

## Advances and Approaches in Ecofriendly Pest Management in Organic Agriculture

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Organic agriculture aims to maintain the farming to be a live production system with sustainable nature. It supports us to live in harmony with nature. Intensive agriculture, on the other hand with a goal of high productivity, makes use of inputs like high yielding varieties, fertilizers, chemical pesticides and farm machineries. Heavy dependence of modern agriculture on these inputs causes several disruptions to the ecological balance. Modern agriculture has definitely helped us to satisfy the nutritive demand of an ever increasing population to a certain extent. At the same time it has been damaging the wealth of this planet largely. Man as a social being has the moral responsibility to sustain nature for future generations. When farming is viewed in this direction, the concept of organic farming gains practical significance as it is a production system respecting the sustainability of nature.

Pests and diseases along with weeds are known to cause an estimated crop loss of about 35% of the potential food production worldwide (Sharma, 2002). In spite of our heavy dependence on insecticides for providing protection to the varieties of crops grown, there has been increasing incidence of pests and diseases causing heavy crop loss mainly due to elimination of natural enemies. In our attempt to save the crops, pest control strategy in modern agriculture has a heavy dependency on pesticides. Excessive use of pesticides has resulted in pesticide residue in food commodities and environment, outbreak of new pests changing the conventional pest scenario of agricultural crops, resurgence of pests and pesticidal resistance among target pest species.

## **Pest Management Concept in Organic Farming**

Pest management requires an overall rescheduling of various components of IPM in organic farming to maintain ecosystem sustainability. In organic agriculture, pest control strategies that compromise with the nature are suitably blended and employed to realize desirable results. Pest control strategies of a preventive rather than reactive nature are advisable in organic farming. The non-chemical and bio-rational methods of pest management that constitute the major components of IPM approach are ideal, ecofriendly and feasible in a sustainable crop production system like organic farming.

## **Biocontrol**

Among the various components of IPM, the most effective tool for organic agriculture is the biological pest suppression that utilizes the natural enemies of pests *viz.*, entomophaga and entomopathogens. One of the major steps involved in the biological control of pests is conservation of natural enemies which helps in regulating a particular species of pest in the ecosystem. The biodiversity of the ecosystem is conserved, in general, in biological pest suppression. A comparatively low level of pest incidence that occurs due to natural disturbances in the ecosystem can be corrected more easily and feasibly by intervention of an appropriate biocontrol agent. When a situation arises where natural enemies present in the ecosystem exert a low level of pest suppression, the need for augmentation through release of recommended natural enemies becomes more imperative. Biocontrol method is an advanced approach in the management of some of the major pests of coconut, oil palm, coffee and black pepper besides many annual crops. When an exotic pest is to be tackled, the need for deliberate introduction and colonization of its natural enemy to suppress the introduced pest becomes essential.

In our attempts to enrich the biodiversity by organic farming practices, several methods of conservation of natural enemies like providing nesting places, perching sites, water pan, nectar and pollen rich plants can be practiced (Sharma, 2002). Attempts to restore natural control mechanisms especially the natural enemies by selectivity of biodiversity within the ecosystem become more relevant in organic farming. Manipulation of the ecosystem inducing added activity of the natural enemies will be beneficial to reduce the pest population resulting in increased yield.

## **Entomophaga**

Entomophaga constitutes one of the major components in the natural control of crop pests. Many species of spiders, coccinellids, reduviids (Fig. 10.1), predatory ants, mites and thrips are well documented as effective predators. Spiders are important predators of insect pests. They suppress pest species to low densities at all growth stages. They are generalist predators and polyphagous in habit. Spider fauna contributes a major group of natural enemies in cropping systems like paddy, tea, etc. A detailed literature on spiders in tea ecosystem is given by Hazarika and Chakraborti (2007) and they stated that the spiders occupy a major share among the natural enemy complex of tea pests. Spiders suppress rice

pests like BPH, GLH, WBPH, etc. (Kamal *et al.*, 1992). Habitat manipulations like conserving ground litter, using safer pesticides *etc.* contribute to their conservation.

