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Biological management of "*Helicoverpa armigera*" using different predators and parasitoids

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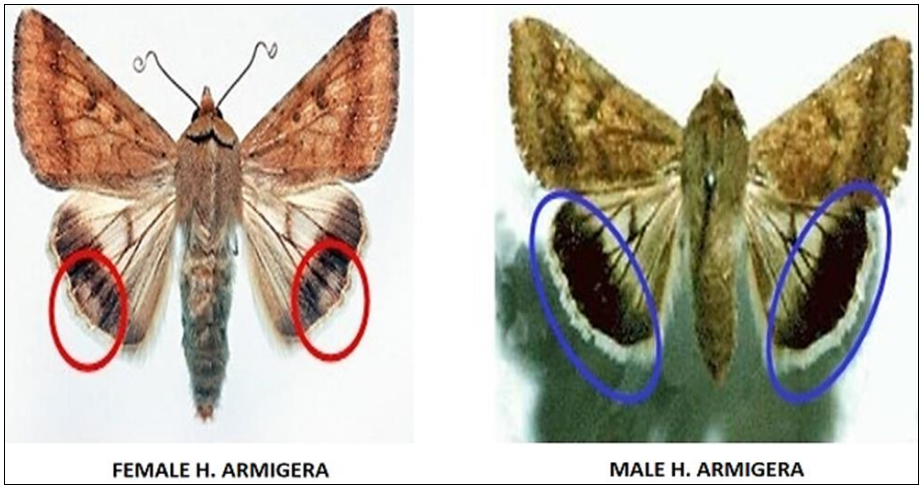
Abstract
As we all know agriculture is the combined study of all things i.e., soil science, agronomy, biotechnology, breeding, entomology etc. in this field we have to deal with every aspect of problems. In this paper we have discussed about the species *Helicoverpa armigera* and its management practices, the species cause many problems and damage the crops by feeding on them, the common name of this pest is cotton bollworm the name itself indicates that it majorly feed on the cotton plant along with chickpea, chilli, tomato, sorghum etc. There are many other practices used to eliminate the pest and insect like by using synthetic or chemical products but there may have some negative effects on soil and plant, to avoid this method one can opt to biological methods like use of parasitoids, predators and entomopathogens. As these methods are very effective and cost very low and along with this they are eco-friendly. In IPM (Integrated Pest Management) biological method plays very important role. In organic farming no chemical products are used for management of pests. This method is also used in USA and other developed countries. There are many species of parasites and predators like various birds which feed on the larva of cotton boll worm, at different stage bollworm feed on the leaves of plant at 1st and 2nd stage the larva of bollworm feed on the reproductive part of plant i.e., flower or flowering bud which cause huge loss of the plant. So, to avoid the loss farmers prefer biological method.

Keywords: *H. armigera*, biological control, predator, parasite, parasitoids, synthetic

Introduction
"Helicoverpa armigera" or commonly known as many names as possible like cotton bollworm, corn earworm (in UK), it is basically a moth larva which feeds on number of plants which include crops too. It comes under the species of polyphagous and cosmopolitan pest, there is also other larvae with same name i.e., *Helicoverpa zea* (Ahmed 2009). Usually, people get confused between these two. There is a variety of cotton bollworm with different shape and sizes as the length can reach up to 12 to 20 millimetres with 30 to 40 millimetres of wingspan (Ali *et al*., 2009) [2]. The colour of the wings in female are yellowish to orange, and in male it is greenish grey and in the distal third there is little darker transversal band as shown in (figure 1).



