*Food and Scientific Reports*
ISSN2582-5437
foodandscientificreports.com

# Bio-rational Pesticides: A novel approaches for Insect Pest Management

**Shivakumara K T[1], Keerthi M C[2], Polaiah A C[1], Manjesh, GN[1], Satyjeet Roy[1]**

[1]ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat, India-387310; [2]ICAR- Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh, India- 284001.

**ABSTRACT**
Insects are the most diverse organisms and beneficial to human beings. Apart from, some insects act as pests, directly damage the plants and indirectly transmit some viral disease to plants and as well as human beings. By the usage of various synthetic chemicals, indirectly we got a negative impact on the environment as well as a public concern. For these circumstances, we need to look forward for use of biologically originated pesticides. Keeping in view, bio-rational pesticides are attracted attention in recent years. Bio-rational pesticides are a natural source and have less adverse effect on the environment. Bio-rational pesticides are the biochemical, plant-incorporated Protestants (PIPs) and microbial pesticide. However, this bio-rational pesticide not only effective in management of insect pests, but also it can reduce the pesticides lode into the environment and potential tool for sustainable integrated pest management (IPM) programme.
**Keywords:** Bio-rational, microbial pathogens, pheromones, botanicals and plant-incorporated Protestants.

Green revolution is one of the important milestones that were happened in India around the 1960s to increase food production to feed the growing population. Besides, usage of indiscriminate agrochemicals for those achievements indirectly got several adverse effects on the environment in terms of soil pollution, pesticide residue problem, pest resistance and toxicity to non-target organisms. Use of bio-pesticides is more than 1 per cent in the total world market unlike 99% of chemical pesticides. In a developing country like India, every year 20,000 peoples were died due to food contamination through pesticides (Bhardwaj and Sharma, 2013). Because of ill effects caused by synthetic pesticides demands were increasing for an alternative solution to the effective safest method of pest management tactics (Pretty, 2012). Recent year's attention towards use of bio rational pesticides are more due to their specificity, safety to non-target organisms (Rosell *et al*., 2008).

Use of bio-rational pesticides will greatly minimise the use of synthetic pesticides and increase crop yield. Generally, bio-rational pesticides are derived from natural materials such as plants, animals, microorganisms and certain minerals. On the other hand, bio-rational pesticides have a low level of acceptance due to uncompetitive price, inappropriate formulations and application in a limited range of pests *etc*. Use of bio-rational Pesticides are not an exact alternative to conventional pesticide use, however, they are an alternative to the use of conventional Pesticides such as organophosphates, carbamates and pyrethroids (Horowitz *et al.*, 2009). Bio-rational pesticides effectively control insect pests and along with low toxicity to non-target organisms such as humans, animals, natural enemies and the environment. Because of this feature, it can be fit into integrated pest management (IPM) programs effectively. In this context, we need to approach maximum usage of biologically originated pesticides like Microbial pesticides, Plant pesticides and biochemical for management insect pests to sustainable and safe agricultural production for future.

## Scope of bio-rational pesticides

Bio-rational pesticides have the inherent capacity to a specific mode of action and there is no cross-resistance with the conventional pesticides. Normally a combination of microorganisms, biochemical and plant-incorporated protectants (PIPs), these are naturally occurring, environment friendly, biodegradable, easily available and easily affordable by farmers as cost of the product is comparatively lesser than the conventional pesticides. Moreover now days need healthy agricultural produce rather than pesticides contaminated product and hence bio-rational pesticides have gained their importance and attention towards higher demands.

## Classification of bio-rational pesticides

Normally classification of bio-rational pesticides includes biochemical (insect growth regulators, semiochemicals, botanicals, etc.) microbial pathogens (bacteria, fungi, viruses, nematodes and protozoan's) and plant-incorporated protectants (PIPs) (alkaloids, steroids, terpenoids, essential oils).

### Biochemical pesticides

Biochemical pesticides are naturally occurring substances such as semiochemicals (Pheromones) insect growth regulators, plant extracts, *etc*.