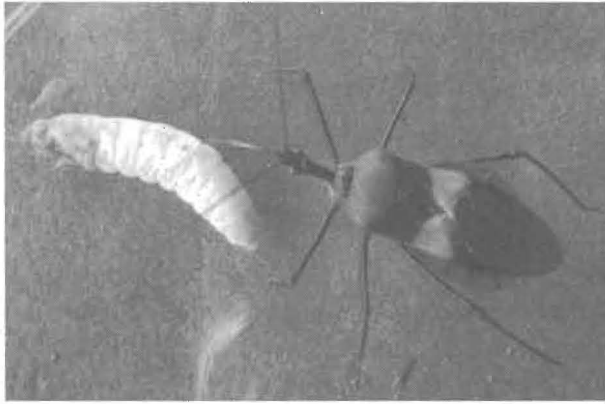


Fig. 10.1. Predator (Reduviid bug)

Among the natural enemies used for biological control of insect pests, the parasitic hymenoptera has been the most successful group comprising families like Ichneumonidae, Braconidae, Encyrtidae, Trichogrammatidae, Pteromalidae, Eurytomidae, Bethyidae, Elasmidae, etc., with more than 279 successful cases reported world over (DeBack and Rosen, 1991; Narendran, 2001). *Bracon brevicornis*, *Goniozus nephantidis* (Fig. 10.2) (Braconidae), *Brachymeria nosatoi* (Chalcididae), *Elasmus nephantidis* (Elasmidae), *Xanthopimpla nana nana* (Ichneumonidae) are effective in biosuppression of black headed caterpillar, *Opisina arenosella* Wlk. of coconut palm in the field (Pillai and Nair, 1983). Members of the family Trichogrammatidae are well known egg parasitoids in the field. Various species of Trichogrammatids like *T. japonicum* and *T. evanescence* are used against stem borers of sugarcane in India (David and Easwaramoorthy, 1985).

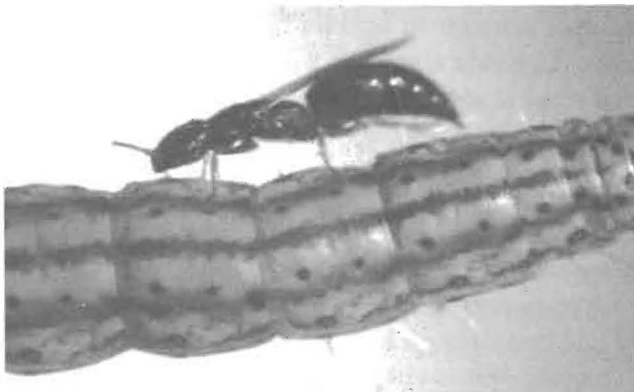


Fig. 10.2. Larval parasitoid (*Goniozus nephantidis*)

## Entomopathogens

Microbial agents are important components in a biological control programme and in organic farming. Use of these agents has wider scope in organic agriculture. Various groups of micro-organisms like bacteria, virus, fungi and nematodes are employed in the bio suppression of many major pests of crop plants. In recent years, the market for microbial pesticides is growing worldwide though it contributes less than 1 % of the total crop protection products (Rabindra *et al.*, 2001).

Of over 750 species of fungi known to be pathogenic to insects, only six have been commercialized (Ambethgar, 2001). Pathogens such as *Beauveria bassiana*, *Metarhizium anisopliae*, *Nomuraea rileyi*, *Verticillium lecanii* and *Hirsutella thompsonii* (Fig. 10.3) are the best known of these fungi. Soil treatment with conidia of *Nomuraea rileyi* along with a solid substrate has been recommended for management of *Spodoptera litura* in ground nut which is a close canopy crop (Vimala Devi, 1995). Fungi require relatively high humid microclimate (>70% RH).

