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AMERICAN BOLLWORM (*HELICOVERPA ARMIGERA*, HUBNER) A POLYPHAGOUS PEST OF COTTON: A REVIEW

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Abstract

Cotton (*Gossypium* sp) popularly called white gold is one of the important commercial crops of India and around 26% of global cotton production happens here only. The crop is attacked by 1326 insect pests. Among them, 12 are major pests and the bollworm complex are most destructive pest. American bollworm is one of the polyphagous, serious, and hard to control pest of cotton in the Indian subcontinent, frequently distributed in most places, alternatively feeding on nearly 181 plant species including majorly all pulses, tomato, tobacco etc crops. The brown coloured moth with a 'V'-shaped speck on the forewing and dull black border on the hind wing which usually lay their eggs singly on the bolls by inserting their head and the body is in hanging position. The persistence of the *Helicoverpa armigera* for having a large number of the host range makes it a great threat in the agricultural field. The adults are mainly nocturnal so it is difficult to control them by only the chemicals. It is advised to go for the biological, cultural, and mechanical control combinedly for the better and long term result and this are also environment friendly.

Keyword : American bollworm, *Helicoverpa armigera*, Polyphagous pest, Natural enemies, IPM Component.

Introduction

Cotton (white gold) is a very important crop for the growth of the Indian economy and livelihood of the Indian cotton farming community. In the 312 lakh hectares of total world's cotton cultivation area around 117 lakh hectares of area are from India which means it's around 37.5%of the total global cotton cultivation area with a 26% (i.e. 6.20 mt) of the global cotton produce(i.e. 23.92 mt). (Chockalingam, n.d.) According to 'The Cotton Corporation of India Ltd.' last year (2019-20) cotton has been cultivated in 125.84 lakh hectares and the total production 360 lakh bales (170kg =1 bale), and the productivity of 446 kg per hectares is recorded.(CCI, 2018)

American bollworm is one of the most serious, polyphagous insect pests in the world. In India, *H. armigera* has been recorded at least 181 plant species from 45 plant families(Manjunath et al. 1989) including major crops such as cotton(*Gossypium* spp.), tomato (*Lycopersicon esculentum* Mill.), pigeon pea (*Cajanas cajan*), chick pea(*Cicer arietinum*). (Romeis & Shanower, 1995).In every crop there are some infestation is seen in the early stages due to the voracious feeding on the leaves by the larvae of the *H. armigera.* But there is a particular stage in every crop which the infestation is more. In cotton in the boll forming stage the infestation is highest. Same like in the pigeon pea and the chick pea in the pod forming stage, the infestation is the highest. In the tomato crop the fruit forming stage, is the most infested stage. American bollworm is a brown coloured moth with a 'V' shaped speck on the forewing and dull black border on the hind wing. It has 7 days of egg period and the eggs are laid singly on the surface of the leaves. The full-grown larvae are about 2 inches long and in its 14 days of the larval period, it shows a colour variation from the greenish to brown. The 10 days of the pupal period mainly happens in the soil. (TNAU, n.d.). This has symptoms of larva's voracious feeding on leaves. The larvae eat the internal part of the boll by thrusting its head

in the boll and the rest of the body is outside of the boll so it look like a hanging larvae. Heavy infestation in the field can destroy the whole crop. The Economic Threshold Level is 10% or one larvae/egg per plant. It is a hard to control pest because of its large host range. Understanding the bio-ecology of American bollworm in relation to climatic parameters is indispensable to control the pest properly. (T.V.Prasad, 2019). When there is identification of this pest in the field for chemical management we can use the endosulfan 35EC 0.2l/ha or quinalphos 25EC 2.0l/ha. Most effective way to decrease the infestation of this pest is the use of Bt- cotton. The *Bacillus Thuringiensis* kurstaki is mainly used for the lepidopterans. And others like *Trichogramma chilonis* as egg parasitoid, *Chrysoperla carnea* as a predator and the HaNPV virus is used to control this pest. And for controlling the next generation of this pest the pheromone traps are used in which males are being trapped because of the use of the sex pheromone Heli-lure which attracts the males.