Source:http://www.agroatlas.ru/en/content/pests/Helicoverpa_armigera/
http://lepidoptera.butterflyhouse.com.au/heli/punct.html

Fig 1: Male and Female *H. armigera*

The cotton bollworm can feed on various type of food as they are polyphagous in nature, the most common plant in which they feed on are tomato, pigeon pea, cotton, sorghum, cowpea, and rice (Ch *et al.*, 2015). As they feed on these crops rapidly they are becoming more threat to farmers as they damage the crop, the major threat caused by bollworm is in the plant cotton, tomatoes, maize, alfalfa and tobacco. The population of this species are increasing day by day due to their rapid reproduction, where they lay 100 of eggs at a day. Mostly cotton plants are the one where they feed on, they usually attack the cotton blooms due to which the plant remains fruitless or premature which cause heavy loss (Ch *et al.*, 2015). In this paper we will discuss the life cycle of this species, problem caused by them and different methods by which we can prevent them by feeding on plants. To manage these species, we must know their lifecycle and morphology and their function too (Ch *et al.*, 2015).

Life Cycle of *Helicoverpa armigera*

To fully develop *H. armigera* takes about 4 to 6 weeks from egg usually in summer and in spring the time taken is little bit longer around 8 to 12 weeks. If the weather is warm around 25°c then the fertile egg will hatch in 3 days, if the weather is cool, it will take time like in 6 to 10 days the egg will get hatched (Cherry *et al.*, 2005). The stage called black head stage where they change their colour from white to brown. The survival percentage of eggs may depend up on the various physical factors like if there is heavy rainfall or high wind the eggs will fall off from the leaves and they die, or the eggs will be dehydrated if the temperature is very high larvae also get killed (Ballal & Verghese, 2015) [4]. The neonate (hatching larva) eats through the shell of eggs, the length is up to 1-1.5mm, the head colour is brown to black or white yellowish and there will be dark spots all around the body. The development of larvae goes through six stages of development and about 2 to 3 weeks it become fully grown in summer and in winter it takes 4 to 6 weeks (Downes *et al*., 2017) [7]. If the temperature is high the development of larvae is fast as compared to winter, the size of fully grown larvae is 40-50mm and colour may vary. When the larvae become fully grown, they try to reach base of the plant, up to 10cm tunnel and into the soil and they pupate by forming chamber. The duration of pupa is dependent on the temperature, in summer it takes 2 weeks while up to six weeks in winter (Cherry *et al.*, 2005). In females the colour of forewings is in brownish to reddish brown in colour, while in male the colour is dull greenish to yellow. In the middle dark region, there is a pale patch, and the margins of hindwings are dark with pale broad middle part (Ballal & Verghese, 2015) [4]. Usually, they feed on nectar and only live for 10 days, around 1000 of eggs laid by females in cluster on leaves, flower buds growing points and in developing fruits or even stems too. And again, this whole life cycle continuous as shown in (figure 2) (Downes *et al*., 2017) [7].