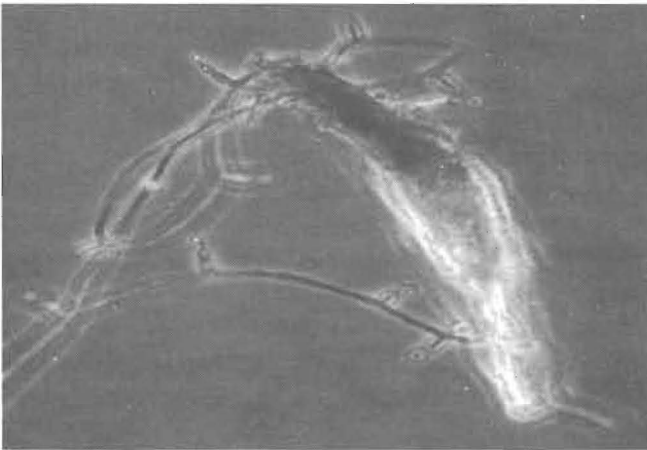


Fig. 10.3. Acaropathogen (*Hirsutella thompsonii*)

*Bacillus popilliae* and *Bacillus thuringiensis* are two major species of bacteria employed in the management of many species of crop pests particularly the caterpillar pests affecting many vegetable and fruit crops. In India, *Bacillus thuringiensis* (B.t) is used in the management of pests like diamond back moth on cruciferous vegetables and pod borers on pulses and okra.

As plantation crops are cultivated in contiguous areas, use of microbial agents is more feasible to achieve effective management of certain pests. In coconut and oil palm, two classical examples of microbial agents viz., the green muscardine fungus *Metarhizium anisopliae* (Fig. 10.4) and the *Oryctes rhinoceros* virus (OrV) have been proved to be highly effective for managing the black beetle, *Oryctes rhinoceros* L.

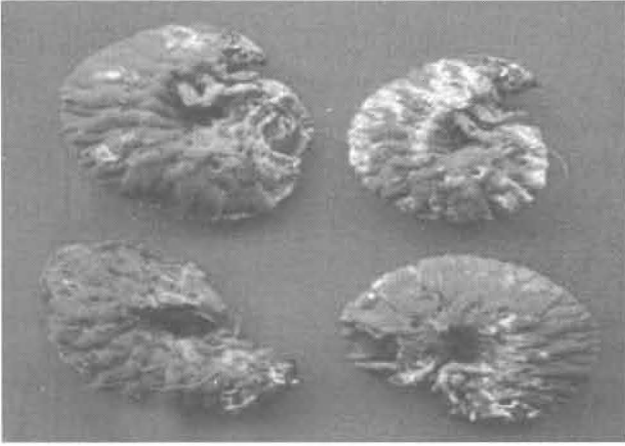


Fig. 10.4. *Oryctes* grubs infected by *Metarhizium*

The entomopathogenic fungus, *Metarhizium anisopliae* (Metch.) Sorokin infects grubs of rhinoceros beetle especially during wet season. Mass culture of this fungus in cheaper substrates like coconut water or cassava chips is standardized with low cost technologies and the fungus can be applied at the recommended dose in the breeding sites of the beetle. The OrV is a potential viral pathogen of rhinoceros beetle in many countries. The successful biocontrol attempts carried out by Central Plantation Crops Research Institute in many coconut growing tracts in India with this virus have established the potential of this pathogen.

### Botanical Pesticides

Botanical pesticides are having a prominent position in pest management under organic agriculture. As botanical pesticides are safe for the non-target organisms, they are preferred in organic pest control strategies. Botanical pesticides are used either as repellents or as primary insecticides having adverse effect on the physiological functioning of insect pests.

Derivatives from various species of plants have been in use for plant protection from ancient days onwards in agriculture. More than 600 plant species are reported to have pesticidal properties. Tulsi, Mahuva, Lantana, Tobacco, Marigold, *Clerodendron infortunatum* (Fig. 10.5), etc., are some important plants used for pest management. Insecticidal properties of neem were proved beyond doubt in ancient times and in modern agriculture neem based pesticides are getting importance because of their versatile ability to control many pests of agricultural importance. *Azadirachtin* is the active principle having insecticidal property present in neem tree. Decoction of neem leaf, neem oil cake, powdered neem seed and seed oil are used in various dilutions mixed with washing soap to effect satisfactory control of various groups of foliage pests in many field crops.