Nomenclature and systematics position

The common name of the *Helicoverpa armigera* is mainly depends on the infestation on the particular crop plant. For example in the cotton crop it mainly infest the fruit which is called 'balls', so this pest is named as cotton bollworm and in grams its mainly infest the pods so it's called pod borer and in the tomato crop its mainly infest the fruit so it's called as the tomato fruit borer. *Helicoverpa armigera* is polyphagous pest which is very hard to control.The systematic position of the *Helicoverpa armigera* is – Domain: Eukarya Carl Woese et al, 1990; Kingdom: Metazoa Ernst Haeckel, 1874; Phylum: Arthopoda Von Siebold, 1848; Class: Insecta Linnaeus, 1758; Order: Lepidoptera Linnaeus, 1758; Suborder: Heterocera Fabricius, 1775; Family: Noctuidae Latreille, 1809; Subfamily: Heliothinae Boisduval, 1828; Genus: *Helicoverpa* Hardwick, 1965. (Wikipedia).

Synonymy

Helicoverpa armigera, Hubner (1805); *Heliothis obsoleta,* Fabricius (1775);*Noctua obsoleta* Fabricius (1793); *Heliothis pulverosa* Walker (1857); *Heliothis uniformis* Wallengren (1860); *Helicoverpa armigera* subsp. Commoni Hardwick, (1965); *Heliothis rama,* Bhattacharjee & Gupta (1972); *Chloridea obsolete* Duncan & Westwood (1841). (Husain & Hasan, 2020).

Distribution

Helicoverpa armigera is a very serious pest of the whole world. In India in 181 plants species from 45 plant families this pest is recorded (Manjunath et al 1989). In India more or less in every state we can notice the infestation of this pest. Those states which are majorly affected by this pest is Punjab, Haryana, Madhya Pradesh, Bihar, Andhra Pradesh, Kerala, Karnataka, Gujrat, Tamil Nadu, West Bengal etc. (CABI, 2020).

Host range

Helicoverpa armigera (Hubner, 1805) the cotton bollworm is a polyphagous pest moth invading a large number of the plants.(Matov *et al*, 2008; Robinson et al, 2010; Paul et al, 2016; Subhalaxmi, 2018). Matov et al (2008) recorded the larvae from wide range of herbaceous plants, shrubs and trees belonging to 38 families, mostly crop of cotton and tomato. The larvae feed on a wide range of the host plants including many important plants. Examples of that plants are, cotton (*Gossypium arboreum*); okra (*Abelmoschus esculentus*); rice (*Oryza sativa*); oat or jui (*Avena sativa*); sorghum or Jwar (Sorghum bicolor); Maize (*Zea mays*); ground nut (*Arachis hypogaea*); pigeon pea (*Cajanus cajan*); chick pea (*Cicer arietinum*); urd bean (*Vigna mungo*); soyabean (*Glycine max*); pea (*Pisum sativum*); moong bean (*Vigna radiata*); the black eyed bean or cowpea (*Vigna unguiculata*); lucerne (*Medicago sativa*); the French bean (*Phaseolus vulgaris*); the castor bean (*Ricinus communis*); the capsicum (*Capsicum annuum*); tomato (*Lycopersicum esculentum*); the tobacco (*Nicotiana*

tabacum); black nightshed (*Solanum nigrum*); potato (*Solanum tuberosum*); brinjal (*Solanum melongena*); safflower (*Carthamus tinctorius*); chrysanthemum (*Chrysanthemum indicum*); the oriental plane (*Platanus orientalis*). It also attacks the weeds like pigweed or jangli palak (*Amaranthus sp.*), Bhang or Ganja (*Canabis sativa*). Major host plant of this pest in India is cotton, pigeon pea, cow pea, moong, sorghum, tomato, marigold etc.

Biology

H. armigera is a holometabola insect, so it has four distinct stages in the life cycle of the bollworm, egg, larvae, pupa, and adult. Life cycle of *H. armigera* take about 30-34 days with an average temperature of 28 degree celcius from egg to adult (Zalucki *et al* 1986) It is a multivoltine insect with diapause, highly fecund and capable of moving long distances as adults (Fitt, 1989). Thus they can rapidly exploit host crops, particularly monocultures. Female moths sized 18 to 19mm in length with a wingspan of 40mm, male moths are usually smaller in size as compared to the female moths with a wingspan of 35mm.Some research scholars from the Aligarh Muslim University conducted and detailed investigation on the *Helicoverpa armigera* with a very controlled environment in the laboratory and revealed that single female produced 413.00 ± 1.89 eggs. The incubation period of egg was 3.37 ± 0.09 days and their size varied 0.42 to 60mm in length and 0.40 to 0.55mm in breadth. The average duration of the first, second, third, fourth, fifth and sixth instar larvae were respectively; 2.27 ± 0.08, 2.42 ± 0.08, 2.67 ± 0.07, 2.83 ± 0.07, 3.40 ± 0.10 and 337 ± 0.11 days. The aged larvae showed lateral brown strips and yellow to green colour. The head as well as pro-thorasic legs were brown to black (Ali, et al., 2009).

