated with fungicides or bio-pesticides helps control seed-borne diseases (e.g., Trichoderma for rice).

Adjusting sowing and harvesting schedules can evade peak pest seasons (e.g., early sorghum sowing for shoot fly). Crop rotation with non-host crops reduces soil-borne diseases. Proper plant spacing enhances plant health (e.g., wider spacing in rice minimizes caseworm damage). Practices like hoeing and racking help control fruit flies, while earthing up in sugarcane reduces shoot borer attacks.

Optimal fertilizer use, including FYM and bio-fertilizers, discourages pests like aphids and thrips. Detrashing sugarcane curbs scales and whitefly. Effective water and weed management prevent pests and diseases like root rot and wilt. Trap crops (e.g., mustard for diamondback moth) and intercropping (e.g., cowpea with sorghum) are beneficial. Harvesting crops close to the ground minimizes pest carryover for the next season, while synchronized sowing enhances pest control. These practices promote healthy crop growth while reducing pest infestations

2. Mechanical Practices under IPM

Mechanical practices in IPM involve the use of physical methods and devices to control pest populations and reduce infestations. Key practices include:

1. **Removal and Destruction of Pest Stages**: Hand-picking and destroying eggs, larvae, pupae, adults, and diseased plant parts help reduce pest populations. For example, removing Spodoptera litura egg masses, Helicoverpa armigera larvae in cotton, and roguing yellow mosaic-affected soybean plants are effective. Other practices include clipping rice seedling tips during transplanting to reduce carryover of pests like caseworm and stem borer and using coir rope to dislodge larvae onto kerosene-treated water.

2. **Bamboo Cage Cum Bird Perchers**: Installing bird perchers or growing intercrops like *Setaria* attracts predatory birds such as drongos and bee eaters, which feed on pests. Using 8-10 perchers per hectare in cotton fields after 90 days helps maintain pest levels below the Economic Threshold Level (ETL). Bird scarers prevent seed damage by birds.
3. **Parasitized Egg Masses**: Placing parasitized insect eggs, such as those of *Corcyra* sp., helps release predators like *Trichogramma* spp., which target pests and naturally regulate populations.
4. **Light Traps**: These are used to monitor and trap nocturnal pests. Funnel-shaped light traps are effective for capturing pests like moths in crops such as mungbean and gram. While non-specific, they are useful for biodiversity studies and pest population monitoring.
5. **Yellow and Blue Sticky Traps**: Yellow sticky traps attract pests like aphids, whiteflies, and flea beetles, while blue traps target thrips. These traps, coated with glue, immobilize and kill pests and are effective for monitoring population densities of flying insects.
6. **Pheromone Traps**: Pheromones attract male insects, disrupting mating and reducing populations. Pheromone baits combined with killing agents target pests such as fruit flies in mangoes and cucurbits, pink bollworm in cotton, and stem borers in rice.

These mechanical practices effectively reduce pest populations, conserve natural enemies, and maintain ecological balance, ensuring sustainable pest management.

3. Biological Practices in IPM

Biological control is a crucial component of IPM, utilizing living organisms to manage pests. It involves introducing or enhancing natural enemies like parasitoids, predators, and pathogens to maintain pest populations below economic damage levels. The major types of biological control are:

1. Classical Biological Control

Introducing a new bio-agent species into a pest's environment after rigorous laboratory and field testing ensures the agent's efficacy and safety.

2. Augmentation

Natural enemy populations are increased through the release of laboratory-reared or field-collected bio-agents to suppress pests effectively.

3. Conservation

Protecting existing natural enemies plays a significant role in pest suppression. Practices include:

- Collecting parasitized egg masses and placing them in bamboo cages for parasitoid emergence.
- Educating farmers to differentiate pests from defenders and protect defenders during pesticide application.
- Using selective, environmentally friendly pesticides and avoiding broad-spectrum pesticides.
- Conducting spot or strip pesticide applications only when necessary.
- Adjusting sowing and harvesting times to avoid peak pest periods.
- Growing trap crops along borders to attract pests and natural enemies.
- Employing root dip or seedling treatments in gall midge-prone areas.
- Crop rotation and intercropping to conserve defenders.