Trials conducted by Indian Institute of Horticultural Research have proved that sprays



Fig. 10.5. *Clerodendron infortunatum* (IGR)

of neem seed powder or neem soap at 1% were effective in the management of tomato fruit borer. Pulverised neem seed powder extract at 4% is recommended for management of foliage pests of cruciferous plants (Amerika Singh *et al.*, 2006). In coconut mite management, use of neem pesticides is recommended either as spray or as root feeding (Nair *et al.*, 2005).

### Semiochemicals

Semiochemicals which are considered to be a modern tool in IPM concept has a pivotal role in eco-friendly pest management programmes. Semiochemicals are compounds released or emitted by plants and animals for specific communication purposes. If the communication is between the same species (Intraspecific), they are called pheromones, and on the other hand if the communication is between two different species (Interspecific), they are called kairomones. Insect pheromones fall into several categories usually related to functions viz., sex pheromones, aggregation pheromones, alarm pheromones, trail pheromones, etc., Pheromones that have been used most successfully in pest monitoring/control are sex pheromones of Lepidoptera and aggregation pheromones of Coleoptera. The application of pheromones in crop protection may be indirect as population monitoring agents or direct as tools in mass trapping, lure and kill and mating disruption techniques (Yadav *et al.*, 2004).

In India successful attempts have been recorded for the control of sweet potato weevil, *Cylas formicarius*, sugarcane pests like early shoot borer, *Chilo infuscatellus*, inter node borer, *Chilo sacharophagus indicus*, tobacco leaf eating caterpillar, *Spodoptera litura* and rice yellow stem borer, *Scirpophaga incertulus* (Ganeshwara Rao *et al.*, 1994) and coconut

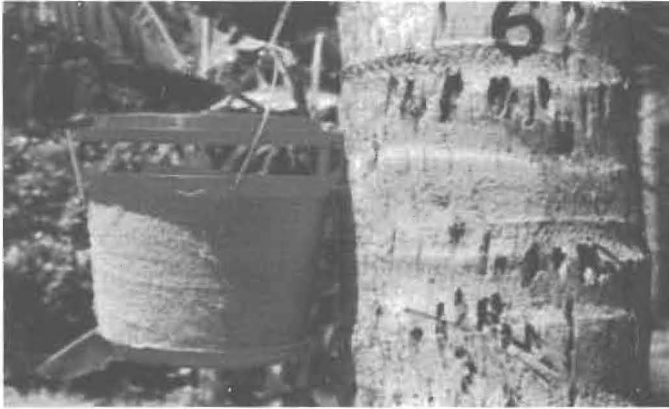


Fig. 10.6. RPW Pheromone trap

red palm weevil, *Rhynchophorus ferrugineus* (Fig 10.6) (Nair and Saritha, 2003).

Kairomones are volatile compounds capable of evoking behavioural response favourable to the receiver. Mostly they are released by the host plant and can be used to trap the insects. Intensive efforts are required to develop strategies exploring the possibilities of semiochemicals in organic agriculture.

### Light Traps or Attractant Traps

Some of the pests like diamond back moth of cabbage, fruit flies damaging mango and cucurbitaceous vegetables, red palm weevil of coconut, etc., are attracted to food lure traps employing the natural food substances. The synthetic attractant like methyl eugenol is employed to trap fruit flies. White grubs are major pests of coconut, arecanut, tuber crops, sugarcane and ground nut and they are successfully managed using light traps. Trapping of adult beetles during their emergence period coinciding with onset of monsoon is found to be one of the effective strategies in IPM of white grubs. Light traps have been successfully used in monitoring of yellow stem borer of rice (Chandramohan and Chelliah, 1984).