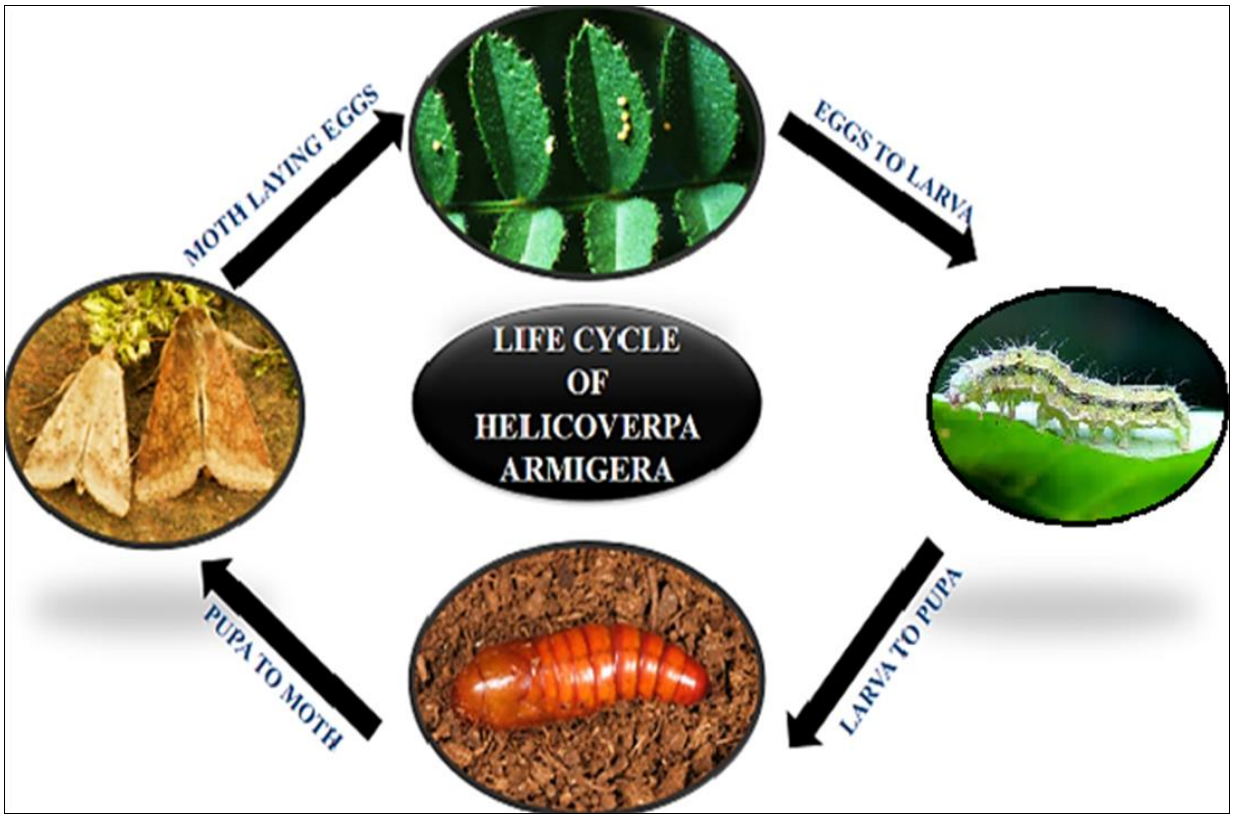


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Fig 2: Life Cycle of *H. armigera*

Problems caused by *Helicoverpa armigera*

Globally the most problematic pest was considered is *H. Armigera* or known as cotton ballworm, among all insect pest *Helicoverpa* is one of the pests that cause major problem to farmers (Fathipour & Sedaratian 2013) [8]. If we talk about its geographical distribution it is extended up to all continents but most damage was observed in semi-arid tropics, it can feed on over 20 crops and 180 wild plants in India only. It has become some serious issue as most of the host plant is cotton and cereal crops and mitigation is very difficult, along with cotton there are also other plants which are hosts to cotton bollworm are chickpea, tomato, chillies etc. as shown in (figure 3) (Ballal & Verghese 2015) [4]. Annually the loss of 290 to 250 million dollar was recorded as tronimally. Around 10 to 30% average loss is done by insect pest in cotton. In grain of pigeon pea, the total loss of 50 to 60.5 caused by *Helicoverpa*, and according to survey it was recorded that 44% pod damage in northwest plain of India in 1974-81 (Forrester *et al*., 1993) [9].

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Fig 3: Damage caused by *H. Armigera* in cotton, chickpea, tomato and chilli

The major loss was mostly caused by larvae which feeds on the flower buds, flower and leaves of the plant. As soon as they hatch, they start to feed on reproductive structures like flowers of the mung bean the third instar where the larva is around 8 to 13mm long they start feeding about 90% which cause major damage, but the most damaging stage is when the larvae is about 24mm (Forrester *et al*., 1993) [9].

Damage in Various Crops

Chickpea: In chickpea the damage of plant started from seedling stage to maturity, the young leaves are the main food of larvae at the stage 1st, 2nd and 3rd instars. They destroy the whole seedling, flower and their buds. At the stage of pod formation usually the population of larvae increases, they dig the pods and feed on seeds (Gowda, 2015).

Cotton: Holes are made at the base of flower buds by the larvae along with this the shoot and leaves are consumed by this instar (Gowda, 2015).

