Research

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Biological control of major insect pests of vegetable crops

Biological control is widely acclaimed due to its target specificity, self-perpetuity and safety to the environment. Biological pest control is mainly achieved by using different parasitoids, predators and microscopic parasitic organisms. Large size organisms, visible with naked eyes, include mainly parasitoids (*Trichogramma spp.*) and predators (lady bird beetle, green lace wing etc.). Entomopathogenic organisms include bacteria (*Bacillus thuringiensis, B. papillae etc.*), viruses (*Nuclear polyhedrosis virus, Granulosis virus etc.*), fungi (*Beauveria bassiana, Metarhizium anisopliae, Lecanicillium* (*=Verticillium*) *lecanii,* etc.), or nematodes (*Steinernema*). The role of these organisms in the management of major vegetable insect pests of tomato, brinjal, okra and cole crops, etc. is discussed herein.

INSECT pests are one of the major biotic limiting factors to increase vegetable production. The crops losses to the tune of 30-40% due to insect pests have been observed in vegetable crops. Vegetable growers by and large depend on chemical pesticides to counter the problem of insect pests. The indiscriminate and excessive use of insecticides resulted in the development of resistance to insecticides in insects, resurgence of insect pests, besides various ecological problems like destruction of natural enemy fauna, detrimental effect on non-target organisms, residues in consumable products, etc. To overcome these problems, in many instances, alternative methods of insect pest management that offer adequate levels of pest control and pose fewer hazards are recommended. One such alternative is the use of biological control agents which are especially valuable because their toxicity to non-target organisms is extremely low.

Many of the vegetables such as tomato, cucumber, carrot, chilli, beet, radish, garden pea etc. are consumed as salad and thereby use of traditional synthetic insecticides may cause health hazards. Using different biocontrol agents would be a safer and cheaper option. Biological control can be defined as 'the action of parasites, predators or pathogens in maintaining another organism's population density at a lower average than would occur in their absence'. All biological control techniques entail using live natural enemy populations to either permanently or temporarily lower pest population densities while actively involving humans. Biological control of pests is a method of controlling pests (including insects, mites, weeds and plant diseases) that relies on predation, parasitism, herbivory, or other natural mechanisms. It can be an important component of integrated pest management (IPM) programs. Modern insect pests control highly rely upon chemical interventions resulting in many associated problems like resistance, resurgence, secondary outbreak of minor pests in addition to these environmental hazards. Therefore, utilization of biocontrol agents which are target specific, ecofriendly with self-perpetuating capacity is an alternate viable option for the pest management practices.

Types of biocontrol agents

Predators: Predators are large, free-living organisms that consume a number of preys during their life cycle. They are not generally specific to a particular species for their feeding. Eg. Lady bird beetle, green lace wing, rove beetle, spiders etc.

Parasitoids: These insects unlike predators complete their development in a single host whereas the adults are free-living. They generally attack the host larger than their size. The parasitoids that are having high host searching ability and high target and stage specificity can be used as a good biocontrol agent. *Trichogramma* sp are widely used egg parasitoid, similarly, *Bracon* sp. as larval parasitoid and *Trichospilus pupivora* as pupal parasitoid.

Pathogens: These are the microscopic parasitic organisms that are causing disease to the insects. These includes bacteria (*Bacillus thuringiensis, B. popillae*), virus (Nuclear polyhedrosis virus, Granulosis virus), fungi (*Beauveria bassiana, Metarhizium anisopliae, Lecanicillium* (*=Verticillium*) *lecanii, Nomuraea rileyi*), nematode (*Steinernema*).

Types of biological control

Broadly biological control can be classified into major types as:

- Classical biological control
- Augmentative biological control
- Conservational biological control

Classical biological control

In classical biological control, a natural enemy (NE) is introduced into a new area where they did not originate or do not occur naturally. This occurs specially when a pest is introduced in a new area without its natural enemy. This is generally done by Government agencies. Successful example of classical biological control is the control of cottony cushion scale of citrus (*Icerya purchasi*) by Vedalia beetle (*Rodolia cardinalis*) imported from Australia in the late 19th century in California, USA.

Augmentative biological control: Augmentation can be done by mass rearing of the natural enemies in laboratory and subsequent release in the field at proper time and proper rate. Augmentative biological control can be done by two ways

Inoculative release: Releasing small number of natural enemies in the field during the crop season and they will multiply and the offspring will control the pests for an extended period of time.