### Agronomic Practices

Historically, agronomic practices or cultural manipulations of plants were the most important methods for controlling and preventing crop losses. Farmers continuously refined them with experience. Among the oldest techniques for managing pests are sanitation, destruction of alternate hosts, tillage, avoidance and planting of crop cultivars that resist pest attacks. The worldwide awareness of safe environment provided impetus to foster non-chemical pest management strategies. Of these strategies, cultural control constitutes the most farmer-oriented approach, where weak points in the biology and behaviour of insects are exploited and pressure is exerted on the population by manipulating the environment. An understanding of natural defense mechanisms present in the host against

the pest is useful to prepare a pest control programme where agronomic methods are to be utilized. Also, a thorough knowledge of pest, host, host-plant interaction and optimum environment for both are necessary in this method. In an agricultural country like India, agronomic management practices are of immense importance because of low cost of inputs, easy in their adoption and acceptance by farmers. The initial build up of a pest in crops is many times influenced by the cultural and crop management methods followed in farming. Nutritional management of the plant is important in managing pest problems. Adjustment of sowing/planting date keeping in mind the peak activity of the damaging stage of the pest helps in avoiding the critical stage of the crop from pest attack. Thus synchronization of most susceptible stage of the crop with the inactive period of insect reduces the infestation and chemical intervention.

### Sanitation

Removal and destruction of breeding materials, manipulating over-wintering sites, pruning of infested plant parts etc. are sanitation methods that can be employed in organic agriculture. Sanitation is important to prevent introduction of insects, pathogens, nematodes and weeds into pest free fields and to reduce losses in infested fields. Sanitation includes all measures aimed at eliminating or reducing the amount of inoculums present in a plant or field and at preventing the spread of pests to other healthy plants and plant products. Sanitation practices such as use of healthy seed material, burning and destruction of crop refuse, clean storage, etc., reduce pest population, discourage breeding and hibernating sites and prevent carry over to the next crop season. These methods are economical, effective and easy to adopt. Depending upon the crops and types of pests that affect the crops, sanitation methods can be practiced by farmers. Destruction of stubble soon after harvesting in cereal crops is advisable to remove the surviving stages of pests like stem borer and gall midges in rice.

Trashing in cardamom reduces the thrips damage on cardamom capsules. Crown cleaning in coconut reduces the coreid bug damage and also removes the nesting sites of rodents. Phyto-sanitation is the key factor in the management of major pests of plantation crops like rhinoceros beetle and red palm weevil of coconut and stem borers affecting crops like cashew, coffee, cocoa, etc. Avoiding breeding sites of black beetle in the immediate vicinity controls its attack in coconut plantations. Soil solarization for six weeks during peak summer and fortification with *Trichoderma harzianum* reduces the foot rot disease in black pepper nursery, besides helping in control of nematodes.

### Tillage

Tillage is an integral factor in destroying food sources and habitat of the pests within the field. In addition tillage plays a major role in rhizosphere microflora and microfauna. Tillage operation changes the texture, nutritional composition and pH of the soil which becomes less favourable to weeds and soil inhabiting insects. Ploughing exposes the grubs and pupae of coconut white grubs to predation by birds. Deep ploughing (Fig 10.7) during

the pre-monsoon and post-monsoon seasons helps in control of soil insects like white grubs, termites and army worms. Many times tillage operations are also essential in managing nematodes and rodents. Deep ploughing of the field after the harvest reduces the activity of fruit fly, red pumpkin beetle and cut worm as these insects remain in the soil in earthen cocoon to complete the dormant stage of their life cycle.



**Fig 10.7.** Predatory birds in ploughed field

### **Resistant Cultivars**

Genetic resistance is one of the oldest methods of pest control. Growing resistant cultivars is the most effective and economic means of controlling plant pests. Resistant cultivars are also the first line of defense against pests. Resistant varieties should be used in concert with other pest suppression or pest control measures. Plant resistance provides a built-in ability to allow fewer pests and cut off the extra load of insecticides in the crop. Keeping in mind the diversity and intensity of pests in a particular place, selection of resistant/less susceptible varieties holds well in pest management. Plant resistance has been well-utilized in the management of pod borers of peas and cotton. The Bt Cotton has become highly popular among farmers for its high level of resistance to bollworms.