### Semiochemicals

Semiochemicals are the chemicals released by plants or animals that perform the response of other individuals of the same or other species of alike or diverse kinds. It comprises pheromones (intraspecific semiochemicals) and allelochemicals (interspecific semiochemicals) (allomones and kairomones). Pheromones are substances released by one individual that can communicate with other individuals of the same species. Female sex pheromones are received by olfactory sensillae of male antennae and some of the female sex pheromones were identified like Bombykol in Silkworm (*Bombyx mori*), Gyplure and disparlure in Gypsy moth (*Porthesia dispar*), Gossyplure in Pink bollworm (*Pectinophora gossypiella*), Looplure in Cabbage looper (*Trichoplusia ni*), Spodolure and litlure in Tobacco cutworm (*Spodoptera litura*). Sex pheromones are used in pest management aspects in the form of monitoring, mass tarping and mating disruption. Pheromones are used in monitoring for detection of introduced or exotic insects such as Mediterranean and Mexican fruit flies (Heath *et al*.,1996), wood-boring and bark beetles (Brockerhoff *et al*., 2006), gypsy Moth (Sharov *et al*., 1997) and pink bollworm (Baker *et al*., 1990) *etc*. Allomones are substances released by one species that alter the behaviour of a dissimilar type to the advantageous of the emitting species. Kairomones are the compounds released by one species, it can change the behaviour of the different species and advantageous to the receptor species.

### Insect growth regulators

Insect growth regulators (IGRs) are the compounds that alter the normal growth of insects and these compounds interfere with insect metamorphosis, embryogenesis or reproduction. IGRs are mainly classified into chitin synthesis inhibitors and substances interfering with the action of insect hormones based on the mode of action. Among the IGRs, Juvenile hormone and chitin synthesis inhibitors are the majors. Juvenile hormones have regulated the metamorphosis and production of eggs in female insects and due to their specificity of mode action now day attention towards the development of bio-rational insecticides. Commercially available Methoprene and hydroprene are used in the household situation. However, use in the agricultural ecosystem has been limited due to their slow toxic action, lack of outdoor stability and stage-specific in nature. Chitin synthesis inhibitors are another important IGRs it comprises benzoyl phenyl urea (diflubenzuron, triflumuron, teflubenzuron, hexaflumuron and novaluron), triazine/ pyrimidine derivatives (Cyromazine, Dicyclanil), and buprofezin. These are the able to effects the production of new exoskeletons at the time of moulting. A substance interfering with the action of insect hormones includes Ecdysteroid agonist are chromafenozide, tebufenozide, halofenozide, and methoxyfenozide, Juvenile hormone analogues are pyriproxyfen, fenoxycarb, Juvocimenes and Antijuvenile hormones are Fluoromevalonate, Compactin and Piperonylbutoxide). These substances are mainly interference with the pupation and induce the vitellogenesis at the time of the reproductive stage of the insect.

### Botanicals Pesticides

These pesticides are normally a mixture of chemical substances obtained from purely different parts of the plants, it may be leaf, stem, shoot, bark, flower and fruits etc. they comprise, normally rotenone from *Lonchocarpus nicou* or *Derris elliptica* (Leguminosae), Pyrethrum *Chrysanthemum cinerariifolium* Vis. (Compositae), nicotine *Nicotianatabacum* (Solanaceae), sabadilla and ryania. However, the most promising botanical insecticide is azadirachtin, the triterpenoid isolated from the seeds of the Indian neem tree. Azadirachtin concentration from 0.2 to 0.6% in seeds compared to other plant parts. Azadirachtin possesses a broad range of mode of actions on various insect pests such as repellents, antifeedant, insect growth regulatory and anti-ovipositional properties have unique among all currently available insecticides. Azadirachtin is most effective against insect species, mostly on Orthoptera, Heteroptera, Isoptera, Lepidoptera, Diptera, Coleoptera, Homoptera, Siphonaptera and Hemipteran orders. Although, Neem extract is the most effective insecticide against various sucking insect pests, like, whitefly, jassid, and mites. Pyrethrum is another most important botanical pesticides used in India. The highest concentration of pyrethrum is found mainly in the flowers compared to other parts of the plant. Normally Pyrethrum is the mixture of six active ingredients, namely, pyrethrin I, pyrethrin II, cinerin I, cinerin II, jasmolin I, and jasmolin II. Pyrethrin I, cinerin I, and jasmolin I are the esters of chrysanthemic acid, whereas pyrethrin II, cinerin II, and jasmolin II are the esters of pyrethric acid.