Tomato: The larvae feed on leaves, flower and their buds during eclosion, they bore the succulent parts of the plant and even in the developing fruits, which caused some serious damage (Gowda, 2015).

Corn: The silk is the site where they lay their eggs, where first and second instar feed on, after which third and fifth instar feed on the ear and hide itself from natural enemies or other predators (Gowda, 2015).

Peanut: The larvae attack the leaves and sometimes flower too and due to the severe feeding plant suffers from defoliation (Gowda, 2015).

Pearl Millet: At the various stage of development like flowering, milky grain and hard grain larvae feed on panicle of the plant. During 1st and 2nd instar larvae feed on the plant but after they form a false web from their own excreta and remain hidden underneath the dried florets (Gowda, 2015).

Sorghum: In the panicle of flower 85% of the eggs are laid, the larvae feed on anther after the eclosion then they switch to seeds which are in developing phase as they step in their 4th instar (Gowda, 2015).

Management Practices to Control *H. armigera*

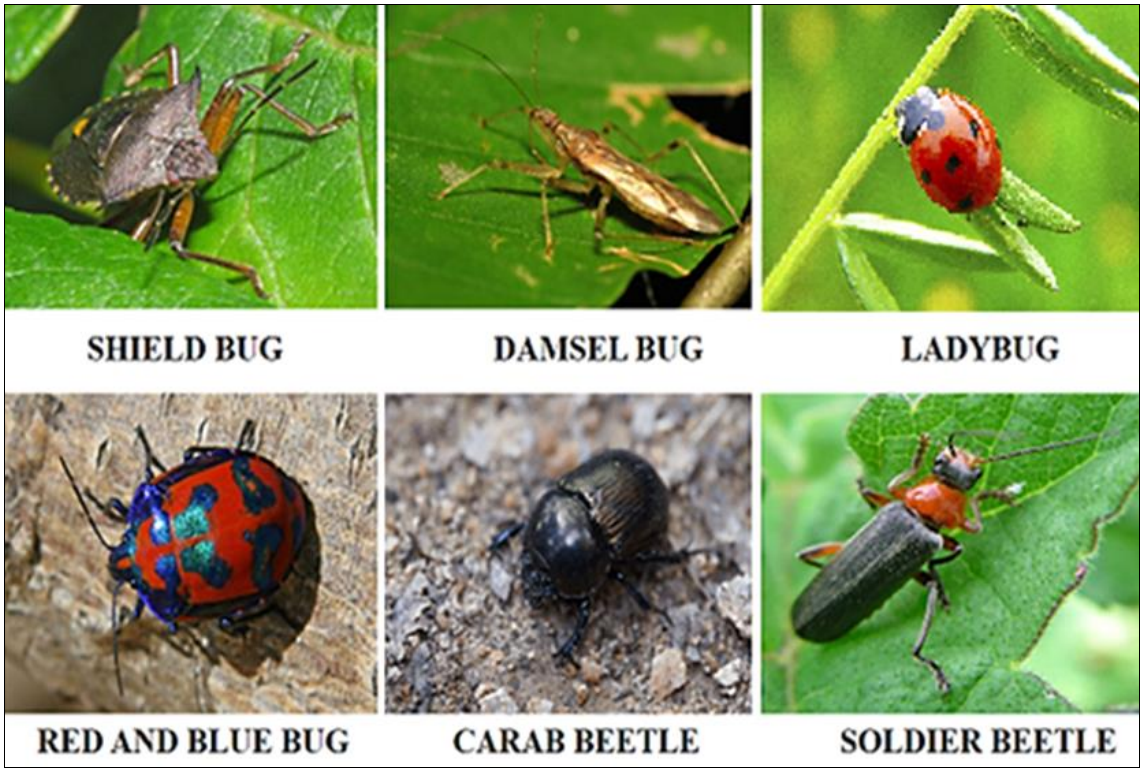
As we discussed earlier in this article that how much damage is caused by the cotton bollworm, to manage the attack of this species there are many management techniques used by farmers i.e., host-plant resistance, genetically engineered plants, chemical methods, and biological control (Herald & Tayde, 2018) [11]. In host-plant resistance method, the farmer cultivates the crops which can tolerate the feeding of cotton ballworm or resistant to it. There are many crops that have the ability to not attract this pest, as the resistance of plant depends upon the cropping system and its type of resistant. The other method is genetically modified plants, genetically engineered plants have the genes of unrelated plants. The genes were collected from superior plants which are both resistant and tolerant to insect and pest and they are modified as per the need (Patil *et al*., 2007) [13]. The most effective management technique is biological control. There are various variety of insects, spider, rodents and birds which feed on the cotton bollworm in their different stages of lifecycle (Herald & Tayde, 2018) [11].