Types of Bio-control Agents

1. **Predators**: Free-living organisms such as spiders, dragonflies, damsel flies, ladybird beetles, and *Chrysoperla* spp. feed on pests like aphids, mites, and small larvae. Predators exhibit high dispersal ability and excellent searching skills.
2. **Parasites/Parasitoids**: Parasites live in or on hosts, with immature stages feeding on them, while parasitoids kill their hosts. Egg parasitoids like *Trichogramma* spp. develop within host eggs, killing them. Other parasitoids target various pest stages (e.g., larval, pupal) and include species like *Apanteles*, *Bracon*, and *Chelonus*.
3. **Entomopathogens and Antagonists**: Pathogenic microbes, fungi, bacteria, nematodes, and viruses target specific pests effectively, contributing to natural pest control.

Biological control integrates various agents and practices to sustainably suppress pests, reduce reliance on chemicals, and maintain ecological balance.

Table. 1. Various types of parasitoids are summarized below

Sr. No.	Type of parasitoid	Parasitoid agents	Parasitized insect
1	Egg parasitoid	*Trichogrammachilonis* *Telenomusremus*	Bollworms in cotton, internodal borer in sugarcane & rice leaf folder. Tobacco caterpillar
2	Egg- larval parasitoid	*Chelonusblackburni*	Spotted bollworm
3	Larval parasitoid	*Campolestischloridae* *Braconhebetor/B. brevicornis*	*Helicoverpaarmigera* Coconut black headed caterpillar
4	Larval- pupalparasitoid	*Isotimajavensis*	Top shoot borer of sugarcane
5	Pupalparasitoid	*Trichospiluspupivora* & *Brachymerianephanditis*	Coconut black headed caterpillar
6	Nymphal& Adult parasitoid	*Aphelinusmali* *Encarsiaformosa*	Apple wooly aphid Whitefly
7	Ecto- parasitoid	*Epiricaniamelanoleuca*	*Pyrillaperpusilla*on sugarcane

3. Entomopathogens/Pathogenic microbes

Entomopathogenic Fungi

Entomopathogenic fungi act as parasites of insects – these fungican kill, or seriously disable insect pests. FungalEntomopathogens are important regulators of insect populationswith considerable potential. Examples: *Metarhizium anisopliae*, *Beauveria bassiana, Verticillium Lecanii* etc.Various formulations of thesebiopesticidesare registered with CIB&RC for use against various insect pests in different crops.

Entomopathogenic bacteria

Bacillus thuringiensis (B.t)

Bacillus thuringiensis (B.t) is a spore forming bacterium that produces crystals protein (cry proteins), which are toxic to many species of insects. *Bacillus thuringiensis* or B.t, is a naturally occurring soil bacterium that is toxic to certain pest insects like caterpillars, certain types of beetles etc. It is successfully used for control of Bollworm in cotton. These formulations are registered with CIB & RC

4. Antagonistic fungi/Bacteria: Species of *Trichoderma, Pseudomonas & Bacillus* are successfully used for control of various diseases in different crops and various formulations of these antagonists are registered with CIB & RC and mostly they used as seed dressers

5. Entomopathogenic viruses

Among insect viruses, the baculoviruses are the most studied andused viral biocontrol agent.i.e.Nucleopolyhedrovirus orNPVs; and Granulovirus or GVs. Various formulations of these Entomopathogenic virusesare registered with CIB & RC and mostly they are used for control of Pod borer (*Helicoverpaarmigera*) in chickpea, tomato &pigeonpea; *Spotopteralitura* in tobacco and *Helicoverpaarmigera*in Cotton

India has successfully implemented biological control programs to manage various pests:

1. **Sugarcane Pyrilla (*Pyrilla perpusilla*)**: Severe outbreaks in 1972-73 and 1987 in states like Punjab, Haryana, Uttar Pradesh, and Bihar were controlled using biocontrol agents such as the egg parasitoid *Tetrastichus pyrillae* and the nymphal predator *Epipyrops melanoleuca*. These interventions saved the government

approximately ₹11 crore in 1972-73 and ₹16 crore in 1987.