### Microbial insecticides

Microbial insecticides are contained microorganisms and their by-products, usually; microbial insecticides are commonly called as biological pathogens. Normally these pathogens comprised of bacteria, fungi, virus, protozoa and nematodes and these microbial insecticides are commonly available in dust, liquids, wettable powder and granules to form for application. These types of pesticides can manage many insect pests, although each separate active ingredient is relatively specific for its target pests. Microbial insecticides are species-specific and not cause any harmful effects on beneficial organisms.

### Bacteria

The most widely used microbial insecticides, *Bacillus thuringiensis (Bt)*, is a gram-positive, spore-forming soil bacterium. It works mainly on lepidopterans insects, the endospores or resting stage of the bacterium contains endotoxin which can able to paralysing and lysing the insect gut and finally mortality of the insect through starvation. There are several insecticides based on various sub-species of *Bacillus thuringiensis* Berliner (*Bt*), such as *B. thuringiensis israelensis* (*Bti*), with activity against mosquito larvae, black fly (simuliid), fungus gnats, and related dipteran species*; B. thuringiensis kurstaki* (*Btk*) and *B. thuringiensis tenebrionis* (*Btt*), with activity against coleopteran adults and larvae; and *B. thuringiensis japonensis* (*Btj*) strain *buibui*, with activity against soil inhabiting beetles. Apart from *Streptomyces avermitilis* (Abamectin, Ivermectin and Emamectin benzoate), and spinosad (bacteria, *Saccharopolyspora spinose)* (Gavkare *et al.*, 2013).

### Viruses

The virus is another important entomopathogens for causing the disease in insects. Normally insects are attacked by different types of viruses, these are obligate and it can only reproduce within a host insect. Baculoviruses are the main group of viruses used as pesticides (Szewczyk *et al.*, 2011) and they can be classified into Nuclear Polyhedrovirus (NPV) and Granulovirus (GV). Most of the viruses are nuclear polyhedrosis viruses (NPV's), in that numerous virus particles are packaged together in a crystalline form within insect cell nuclei like *Helicoverpa armigera* (HaNPV), *Spodoptera litura* (SlNPV) *Autographa californica* (AcNPV). When larva infected by this virus in field condition, the larva hangs from the top of the plant with the help prolegs and this condition is called Tree top disease or "Wipfelkrankheit". Granulosis viruses (GV's), is another virus it can one or two virus particles are surrounded by a granular or capsule-like protein crystal found in the host cell nucleus. These groups normally infect caterpillars and the larval stages of sawflies.

### Fungi

Fungal pathogens are pathogenic to the insect host, and these are referred to as entomopathogenic fungi. It can infect eggs, immatures and adults of a variety of insect species. These insect pathogenic fungi produce many toxins and extracellular enzymes such as proteases and chitinases which aid penetration of the insect cuticle. Currently used *Beauveria bassiana* (caterpillars of yellow stem borer and leaf folder of rice, white grub of groundnut, sugarcane pyrilla, coconut rhinoceros beetle, caterpillars of pulses, tomato and cotton, diamond back moth, leaf-eating caterpillars of tobacco and sunflower etc.) *Metarhizium anisopliae* (coconut rhinoceros beetle, groundnut cutworm, rice brown plant hopper, diamond back moth and early shoot borer, top shoot borer and internode borer of sugarcane) *Nomuraea rileyi* (pod borers, cut worms, cabbage borers etc)*Vericillium lecanii* (whiteflies, aphids, thrips, brown plant hopper, scale insects, mealy bugs) *Lagenidium giganteum* and *Hirsutella thompsonii* (Different hoppers and bug pests, whiteflies, red mites etc.)

