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Approaches to the Biological Control of Crop Insect Pests

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Abstract

Biological control is the use of non-chemical and environmentally friendly methods of controlling insect pests by the action of natural control agents. In recent decades, the increase use of biological control is due to its safety, species specific and long-term action on the target pests. Unlike chemical method, which kills non target species, cause detrimental health effects to human beings and pollute environment. However, the most common biological control agents used in the pest control are Predators, parasitoid and microbial antagonists with emphasis on entomopathogenic nematodes, fungi, Bacillus thuringiensis (Bt) and Baculovirus. They are manipulated and applied for various integrated pest control programs in Agriculture. Additionally, future directions for this crop protection strategy are suggested. Unfortunately, the primary factors affecting adoption of biological control are efficacy, predictability and high cost.

Key words: biological control, biocontrol strategies, natural enemies/biocontrol agents.

Introducation

Biological control is an environmentally sound and effective means of reducing or mitigating pests and pest effects through the use of natural enemies. It relies on predation, parasitism, herbivore or other natural mechanisms, but typically also involves an active human management role (J. Brodeur *et al*. 2013). According to S. H. Dreistadt, 2007 biological control is the beneficial action of predators, parasites, pathogens and competitors in controlling pests and their damage. Bio-control provided by these living organisms (collectively called natural enemies) is especially important for reducing the numbers of pest insects and mites. Biological control endeavor against plants and insects have different histories, with insect biological control being used for much of its first century largely against crop pests. Biological control has been actively practiced for more than 100 years and the history of bio-control, its failures and successes, has been extensively reviewed. Interest in biological control has increased over recent decades for many reasons (Bailey *et al*., 2009). First, a greater appreciation for environmental stewardship among regulators, growers, and the public has promoted development of more sustainable farming practices. Second, a number of arthropod pests have developed resistance to one or more pesticides leaving growers to search for alternative management strategies (McCaffery, 1998). Finally,

consumers increasingly demand products that are grown in a sustainable manner and are free of insecticide residue (Dabbert *et al*., 2004). Despite this, growers have been slow to adopt biological control as part of their pest management program. The primary factors affecting adoption of biological control are efficacy, predictability and cost (Van Driesche and Heinz, 2004). Basically there are three types of biological control strategies applied in pests control programs. These are Importation (sometimes called classical biological control), Augmentation and Conservation. Classical bio-control is defined; as the intentional introduction of an exotic (nonnative), usually co-evolved biological control agent for permanent establishment and long-term pest control (Van Driesche, 2008). The conservation of existing natural enemies in an environment is the third method of biological pest control. Natural enemies are already adapted to the habitat and to the target pest and their conservation can be simple and cost-effective, through vegetation manipulation. Classical Biological Control can provide control of both primary and secondary pests, while reducing the likelihood of pest outbreaks and resuscitation (Naranjo and Ellsworth, 2009, Godfray *et al*., 2010). Similarly, natural enemies of insect pests, (biological control agents) include the following; predators, parasitoids, and pathogens. Predators are mainly free-living species that directly consume a large number of preys during their whole lifetime. A parasite is an organism that lives and feeds in or on a larger host. Insect parasites (more precisely called parasitoids) are smaller than their host and develop inside or attach to the outside of the host's body (S. H. Dreistadt, 2007). Pathogenic micro-organisms include bacteria, fungi and viruses. They kill or debilitate their host and are relatively host-specific. Populations of some aphids, caterpillars, mites and other invertebrates are sometimes drastically reduced by naturally occurring pathogens, usually under conditions such as prolonged high humidity or dense pest populations (S. H. Dreistadt, 2007).

History of biological control

- In 900 A.D. Chinese citrus growers used red ant, *Oecophylla smaragdina* on mandarin trees to control leaf chewing insects. This was the first use of insect predators.
- In 1602, an Italian, Aldrovandi noted the hymenopteran parasite, *Apanteles glomeratus* laying eggs in the pupae of the cabbage butterfly, *Pieris brassicae*.
- In 1762, Indian mynah bird, *Gracula religiosa* was exported from India to Mauritius to control red locust, *Nomadacris septemfasciata*.
- In 1888, vadalia beetle, *Rodolia cardinalis* was brought from Austrilia and introduced into California (USA) to control cottony cushion scale, *Icerya purchasi* on citrus.
- In 1989, cocoinellid lady bird beetle, *Cryptolaemus montrouzieri* was introduced into India from Austrialia for the control of Coffee green scale, *Coccus viridis*.
- In 1929, Vadalia beetle, *Rodalia cardinalis* was introduced into india (Tamil Nadu) for control cottony cushion scale, Icerya purchase.
- In 1937, *Aphelinus mali* was introduced from North America into Tamil Nadu for control of apple wooly aphid, *Eriosoma lanigerum*.
- In 1960, a tachnid, *Spogossia bezziana* was introduced into India from Srilanka for the control of coconut black headed caterpillar, *Opisina arenosella.*

