Bio-Pesticides and Its Classification

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ABSTRACT

Bio pesticides are living organisms which can intervene the life cycle of insect-pests in such a way that the crop damage is minimized. The agents employed as bio pesticides, include predators, parasitoids and disease causing fungi, bacteria, nematodes and viruses, which are the natural enemies of pests. Further, they complement and supplement other methods of pest control. Utilisation of naturally occurring parasites, predators and pathogens for pest control is a classical biological control. It is the very important component of IPM (Integrated Pest Management) that helps in successful control of key insect pest under different agro-ecosystem. Among the bio pesticides, the products based on entomopathogenic bacteria (EPB) are most commonly used in farming community. It affects only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides and also effective in very small quantities and often decompose quickly, resulting in lower exposures and largely avoiding the pollution problems.

INTRODUCTION

Bio-pesticides or biological pesticides are derived from naturally occurring living organisms including plants, animals, and microbes (fungi, bacteria, virus, nematodes and protozoa) used as such or as their products or by-products that can control serious pest and diseases of plants by their non-toxic eco-friendly mechanism.

Bio-pesticides are described as mass-produced agents obtained from living organisms or a natural material manufactured and marketed

for the control of plant pests, according to the Organization for Economic Co-operation and Development (OECD). The target specific bio pesticides gaining importance all over the world because as they offer an effective and ecologically sound solution to the pest problems. Bio-based approaches, including biological control agents such as beneficial bacteria, fungi and viruses, have shown promise for suppressing soil-borne pathogens. Genetic improvement of crops for enhanced resistance combined with induced resistance using natural or synthetic elicitors represents another important dimension of disease control (Venkateswarlu *et al*., 2026). Agriculture is heavily dependent on pest control. Conventional pesticides have caused ecosystem imbalances, soil fertility loss, and a drop in marine life. The development of novel and effective insecticides is critical to combating rising resistance rates. Bio pesticides are well-known as appealing alternatives to synthetic chemical pesticides for pest management since they are thought to be safe for both the environment and human health (Mishra ***et al***., 2023).

Bio pesticides are broadly classified into four different categories based on the origin of the active substance or the living organism used in the control of target pest. It includes

1. Microbial pesticides.
2. Natural Biochemical pesticides.
3. Transgenics pesticides.
4. Natural enemies.

1. **Microbial pesticides:** Microbial pesticides are the pest control products comprising of several pathogenic microorganisms such as bacteria, fungi, protozoa and nematodes as their active ingredient. Entomopathogenic viruses, bacteria, and fungi are the most commonly used among farming community used as alternatives to traditional insecticides. Some of the examples of commonly used microbial pesticides and their target pests are listed in Table:1. Among various microbial pesticides, ***Bacillus thuringiensis (Bt)*** is the most widely used entomopathogenic bacterial bio pesticide. Nearly 90% of the bio pesticide market was covered by the different strains/serotypes and subspecies of ***Bt*** (Romeis *et al*. 2006).

Microbial Species	**Target Pest**
Bacterial	
Bacillus thuringiensis var. kurstaki	Lepidoptera insect (Attack on Larva of *Helicoverpa armigera, Spodoptera litura, Spodoptera frugiperda* and *Mythimna unipunctata*)
Bacillus thuringiensis var. thuringiensis	***Plutella xylostella*** (DBM)
Bacillus thuringiensis var. sotto	***Pieris brassicae*** (Cabbage Butterfly)
Bacillus thuringiensis var. aizawai	Diptera
Bacillus thuringiensis var. israelensis	Mosquito and Black flies
Bacillus thuringiensis var. morrisoni	Coleoptera
Bacillus thuringiensis var. tenebrionsis	Coleoptera (Colorado potato beetle)
Bacillus thuringiensis var. sandiago	Coleoptera
Bacillus popilliae	***Popillia japonica***
Bacillus lentimorbus	***Popillia japonica***
Serratia marcescens	***Opisinia arenosella***
Fungal	
Green Muscardine (***Metarrhizium anisopliae***)	Rhinoceros beetle (***Oryctes rhinocerous***)
Metarrhizium flavoviridae	Desert locust and Grasshoppers
White Muscardine (***Beauveria bassiana***)	Tobacco caterpillar (***Spodoptera litura***)
Fusarium oxysporium	BPH (***Nilaparvata lugens***)
White halo (***Verticillium***	***Coccus viridis***, whitefly, thrips and mite