Management of *H. armigera* by Using Predators and Parasites

This type of control management technique is used where the population is less by introducing parasites, pathogen and predators. By releasing the exotic natural enemies' biological control has been initiated (Patil *et al*., 2007) [13].

By Introducing Predators

There are various types of predators which feed on *helicoverpa*, at the stage of eggs and larvae which include predatory bugs i.e. shield bug, damsel bug, predatory beetles i.e. ladybirds, red and blue beetle, carab beetle and soldier beetle, green and brown lacewings and ants, they feed on the larvae of cotton bollworm and reduce the population of this pest as shown in (figure 4) (Fernandes *et al*., 2015) [14].



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https://www.ourbreathingplanet.com/wp-content/uploads/2018/07/1-15.png
https://www.marinrose.org/care-basics/beneficials/soldier-beetles/

Fig 4: Predators of *H. Armigera*

By Using Parasitoids

The eggs, larvae and pupae of *Helicoverpa* is the food of some wasps and flies. Basically, they did not kill the larva they just slow down the host and feeding of caterpillar and reduce the damage. The species of small wasp which is used as a predator are, *microplitis*, *Trichogramma* and *telenomus*, large parasitioid wasp's species are *Netelia*, *heteropelma* and *ichneumon*, some fly's species are *carcelia* and *chaetopthalmus* as shown in (figure 5) (Sai *et al*., 2018) [15].