Biological Control

The use of natural enemies for the control of harmful insect, other animals and plants is known as biological control. The term biological control was first used by Smith 1919 to signify the use of natural enemies. In other word collecting and rearing of natural enemies in great numbers in the laboratories and releasing them on harmful insects, other animals and plants is known as biological control.

In general we can say that the study and utilization of predators, parasites and pathogens for the control of injurious insects is known as biological control.

The different bio-control agents are:-

1) Predators
2) Parasitoids
3) Insect pathogens

1. Predators: Predators are free living and require several preys to complete the life cycle. They tend to feed on preys smaller than themselves.

Ex: Coccinellid beetles, ground beetles, anthocorid bugs, syrphid flies, predatory mites. Coccinellid beetles are commonly called as ladybirds. These feed on aphids, scale insects, mealy bugs and mites. Both grubs and adults are voracious feeders. Vadalia beetle, *Rodolia cardinalis* is used for the control of cottony cushion scale on citrus. Australian lady bird beetle, *Cryptolaemus montrouzieri* is commonly used for the management of mealy bugs and scale insects. Coccinellids, *Pharoscymnus horni* and *Chilocorus nigrita* and *Stichlotis madagassa* are used in sugarcane for the control of scale insect, *Melanaspis glomerata*. Lady birdbeetle, *Curinus coerulens* is used for the control of phyllid, *Heteropsylla cubana* on subabul plantations. *Chrysoperla carnea* and *Mallada boninensis* are used in cotton and citrus ecosystem for protection from aphids and other soft bodied insects. *C. carnea* feed on aphids, red mites, thrips, white and black flies, eggs of leaf hoppers, moths, leaf miners and small caterpillars.

Anthocorid bugs are used in sunflower for the management of thrips, aphids, eggs and young larvae of mouth. Syrphid or hover flies are important predators of aphids of several crops. Syrphid, *Ischiodon scutellaris* is used in large scale in mustard and other crops. *Crytorhinus livedipennis* is the most promising predator for the control of brown plant hopper, *Nilaparvata lugens* in paddy. Predatory mites, *Phytoseiulus* spp. *Amblyseius* spp. are important in controlling phytophagous mites in several crop ecosystem.

2. Parasitoids: Each parasitoid requires only one host, which it kills for its development into a free living adult. Parasitoids are of the same size as the hosts, or sometimes even smaller. The adult food of parasitoids is different from that of larvae. Many adult parasitoids feed on nectar or pollen. Parasitoids may be specific polyphagous. The specific parasitoids are generally preferred for classical biological control for the management of introduced pests.

Parasitoids are of different types

a) *Egg prasitoids*: *Trichogramma* egg parasitoids are used for the management of tissues borers in sugarcane, stem borer in rice, boll worms in cotton and pests of several crops. *Trichogramma chilonis* is used for the control of bollworms in cotton, intermodal borer in sugarcane and rice leaf folder. *Telenomus remus* is used for the control of tobacco caterpillar.

b) Egg larval parasitoids: *Chelonus balackburni* is used for the control of spotted boll worm.c) *Larval parasitoids*: *Campolestis chloridae* is used the control of *Helicoverpa armigera*. *Bracon hebetor* and *Bracon brevicornis* for the control of coconut black headed caterpillar *Platygaster oryzae* is used for the control of rice gal midge.

d) Larval pupal parasitoids: *Isotima javensis* is used for the control of top shoot borer of sugarcane.

e) *Pupal parasitods*: *Trichospilus pupivora*, and *Brachymeria nephantidis* are used for the control of coconut black headed caterpillar.

f) Nymphal and adult parasitoids: *Aphelinus mali* is used for the control of apply wooly aphid. *Encarsia formosa* for the control of whitefly.

g) *Ecto-parasitoid*: Ecto-parasitoid, *Epiricania melanoleuca* is used for the control of *Pyrilla perpusilla* on sugarcane

3. Entomopathogens: Entomopathogens are disease causing organisms such as bacteria, viruses, fungi and protozoa in insect pest, which kill their host or debilitate the future generations. The infected insects are unable to feed properly, remain stunted, lose their body

colour and gets immobile or paralyzed. Under certain conditions they cause disease epizootics in the field.