lecanii)	
Nomuraea rileyi	***Helicoverpa zea***, ***Helicoverpa virescens*** and ***Spodoptera litura***
Hirsutella thompsoni	***Phyllocoptruta oleivora*** and ***Tetranychus urticae***
Hirsutella citriformis	***Nilaparvata lugens***
Paecilomyces lilacinus	Whitefly, ***Meloidogyne incognita, M. javanica*** and ***M. arenaria***
Virus	
Nuclear polyhedrosis virus(NPV)	***Helicoverpa armigera, Heliothis virescens, H. zea, Spodoptera litura, S. littoralis, S.exigua*** and ***Lymantria dispar***.
Granulosis virus (GV)	***Chilo infuscatellus, Adoxophyes orana, Plutella xylostella, Cydia pomonella*** and ***Phthorimaea operculella***
Entomopathogenic Nematode	
Steinernema carpocapsae	Caterpillar, ***Rhynchophorus ferrugineus*** and ***Tipula paludose***
Steinernema feltiae	***Bradysia coprophila, Chromatomyia syngenesiae*** and Soil dwelling pest.
Heterorhabditis bacteriophora	***Melolontha melolontha, Otiorhynchus spp*** and Soil Dwelling beetle
Protozoa	
Nosema and Vairimorpha	Lepidopteran and Orthopteran insects

Table- 1. Some of the example of Microbial Bio-pesticides for insect-pests management.

These pesticides suppress insect pests by causing disease or by producing specific toxins against the target pest or through competition by preventing the establishment of other organisms.

2. Natural Biochemical pesticides: Naturally occurring biochemical substances are derived from plants or insects and it is used in pest management by eco-friendly mode of action. Biochemical pesticides are broadly classified into two categories that include botanical pesticides and semiochemicals. It is estimated that approximately 2500 plant species belonging to 235 different families have showed measurable bio-cidal properties against various pests (Ansari *et al*., 2012). The natural compounds derived from plant extracts have biologically active compounds that are employed in pest control. Among different botanical pesticides Neem tree (*Azadirachta indica*) is one of the best known and most effective plant that contains Azadirachtin as active ingredient, which has various effects on insects such as antifeedant, repellent, deterrent (Saxena 1989). Semiochemicals are organic compounds produced by an organism (either plant or insect) that mediate interactions between individuals of same species (intraspecific communication caused by pheromones) or individuals of a different species (interspecific communication caused by allelochemicals). Semiochemicals include pheromones and allelochemicals. They can be used for behavioral manipulation of insects and can be used in the control of insect pest. The most commonly used semiochemicals in insect pest management are sex pheromones and aggregation pheromones. Insect sex pheromones are an essential component of insect pest control because of their high species specificity and low toxicity (Goldansaz *et al*., 2004). Some of the examples of biochemical pesticides are listed in Table -2.

Botanical Pesticides		
Plant	**Active compound**	**Target Insect**
Neem tree	Azadirachtin /NSKE	Most of the herbivorous insect
Chrysanthemum	Pyrethrum	Most of the herbivorous insect
Tobacco	Nicotine	Most of the herbivorous insect/Sucking insect
Tuba/Derrris	Rotenone	Herbivorous insect, Mite and Fish
Sabadilla	Cevadine and Veratridine	Sucking insect, Beetle and Fleas
Ryania	Ryanodine	Codling Moth and Corn Earworm
Quassia/Bitterwood	Quassin and Neoquassin	Aphids, Spider,