### Protozoa and Nematodes

Entomo-pathogenic protozoa are generally hosted specific and slow acting. The entomopathogenic protozoa belong to *Nosema* spp., and *Vairimorpha necatrix*. Among the *Nosema* spp., *Nosema locustae* is the only commercially available species of microsporidium, and marketed under several labels for control of grasshoppers and crickets. Furthermore, Entomopathogenic nematodes from the genera *Steinernema* and *Heterorhabditis are used in pest management practises. Steinernema feltiae* (*Neoaplectana carpocapsae*), *S. scapteriscae, S. riobravis, S. carpocapsae* and *Heterorhabditis heliothidis* are the most commonly used entomopathogenic nematodes.

### Plant Incorporated Protectants

These compounds are usually phyto-chemicals which are naturally occurring bioactive compounds obtained from plants or and their derivatives. PIPs such as alkaloids, steroids, terpenoids, essential oils and phenolic were previously reported as the compounds having insecticidal activities (Shaalan *et al.*, 2005). These

naturally occurring compounds are easily biodegradable and there are no adverse effects to non-target organisms. Naturally, Myrtaceae, Lamiaceae, Asteraceae, Apiaceae, and Rutaceae plants are having highly pesticidal activity against different kinds of insect pest.

## Mode of action

Bio-rational pesticides are more specific, biodegradable, and much safe for handling and there is no ill effect to beneficial insects compare to chemical pesticides. Bio-rational pesticides have nerve poisons that result from knocking-down, rapid intoxication, lack of coordination, paralysis and death of insects. These pesticides are better control than conventional insecticides that solve the demands of farming communities and consumers to require pesticides with low to moderate mammalian toxicity. Bio-rationals are not phytotoxic and usually do not persist in the environment. Most of the bio-rational insecticides have diverse modes of action and effective against different strains of resistant species, with there is no evidence of cross-resistance and they can play an important role in IRM-strategies (Denholm *et al.*, 1998). Bio-rational pesticides also known as low-risk pesticides have a relatively low detrimental effect on the environment and have little or no adverse effect on non-target organisms.

## Role of Bio-rational pesticides in IPM

From the ancient time to till date we were using one or the other chemicals for management of various insect pest in nature but since the introduction of DDT and related pesticides the farmers and public have applied these pesticides indiscriminately, Fortunately, knowing about the negative effects of the chemical pesticides on nature and natural resources, such as pollution, pesticide residues and pesticide resistance problems and finally raised the voice against these pesticides. Rachel Carson in her classic book entitled *Silent Spring* (1962) narrates the ill effects of direct and indirect consequences of chemical pesticides to the agriculture production system and public (reference missing). For this instance farmers and publics slowly shift to focus on more reliable, sustainable and environment friendly agents of pest control. In India nearly about 4.2 per cent occupying bio-pesticides in overall pesticides market (Das, 2014). Globally bio-rational pesticides were well adopted in the IPM programme and insect resistance management programme due to their potential ability to reduce the conventional pesticides, while the crop yield remains high. The commonly used bio-pesticides are living organisms (bacteria, viruses and fungi) are pathogenic to a various insect pest in the agricultural ecosystem.

## Conclusion

The globally emerging trend of a new pest in their agricultural ecosystem and simultaneously are using conventional insecticides to manage for them. Unfortunately got some side effects to the environment. For this instance, need to develop an appropriate technology like bio-rational pesticides. These pesticides are promising alternatives for use in pest management tactics. However, bio-rational pesticides like entomo-pathogens (bacteria, fungi, viruses, protozoa, and nematodes), insect growth regulators, semiochemicals (Pheromones), botanicals, plant-incorporated protectants (alkaloids, steroids, terpenoids, essential oils) have been proposed as safer and ecologically alternative to conventional synthetic pesticides for sustainable agricultural production.

## References

Bhardwaj, T., & Sharma, J. P. (2013). Impact of pesticides application in agricultural industry: An Indian scenario. *International Journal of Agriculture and Food Science Technology*, *4*(8), 817-822.

Brockerhoff, E. G., Jones, D. C., Kimberley, M. O., Suckling, D. M., & Donaldson, T. (2006). Nationwide survey for invasive wood-boring and bark beetles (Coleoptera) using traps baited with pheromones and kairomones. *Forest Ecology and Management*, *228*(1-3), 234-240.