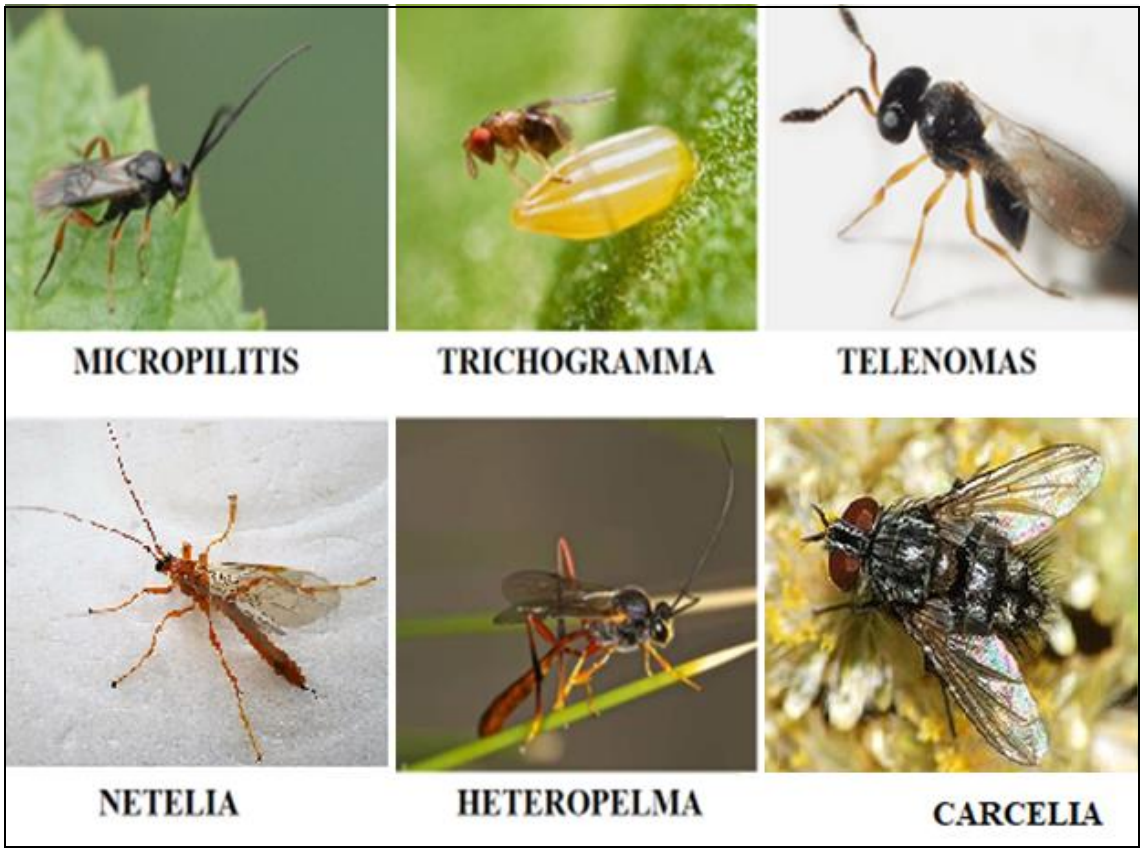

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Fig 5: Parasitoids of *H. armigera*

According to the locality and place the importance of parasitoids and predators vary, if we take an example of Kenya, crops like sunflower, maize, sorghum and cotton the infestation of *H. Armigera* was controlled by Anthocoridae (Sai *et al*., 2018) [15].

As we say prevention is better than cure, it is better that in initial stage we prevent them by spreading, we must follow some preventive measures because as the population increased, controlling them will become difficult (Sharma *et al.*, 2018). First of all, use the resistant variety or plant early to avoid infestation of pest, or to avoid spread of pest sow the seeds at some distant, or introduce some birds or insect parasite which can feed only in pest not in plants, inspect the plant at every stage (Sai *et al*., 2018) [15]. If the larvae population is less we can even hand-pick them and kill them before it damages the plant, infected plants have to be removed from the field as soon as possible, the residues should be cleared on time, avoid monoculture and prefer multi cropping, intercropping or relay cropping (Wubner, 2016). There are other management options too known as cultural manipulation at the time of sowing application of fertilizer minimize the population of pest, along with this deep ploughing is also very helpful. Flooding the field is also very helpful, in crops like marigold, soybean, mungbean and cowpea practices like intercropping and strip cropping is very helpful. Strip cropping is very advantageous if we are preferring chemical method (Wubner, 2016).

Conclusion

As there are many methods of insect pest control but the biological control method is regarded as the safest method among all the methods. The biological control method is environment friendly as well as it does not provide harm to any beneficial insect. Different predators and parasitoids are used to control *Helicoverpa*

armigera. To control this pest, the best stage is larval stage, so the control of this insect at larval stage is must because after that this will harm the crop drastically. At the flowering stage, the incidence of bollworm increases so the control at this stage is very important. There are many other control methods but the biological control method is regarded as best. The incidence of this pest is very much on cotton crop hence, it is also known as cotton bollworm. The crops like cotton, peanut, pearl millet, sorghum, tomato, chickpea and corn are affected by this pest but the control is also available. This pest damages the cotton crop at a very peak level so it is suggested to use the resistant varieties of cotton as well as famer can opt the biological control method. For the control of *Helicoverpa armigera* various predators are used like shield bug, damsel bug, predatory beetles i.e., ladybirds, red and blue beetle, carab beetle. All these predators are very good for controlling this pest. Wasps and flies are also used as parasitoids for the control of *Helicoverpa armigera*. The use of biological control method is one of the best methods.

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