Inundative release: Mass culture and release of the NEs to suppress the pest population directly by themselves. These are more economical against pests that have only one or at the most of a few discrete generations every year. Eg. Inundative release of *Trichogramma* sp. as egg parasitoid, lady bird beetle, *Coccinella septempunctata, Menochilus sexmaculatus* etc.

Conservational biological control (CBC): CBC is among the earliest documented pest control measures, dating to third century BC in China, where bamboo poles were placed between trees in orchards to facilitate dispersal of predatory ants, thus enhancing predation of citrus pests. CBC can be defined as the modification of the environment or existing practices to protect and enhance specific enemies or other organisms to reduce the effect of pests.

Some of the practices that enhance natural enemy effectiveness are summarized below:

- Diversification of crop plantings using intercropping, mixed cropping, relay cropping, etc.
- Application of sugar-water or protein sprays to attract / maintain natural enemies
- Providing shelters or avoiding destruction of nests of social wasps
- Planting 'banker plants' that harbour alternative (non-pest) prey
- Altering harvest and/or cultivation practices to maintain 'refuge strips' for natural enemies
- Using cover crops to increase over wintering survival of natural enemies
- Planting flowers/using cultivars that provide pollen and nectar sources
- Avoid use of broad spectrum pesticides that are detrimental to the NEs

Some examples of biocontrol agents in vegetable pests management

Pests of brinjal: Among the different brinjal pests, brinjal shoot and fruit borer, *Leucinodes orbonalis* (Pyralidae: Lepidoptera) is important. Larvae bore the shoot as well as fruit of the plants. Damage due to this insect ranged from 11-93%. Inundative release of *Trichogramma chilonis* @ 2,50,000 parasitized eggs/ha or weekly inoculative release of 50,000 parasitized eggs/ha is promising. Conservation of the larval parasitoid *Trathala flavo-orbitalis* and pupal parasitoid *Goryphus nursei* (Cameron) (Hymenoptera: Ichneumonidae) is beneficial. Hadda beetle *Epilachna vigintioctopunctata* (Coccinellidae: Coleoptera) was reported as a pest of brinjal. Recently a serious proportion of its infestation was reported in cowpea in and around IIVR, Varanasi. Conservation of parasitoid *Pediobius foveolatus* (Eulophidae: Hymenoptera) is beneficial.

Grubs, pupae and adults of lady bird beetle, a polyphagous predator

Table 1. Difference between biological control and conservational biological control (CBC)

Parameter	Biological control	CBC
Fundamental goal	Curbing insecticide use	Manipulation of properties of crop and non-crop vegetation
Focus	Agroecosystems	Specific crop field
Area of interest	Promote the conservation of natural enemy diversity at the landscape level ranging from single cropping system, to complex areas with diverse cropping systems	Promote the conservation of natural enemy diversity within the field, and within a few adjacent fields within a farming unit by increasing taxonomic diversity of plants through mixed cropping, alley cropping, intercropping, and strip cropping etc.
Approach	Natural enemy of community as a whole	Enhance the activity of one or a few key natural enemies.

Red spider mite or *Tetranychus cinnabarinus, T. urticae* (Tetranychidae: Acarina) are the serious pests of brinjal, lady finger, beans, pointed gourd, cucumber, etc. both in field as well as in poly house conditions. Prolonged dry condition favours its rapid multiplication. Both the nymphs and adults suck the sap from the under surface of the leaves and in severe infestation from both side of the leaves. Profuse webbing is the characteristics symptoms of this non-insect pest. Release of predatory mite *Amblyseius tetranychivorus* (Phytoseiidae: Acarina) @ 100 mite/m^2 in greenhouse conditions will be promising to control this mite.

Pests of tomato: Tomato fruits are attacked by *Helicoverpa armigera* and *Spodoptera litura* (Noctuidae: Lepidoptera). Both the insects are polyphagous and feed on a number of vegetables. *H. armigera* lays eggs singly on flower, buds, tender leaves whereas *S.litura* lays eggs in masses covering in anal tuft of hairs mostly on under surface of the leaves. Larvae bores the immature fruits and feed on the internal content of the fruits and such fruits are unsuitable for consumption.