		Mite and Mosquito
Vogel tephrosia	Tephrosin	Storage insect-pest
Sweet flag	Acorus/Asarone	Rice weevil and Pulse beetle
Garlic	Allicin/ Diallyl disulfide	Cabbage Aphid, DBM and Storage pest
Basil	Juvocimenes	Several field crops
Bluemink	Precocene	Sucking and Chewing insect
Insect Pheromone		
Insect	**Compound**	**Type**
Helicoverpa armigera	(Z)-11-hexadecenal+(Z)-9 hexadecenal and (Z)-9-tetradecenal	Sex pheromone
Spodoptera litura	(Z,E)-9, 11- and (Z,E)-9, 12-tetradecadienyl acetate	Sex pheromone
Leucinodes orbonalis	(E)-11-hexadecenylacetate,(E)-11 hexadecen-1-ol	Sex pheromone
Spodoptera frugiperda	7-dodecen-1-olacetate, dodecan-1-olacetate, (Z)-11-dodecen-1-olacetate, (Z)-9	Sex pheromone
Pectinophora gossypiella	(Z,Z)-7,11-and(Z,E)-7,11-hexadecadienyl acetates	Sex pheromone
Popillia japonica	(R,S)-5-(1-decenyl)-dihydr0-2-(3H) furanone	Sex pheromone
Anthonomus grandis	Cyclobutanealcohol +cyclohexanealcohol + Z- and E cyclohexaneandacetaldehydes	Aggregation pheromone
Leptinotarsa decemlineata	(S)-3,7-dimethyl-2-oxo-oct-6-ene-1,3-diol	Aggregation pheromone
Dendroctonus frontalis	1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane	Aggregation pheromone
Ips confusus	(+)-2-Methyl-6-methylene-2,7-octadien-4-ol	Aggregation pheromone
Myzus persicae	(E)-β-farnesene	Alarm pheromone

Table-2. Some of the examples of biochemical pesticides for insect-pest management.

3. **Transgenics pesticides:** Transgenic crops are referred as plant-incorporated protectants (PIPs), which are grouped under bio pesticides as an alternative to chemical insecticides. Plants themselves produce protecting substance (toxins) after the introduction of genetic material coding for that toxic substance. Plants inserted with such transgene are called genetically modified crops, plant pesticides, or plant-incorporated protectants. The best-known example for the PIPs is Bt transgenic plants inserted with gene coding for the Bt toxin into the chromosome of the crop plants, thus the plants become toxic to the pest. In this situation, the Environmental Protection Agency (EPA) regulates the Bt pesticidal protein and its genetic content, but not the plant itself (Mazid *et al*., 2011). Transgenic crops are low cost and eco-friendly technology for the resource poor farmers to manage pests and diseases as well as other constraints such as abiotic stress and human vitamin A deficiency (SP-IPM 2006).

Plant	**Gene**	**Target pest**
Tomato	cry1 Ab, cry1 Ac	***Heliothis virescens***, ***Manduca sexta*** and ***Helicoverpa armigera***
Potato	cry 3, cry 3a, cry 3b, cry 2a5, cry 1Ab, cry 1Ac9, cry 5	***Leptinotarsa decemlineata*** and ***Phthorimaea operculella***
Soybean	cry1 A(c)	***Helicoverpa zea***, ***Helicoverpa virescens***, ***Lasioderma serricorne*** and ***Pseudoplusia includes***
Maize	cry1Ab, cry9C, cry3Bb, cry 1F, cry34Ab1/ cry35Ab1 cry1Ab+cry3Bb, cry 1F+ cry34Ab1 /cry35Ab1	***Ostrinia nubilalis, Chilo partellus, Busseola fusca, Heliothis zea, Diatraea grandiosella, Diatraea saccharalis, Spodoptera frugiperda, Diabrotica undecimpunctata howardi*** and ***Diabrotica virgifera***
Rice	cry 1Ab, cry 1Ac, cry 1Ab/cry 1Ac, cry 2a	***Chilo suppressalis***, ***Cnaphalocrocis medinalis and Scirpophaga incertulas***
Cotton	cry1Ac,cry1Ab/ cry1Ac,cry 1Ac+cry2Ab, cry1C	***Helicoverpa armigera, Pectinophora gossypiella, Earias spp., Heliothis virescens, Heliothis zea, Trichoplusia ni*** and ***Spodoptera litura***
Canola/ Rapeseed	cry1A(c), cry1C	DBM, ***Heliothis zea*** and ***Trichoplusia ni***

Poplar	cry1Aa,cry3Aa	***Lymantria dispar*** and ***Chrysomela tremulae***
Sorghum	cry 1Ac	***Chilo partellus***
Sugarcane	cry 1 Ab	***Diatraea saccharalis***
Chickpea	cry 1 Ac	***Helicoverpa armigera***
Tobacco	cry3,cry2a5, cry1Aa,cry 1Ab,cry1Ac	***Heliothis virescens, Manduca sexta, Helicoverpa armigera, Heliothis zea*** and ***Leptinotarsa decemlineata***
Brinjal	cry1Ac,cry3b	***Leucinodes orbonalis*** and ***Leptinotarsa decemlineata***
Chinese cabbage	cry1Ab, cry1Ac	***Plutella xylostella***
Broccoli	cry 1C	***Plutella xylostella, Trichoplusia ni*** and ***Pieris rapae***
Groundnut	cry 1Ac	***Elasmopalpus lignosellus***
Alfalfa	cry 1C	***Spodoptera littoralis***

Arora and Shera (2014)

Table 3: Examples of some of the transgenic plants developed for management of insect.