Tall varieties of coconut are found to be tolerant to red palm weevil damage and Malabar varieties of cardamom are tolerant to shoot and capsule borer damage. Orange dwarfs are tolerant to mite damage in coconut. In paddy cultivation, use of resistant varieties especially to tackle the brown plant hopper and green leaf hopper problems has been successfully implemented in more than 20 million hectares in Asia (Panda and Khush, 1995).

### **Trap Crops**

Trap crops or catch crops are species of plants which are planted to attract and retain a pest species or to provide a more favourable habitat to increase natural enemies. Trap crop

(Fig. 10.8) must be definitely and distinctly attractive to the pest than the main crop. Trap crop provides protection either by preventing the pest from reaching the main crop or by concentrating them in certain parts of the field, where they can be economically destroyed. Trap crops have been utilized in control of nematodes. Marigold as a trap crop for nematodes in vegetable fields and black pepper garden is common at many places. Use of mustard and marigold as trap crops have become highly popular in management of pests affecting vegetable crops, particularly tomato and cabbage.



**Fig. 10.8.** Trap crop (Marigold) in cardamom

### **Removal/Regulation of Alternate Hosts of Pests**

Many economically important pests are known to survive on collateral hosts which constitute mainly the weeds grown in the vicinity of the agricultural land or a subsidiary crop grown in the field. The coreid bug of coconut not only infests coconut but also infests collateral hosts like guava, cashew, cocoa and tamarind. Knowledge on the feeding behaviour and biology of the pests of cultivated crops would enable the farmer in utilizing the technology effectively.

### **Crop Rotation**

Crop rotation and fallowing were reported to be of common usage in Roman times as methods of increasing crop production and avoiding losses due to adversity. Continuous production of one crop over an area virtually assures an increase of those pest species adapted to attack that particular one. Substitution of a crop belonging to a different plant family will eliminate or greatly reduce population of those pest species associated with the earlier crop. Crop rotations are very effective in breaking insect build-up, especially for insects of limited host range. Crop rotation with a view to avoid continuous supply of food

plants for pests particularly the oligophagous pests is an advisable step in eco-friendly pest management. Similarly to tide over the colonization of pests, adjustment of sowing time not to synchronize with the crop phenology and pest stages is another method practiced by farmers. Crop rotation practice helps in reducing population build up of soil insects and nematodes. It also enhances the biodiversity which in turn is beneficial to the natural enemies.

### **Pest Surveillance**

Pest surveillance and monitoring system play a major role in pest management in an organic farming system. The farming community has to be aware about the pest problems of the crop, the behavior and population ecology of the pests and their natural enemies for employing appropriate technology at a time of urgency. This is possible only through an effective transfer of technology programme by an interactive involvement of research-extension agencies and farming community.

### **Future Thrusts**

The increasing awareness on the ecological aspects of pest management and the inclination to conserve ecosystem without disruption for maintenance of sustainability among various stake holders are appealing in recent years. Utilization of frontier areas like information technology can make tangible effects in safer pest management systems. Proper planning on the adoption of apt control measures to save the crop is possible through reliable prediction of pest out break based on weather forecast. Employment of modern tools like remote sensing and geographical information system (GIS) will be useful in assessing crops loss and pest incidence and using the information from such sources, advance action plan can be taken up to schedule effective plant protection strategies over larger areas within short period. Exploring the potential of farmer's knowledge and finding out scientific basis for such indigenous technical knowledge of farmers are to be priority areas in our attempts to manage the pest problems in organic agriculture. Bio informatics is a recent field by which speedy dissemination of information is achieved. This helps in proper understanding and timely action to tackle situations like accidental introduction or sudden out breaks of pest species.

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