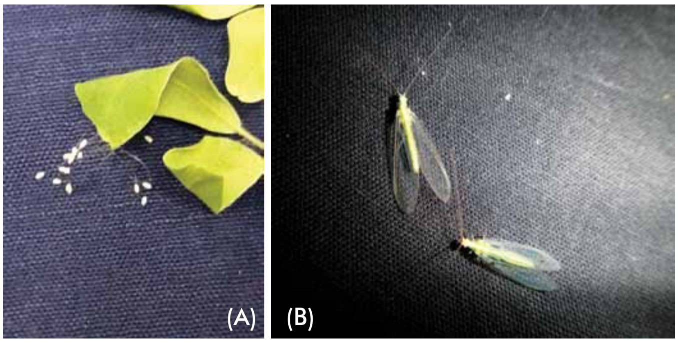
Campoletis chlorideae (Ichneumonidae : Hymenoptera) is an important larval parasitoid of *Helicoverpa* and conservation of this parasitoid and mass release of 15,000 adults per ha coinciding with 5th day after mass hatching of the eggs ensuring the sufficient larvae for parasitization is recommended. Periodical release of *Trichogramma* egg parasitoid @ 50000/ha at 10 days interval and six releases from 45 days after transplanting is beneficial. Spraying of HaNPV, a specific virus to *H. armigera* @ 250-300 Larval Equivalent mixed with jaggery (1%), Teepol (0.1%) per hectare at the evening hour is recommended. Three applications at fortnightly interval may be done. Spraying of *Bacillus thuringiensis* @ 1 kg/ha is recommended.

Table 2. Biocontrol agents recommended in vegetable crops

Bioagent	Dose	Target pest
Trichogramma pretiosum	2,50,000 parasitized eggs/ha (Inundative release) 50,000 parasitized eggs/ha (Weekly inoculative release)	Tomato fruit borer *(Helicoverpa armigera)*
Chrysoperla zastrowi sillemi	50,000 first instar larvae/ha (weekly release)	Okra aphid Cabbage aphid
HaNPV	250 LE/ha (10 days interval)	*Helicoverpa armigera*
SlNPV	250 LE/ha (10 days interval)	*Spodoptera litura*
Bacillus thuringiensis	500 g ai/ha (10 days interval)	Diamond back moth Shoot and fruit borer of brinjal and okra Tomato fruit borer

(Source: Rai *et al*. 2009. Integrated Pest and Disease Management, Training Manual, IIVR, Varanasi, Uttar Pradesh, pp.5.)

Solenopsis mealybug, *Phenacoccus solenopsis* (Pseudococcidae : Hemiptera) (Tinsley), an invasive, emerging, polyphagous pest has been observed in serious proportion on number of solanaceous (tomato, brinjal, chillies), malvaceous (lady finger) and cucurbitaceous (pointed gourd) vegetables and other crops including many weeds like *Parthenium hysterophorus.* Conservation of parasitoids, viz. *Aenasius arizonensis* Hayat (Encyrtidae: Hymenoptera) was promising. Amongst the entomopathogenic fungi tested, *Lecanicillium* (=*Verticillium*) *lecanii* @ 5 g/L is most effective against 7±1 day old nymphs of *P. solenopsis* under laboratory conditions.



Eggs (A) and adults (B) of green lace wing, a common predator in vegetable ecosystem

Pests of Cole crops: Diamond back moth (DBM), *Plutella xylostella* (Plutellidae: Lepidoptera) is a serious pests of cruciferous crops particularly cabbage and cauliflower. Damage due to this pest is reported up to 17-99%. One egg parasitoid, one egg-larval parasitoid and 29 larval parasitoids have been reported on DBM.

Cotesia plutellae (Braconidae: Hymenoptera), a larval, gregarious, endoparasitoid, is one of the most common parasitoid of DBM in India. On an average, 10-40% larval mortality is caused by the *C. plutellae.* The parasitoid was active from first week of February to second week of April with maximum parasitization during second fortnight of March synchronized with the maximum incidence of host larvae. The activity of parasitoid have a significant positive correlation with incidence of host larval population, temperature and sunshine, negative correlation with relative humidity and total rainfall. *Diadegma semiclausum* (Hymenoptera: Ichneumonidae) is one of the most important larval parasitoids of *P. xylostella* across the world whereas *D. fenestralis* is predominant in the hilly regions of India and extent of parasitization varied from 73.33 to 86.67%.