Das, S. K. (2014). Recent development and future of botanical pesticides in India. *Popular Kheti*, *2*(2), 93-99.

Denholm, I., Horowitz, A. R., Cahill, M., & Ishaaya, I. (1998). Management of resistance to novel insecticides. In *Insecticides with novel modes of action* (pp. 260-282). Springer, Berlin, Heidelberg.

Gavkare, O., Patil, M. U., Kulkarni, A. V., & Gupta, S. (2013). New group of insecticides. *Popular Kheti*, *1*(3), 34-39.

Heath, R. R., Epsky, N. D., Dueben, B. D., & Meyer, W. L. (1996). Systems to monitor and suppress Ceratitis capitata (Diptera: Tephritidae) populations. *Florida Entomologist*, 144-153.

Horowitz, A. R., Ellsworth, P. C., & Ishaaya, I. (2009). Biorational pest control–an overview. *Biorational Control of Arthropod Pests*, 1-20.

Pretty, J. N. (Ed.). (2012). The pesticide detox: towards more sustainable agriculture. Earthscan. London, UK.

Rosell, G., Quero, C., Coll, J., & Guerrero, A. (2008). Biorational insecticides in pest management. *Journal of Pesticide Science*, *33*(2), 103-121.

Shaalan, E. A. S., Canyon, D., Younes, M. W. F., Abdel-Wahab, H., & Mansour, A. H. (2005). A review of botanical phytochemicals with mosquitocidal potential. *Environment international*, *31*(8), 1149-1166.

Sharov, A. A., Liebhold, A. M., & Roberts, A. E. (1997). Methods for monitoring the spread of gypsy moth (Lepidoptera: Lymantriidae) populations in the Appalachian Mountains. *Journal of Economic Entomology*, *90*(5), 1259-1266.

Szewczyk, B., de Souza, M. L., de Castro, M. E. B., Moscardi, M. L., & Moscardi, F. (2011). Baculovirus biopesticides. In *Pesticides-Formulations, Effects, Fate*. IntechOpen.

Keywords: Biopesticides ,Integreated Pest Management , Microbial Biopestcides. INTRODUCTION In recent years, few environmental issues have aroused the concern of the public as much as pesticides, especially in relation to the health of children. In spite of the many published studies on the subject of pesticides and human health, there remains deep controversy surrounding this crops.They are in a dilemma to either sacrifice a significant share of their crops to pests or use highly toxic pesticides that can harm human health and the environment.Biopesticides are key elements of incorporated ins... 30 Bio-rational Pesticides ï‚§ Look for compatibility with natural enemies ï‚§ Specific target pest ï‚§ Specific life stage (IGRs) ï‚§ Short residual time ï‚§ Short Restricted Entry Interval (REI). 31 Case #3 Green Peach Aphid (GPA) Myzus persicae Unwinged GPA adults and nymphsAphid damage Winged GPAESM GPA. 32 Natural Enemies of Myzus persicae Aphidoletes aphidimyza Chrysoperla carnea Aphidius colemaniMummified aphid.Â  IPM (integrated pest management) is a sustainable approach to managing pests by combining biological, chemical, cultural, and physical. Fruit & Vegetable Production Unit for Plant Science Core Curriculum Lesson 4: Integrated Pest Management Fruit & Vegetable Production Unit for Plant Science. Plant Disorders Insects and Pest. Within the bio-rational pesticides, nimbecidine gave the greatest thrips control whereas products showed no significant difference for whiteflies. The study recommends those bio-rational compounds to join Integrated Pest Management programs of both pests in Egypt, taking into consideration spraying for 3 consecutive times with at least 5 days intervals.Â Effectiveness of bio-pesticide (Beauvaria bassiana), natural oil (anti-insect), a botanical extract (nimbecidine) and malathion insecticide was evaluated against Thrips spp. and Bemisia tabaci attacking tomato in Kafr El Sheik, Egypt.Â  Bio-rational pesticides include several compounds such as soap, horticultural oil and neem.