4. **Natural enemies:** Plants are protected or vector colonies are reduced by natural enemies such as insect predators (Coccinellid beetle and lacewings) and parasitoids (hymenopteran wasps and dipteran flies). Natural enemies are responsible for natural suppression of pest population. A few of the most common insect predators and parasitoids, respective target pests and their host plants are provided in Table 4.

Natural Enemies	**Target Pest**	**Host**
Predators		
Rodolia cardinalis	***Icerya purchasi***	Citrus, wattle and other Acacia spp.
Cryptolaemus montrouzieri	***Coccus viridis, Planococcus citri, P. lilacinus, Ferrisia virgata*** and ***Maconellicoccus hirsutus***	Several plantation and horticultural crops
Coccinella septempunctata	***Lipaphis erysimi*** and ***Brevicoryne brassicae***	Mustard and Cabbage
Brumus suturalis	***Phenacoccus solenopsis*** and ***Bemisia tabaci***	Cotton
Menochilus sexmaculatus	***Aphis craccivora, Aphis punicae, Lipaphis erysimi*** and ***Aphis gossypii***	Cowpea, Guava, Mustard and Cotton
Cryptognatha nodiceps	***Aspidiotus destructor***	Coconut
Chilocorus nigritus	***Aonidomytilus albus***	Cassava
Curinus coeruleus	***Heteropsylla cubana***	Subabul
Platymeris laevicollis	***Oryctes rhinoceros***	Coconut
Phytoseiulus persimilis, P.longipes, P. longipes P.fragariae and ***P. robertsi***.	***Tetranychus urticae Tetranychus evansi***	Bean, Tomato and Strawberry
Neoseiulus californicus N. cucumeris and ***N. longispinosus***	***Tetranychus urticae Oligonychus perseae Thrips and Aphids***	Broad bean, Chilli and Avocado
Amblyseius swirskii and ***Amblyseius cucumeris***	***Scirtothrips dorsalis*** and ***Bemisia tabaci***	Chilli
Epiricania melanoleuca	***Pyrilla perpusilla***	Sugarcane
Parasitoids		
Trichogramma spp.	Many lepidopteran pests	Several field and horticultural crops
Copidosoma koehleri	***Phthorimaea operculella***	Potato
Cotesia angaleti	***Chilo infuscatellus, C. sacchariphagus indicus, Scirpophaga excerptalis*** and ***Pectinophora gossypiella***	Sugarcane and Cotton
Chelonus blackburni	***Pectinophora gossypiella, Earias vitella ,E. insulana*** and ***Phthorimaea operculella***	Cotton, okra, hollyhock and Potato
Diadegma semiclausum Cotesia vestalis	***Plutella xylostella***	Cruciferous vegetables
Encarsia guadeloupae Encarsia haitiensis and E. formosa	***Aleurodicus dispersus Trialeurodes vaporariorum***	Several horticultural and ornamentals crops
Aphidius colemani	***Aphis gossypii***	Garden Chrysanthemum
Ooencyrtus pyrillae	***Pyrilla perpusilla***	Sugarcane
Eriborus trochanteratus	***Opisinia arenosella***	Coconut

Elasmus nephantidis		
Sturmiopsis inferens	***Bissetia steniellus Chilo infuscatellus***	Sugarcane
Platygaster oryzae	***Orseolia oryzae***	Paddy
Telenomus beneficiens Telenomus rowani	***Scipophaga incertulus***	Paddy

Table-4. Example of Some predators and parasitoids & their Host

CONCLUSION

Bio pesticides are the natural pest control agents or biological organism. They offer an environmentally safe and economically viable approach to pest management. Due to their low toxicity, biodegradability, and specificity, bio pesticides reduce chemical residues in food and protect beneficial organisms. Their application supports sustainable agriculture crop production and integrated pest management systems.

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