T**he various entomophatogens are:-**

a) Entomopathogenic bacteria
b) Baculoviruses
c) Entomo-fungi
d) Protozoans
e) Entomopathogenic nematodes (EPN)

a) Entomopathogenic bacteria: They are extra cellular associated with insects and enter the body cavity through contaminated feed and multiply. Death of the insect may be either due to*intoxication*, sudden lack of oxygen, chemical changes in the gut or by the toxins or crystal produced in the bacterial cells. Several commercial products based on *Bacillus thuringiensis* and its sub sp. are available and are widely used for controlling lepidopteran pests. *B thruingiesnsis* is recommended for the suppression of *Helicoverpa armigera* on tobacco, sunflower and pulses; *Achaea janata* on castor; *Spodotera litura* on tobacco and beet root and *Adisura atkinsoni* on field beans. *Bacillus thuringiensis* var. *kurstaki* against Lepidoptera. *Bacillus thuringiensis* var. *galleraie* against wax moth *Bacillus thuringiensis* var. sandiego and *Bacillus thuringiensis* var. *tenebrionsis* against beetles and weevils. *Paenibacillus popilliae* is used against several species of white grubs including *Holotrichia consaguinea* and *Leucopholis coneophora* on groundnut and *L. lepidophora* on sugarcane.

b) Baculoviruses: Viruses are sub microscopic, obligate, intracellular pathogenic entities. Viruses in the family of baculoviridae are the best known of all the insect viruses because the disease symptoms are easily recognized and they have potential for the development as microbial insecticides. Baculoviruses are double stranded DNA viruses having bacilliform or rod shaped virions. Important sub groups with in the family are Nuclear Polyhedrosis Viruses (NPV) and the Granulosis Viruses (GV) which are widely used in pest control the NPVs are specific to host species or genus. GVs are more specific than the NPVs and are reported from Lepidoptera. Commercial formulation of NPVs are commonly used by the farmers for the management to tobacco caterpillar and gram caterpillar. Addition of optical *brighteners*, tannic acid, boric acid, jaggery improves the effectiveness of NPVs. NPV of *Amsacta albistrigs* and *A. moorei* are used on groundnut for the control of red hairy caterpillars. Ha-NPV is used for the control of *Helicoverpa armigera* on cotton, chickpea and groundnut. SI-NPV is used for the control of *Spodoptera litura* on tobacco, groundnut, black gram and cotton. GV of *Chilo infuscutellus* is used for the management of shoot borer on sugarcane**c)**

c) Entomofungi: Different enotmofungal pathogens such as white muscardine, green muscardine and yellow muscardine are known to attack various pest. The spores of the fungus directly penetrate integument of pest and body cavity is attack. The fungus with its mycelium and spores cover the body of host. *Beauveria basiana* against rice hispa, *Spodoptera litura* and lepidopteran tissue borers sugarcane. *Metarrhizium anisopliae* and *Beauveria brongniartii* against *Holotrichia serrata* and Leucopholis lepidophora on sugarcane and *Holotrichia consanguinea* on groundnut and on *Oryctes rhinoceros*. *Nomurae rileyi* against *Spodoptera litura*; *Fusarium oxysporum* on *Nilaparvata Lugens*, *Verticllium lecanii* on *Coccus viridis* and *Hirsutella thompsoni* on mites.

d) Protozoans: Protozo kill the insect either directly or by reducing the fecundity of the adult. Their effect on host is chronic. The prolong the larval life in the field, thus exposing the insect longer to predators and parasitoids. These are called debilitating infections. They are always associated with other pathogens. Ex : *Nosema melolonthae* against chaffer beetles *Farinocystis triboli* against red flour beetle *Nosema locustae* against grasshoppers

e) Entomopathogenic nematodes (EPN): Entomopathogenic nematodes (EPN) (Steinernematids and Heterorhabdits) directly attack the insect pest. The invasive larvae of

EPNs carry the associated bacteria *Xenorhabdus* sp. or *Photorhabdus* sp. In their gut, which not only kill the invaded host with in 24-48 hr but also produce a biostatic substance that retards the purification of the cadaver. The nematodes feed on these bacteria and are capable of producing several generations in their dead hosts. The EPNs are susceptible to desiccation. Ex: *Steinernema carpocapsae* and *Heterorhabdits bacteriophora* against soil inhabiting insects and tissue borers.

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