Bacillus thuringiensis var. *Kurstaki,* a soil-borne, gram positive, aerobic, spore forming bacteria is found very effective for managing the DBM. Commercial *Bt* formulations (*Bt* var *Kurstaki*) can be applied in the field @ 1 kg/ha.

Aphids (*Myzus persicae* and *Brevicoryne brassicae*): Both the aphids are the serious pests of cole crops like

Table 3. List of some parasitoids along with their hosts recorded from the vegetable ecosystems at ICAR-IIVR, Varanasi

Parasitoid	Host insect	Crop(s)	Major activity	Highest parasitization (%)
Aenasius arizonensis	*Phenacoccus solenopsis*	Tomato, Chilli, Okra, Brinjal	August – March	22.35
Diaeretiella rapae	*Myzus persicae, B. brassicae, L. erysimi*	Cabbage, Cauliflower	January – April	21.60
Pediobius foveolatus	*Epilachna vigintioctopunctata*	Cowpea, Brinjal	August – October	36.60
Campoletis chloridae	*Helicoverpa armigera*	Tomato, Pea	January – March	17.63
Apanteles paludicole	*Sphenerches caffer*	Bottle gourd	June – September	48.33
Trathala flavo orbitalis	*Leucinodes orbonalis*	Brinjal	August – March	17.25
Cotesia plutellae	*Plutella xylostella*	Cabbage, Cauliflower	February – April	22.35 25.75
Chelonus blackburni, Agathis sp.	*Earias vittella, E. insulana*	Okra	August – October	19.58
Microplitis tuberculifer	*Spodoptera litura*	Cauliflower	October – November	7.55
Cotesia glomerata	*Diaphania indica*	Cucumber	September – October	28.34
Neochrysocharis formosa	*Liriomyza trifolii*	Tomato, Marigold	December – March and January – March	37.50 48.30
Dinarmus basalis	*Callosobruchus chinensis, C. analis, C. maculatus*	Pea, French bean	July – October	33.33
Apanteles obliqua, Meteorus sp.	*Spilosoma obliqua*	Cowpea, Field bean, Brinjal	March – April	22.86
Brachymeria lasus	*Diaphania indica*	Bitter gourd, Cucumber	August – October	19.20
Pristomerus euzopherae	*Euzophera perticella*	Brinjal	May – July	12.48

Brachymeria lasus, an endoparasitoid of *Diaphania indica*

Pristomerus euzopherae, an endoparasitoid of brinjal stem borer, *Euzophera perticella*

Corcyra production unit at ICAR-IIVR, Varanasi

cabbage and cauliflower even under protected cultivations. Both the nymphs and adults suck the sap from the leaves resulting in the plants turning yellow and losing its vitality. Beside sap sucking, they also secrete the honeydew which when deposited on the plants creates black sooty mould which inhibits the photosynthesis. Conservation of solitary endoparasitoid *Diaeretiella rapae* (Braconidae: Hymenoptera) is effective. The parasitoid preferred maximum for cruciferous aphids is *Myzus persicae* (59%) followed by *Brevicoryne brassicae* (51%) and *Lipaphis erysimi* (46%). However, among the cruciferous aphids, highest parasitoid emergence was observed from *L. erysimi* (88%) followed by *B. brassicae* (81%) and *M. persicae* (80%). Peak period of activity of this parasitoid is February-March under Varanasi condition. Ladybird beetle, *Coccinella septempunctata, Menochilus sexmaculatus* (Coccinellidae: Coleoptera) is an important polyphagous predator of aphid and other soft-bodied insects. Artificial release of 25-30 beetles per square meter is effective to control the aphids.

Advantages of biological control

- Biocontrol techniques are target-specific with no or very few side effects, comparatively cheaper and eco-friendly as compared to synthetic chemical pesticides.
- Lack of residues on the marketed product and lack of phytotoxic effects on plants.
- Development of resurgence in pest against biocontrol agents is unlikely.
- With biological control agents, generally no waiting periods are required between application and harvesting of crop.
- Release of natural enemies is much more comfortable to spray personnel than applying chemicals.
- Biological control agents are very effective in inaccessible areas.

Limitations of biological control

- Biological control sometimes cannot bring immediate and absolute control to pests.
- Biological control restricts the subsequent application of chemical pesticides.
- Sometimes biological control may be uncertain / unpredictable.

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