2. **Apple Woolly Aphid (*Eriosoma lanigerum*) and San Jose Scale (*Quadraspidiotus perniciosus*)**: In apple-growing regions, natural enemies like the parasitoid *Aphelinus mali*, syrphid flies (*Syrphus confrater*), and ladybird beetles (*Chilocorus bijugus*) have effectively managed these pests.
3. **Water Hyacinth (*Eichhornia crassipes*)**: In southern India, the introduction of phytophagous weevils *Neochetina eichhorniae* and *Neochetina bruchi* has successfully controlled this invasive aquatic weed.
4. **Sugarcane White Woolly Aphid (*Serianthes vacciniifolia*)**: In Maharashtra and Karnataka, biocontrol agents like the parasitoid *Dipha aphidivora*, lacewing species (*Chrysoperla* spp.), coccinellid beetles, syrphid flies, and spiders have managed outbreaks of this pest.
5. **American Bollworm (*Helicoverpa armigera*)**: The use of Nuclear Polyhedrosis Virus (NPV) has effectively controlled this polyphagous pest across cotton, pulses, vegetables, and oilseeds in India.

Impact of IPM programmes in India

Table 2. The major qualitative outcomes of conducting these programmes are summarized as follows:

	Before training	**After training**
1. Use of pest management methods	Chemical pesticides	Cultural, Seed treatment, Mechanical (pheromone trap, sticky trap, light trap, collection & destruction etc.), use of biocontrol agents, bio-pesticide, botanical pesticides, neem seed karnel extracts, neem leaf extracts etc.,
2. Spray of chemical pesticides	1. Make calendar based (Scheduled) spray of pesticides without considering pest/ disease infestation/ infection in the crop field. 2. Farmers do not verify label claim status of pesticides 3. Do not follow waiting period for harvest after spray. 4. Normally use pesticide more or less than requirement 5. Personnel protective aprons are not used during spray	1.Take decision on AESA based. Means only need based. 2. Use only CIB&RC approved label claim pesticides 3. Follow waiting period for harvest alter spray. 4. Only required quantity of pesticides are used. 5. Personnel protective aprons are used during spray
3. Understanding on beneficial organism	Farmers normally consider all insects & microorganism as their enemy.	Farmers identity beneficial organism and conserve them.
4. Status of crop ecosystem	Due to indiscriminate use of pesticides- beneficial & neutral organism are killed	Crop ecosystem is protected due to targeted pest management
5. Input cost	Input cost on Pesticides & spray is very high.	Input cost greatly reduced due to application of Agro Ecosystem Analysis based decision making. Thereby increase farmers' income which helps in Prime Ministers vision of doubling farmers income.

4. Chemical Practices in IPM

Use of chemical pesticides is the last resort when all other methods fail to keep the pest population below economic loss. Although there is a great advancement in pest management research, yet pesticides would continue to play an important role in crop protection in view of complexity of pest problems. Therefore, use of pesticides should be need based, judicious, based on pest surveillance to minimise not only the cost involved, but also to reduce associated problems. While going for chemical control, we must understand thoroughly what to spray, when to spray, where to spray and how to spray, keeping in mind the following points.

- Pest defender ratio must be observed.
- Relatively safer pesticides should be selected e.g. neem based and biopesticides.
- If pest is present in strips or isolated patches, whole field should not be sprayed.

Relevance of IPM practices is more important in vegetables and fruit crops because of their unique mode of consumption by human being. CIB&RC approved pesticides should be used against target pest for recommended crops. Farmers should not use another pesticide until waiting periods of first pesticides completes and crop should be harvest after completion of waiting period. We have to be more careful and cautious in applying pest control practices in field crops

Role of DPPQS in implementation of IPM in India

Govt. of India has adopted Integrated Pest Management (IPM) as cardinal principle and main plank of plant protection in the overall Crop Production Programme since 1985. The IPM approach is being disseminated through various schemes/ projects at national and state level

Under the ambit of IPM programme, the Government of India under Directorate of Plant Protection Quarantine and Storage, Faridabad has established Central IPM Centres (CIPMCs) in 28 States and 2 UT. The mandate of Central IPM Centres isto popularize adoption of Integrated Pest Management (IPM) through training and demonstration in crops inter-alia promotion of biological control approaches in crop protection technology.

In addition to the above, agriculture produce or IPM fields are pesticide residue free and healthy. Pesticide residue in agriculture produce is one of the major constraints of export.

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