Eggs : Freshly laid eggs of *Helicoverpa armigera* are usually pale white and changed in dark brown before hatching. Eggs are rigid and clinodome shaped and the apical area of the egg was smooth and the rest of the surface sculptured in the form of longitudinal ribs. The incubation period of the eggs is nearly 3-4 days. Those eggs did not hatched in 5 days, they are infertile. The average percentage of eggs hatched was recorded as 53.33 ± 0.47%.

Larvae : The larval period of *Helicoverpa armigera* completed through six distinct instar. The first and second larval instars were yellowish-white to redish-brown with a dark brown to black head capsule. First instar measures between 35-42mm in length. The movement of first and second instar larvae is very little. The prolegs were developed in third instar stage on 3rd, 4th, 5th, 6th, and 10th abdominal segments and remained until the last larval instar. The last instar larvae is more voracious in nature and eats about80% of the total food consumes by the larvae. A full grown larva was brown to green in colour with lateral brown strips and the head as well as prothoracic legs were dark brown to black in colour. The larval stage is of 15 to 30 days depending on the environ factors and the weather condition.

Pupa : The pupa of *Helicoverpa armigera* was obtect type and the anterior and the posterior ends of the pupa are round and two parallel spines can be seen on posterior side. Pupa is brown coloured. This stage took minimum and maximum period of 10 to 14 days respectively. The pupal stage is mainly held in the soil.

Adult : The bollworm moths are very readily seen in the cotton field and are more active at night. At night they mainly come out of their hiding points to oviposite and for the seek of food. But adults are not foliage feeder they only feed on the nectar secreted by thw cotton plants and other host plants. At the vertex of the tail, hair tufts can be seen. Male moth sized smaller and owns a wingspan of 35mm. Female moths owns a wingspan of 40mm and lay their eggs from 2nd to 7th day of their lifespan. Lifeapan of the moth depends pn the availabality and the quality of the foodstuff.

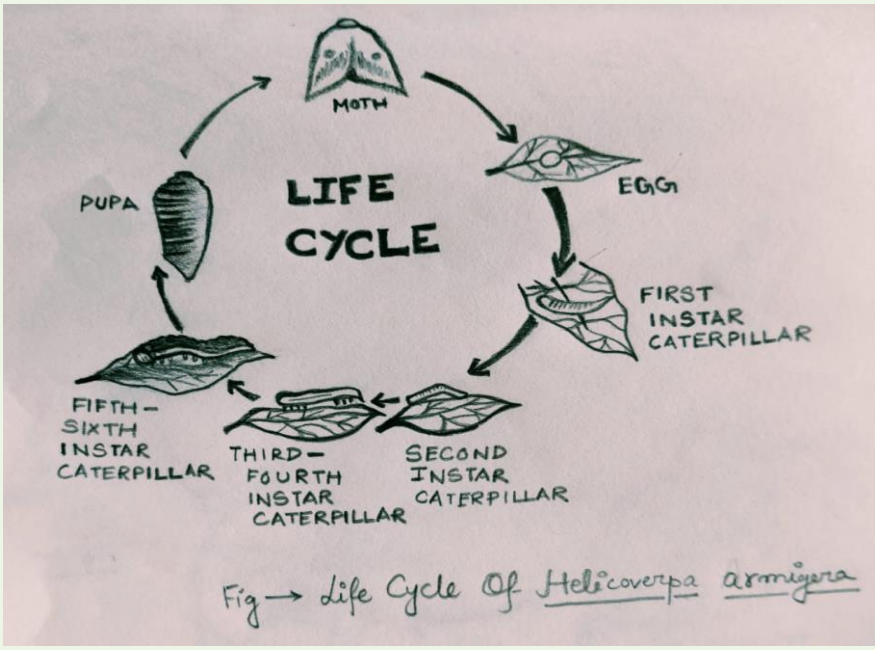

Fig → Life Cycle Of Helicoverpa armigera

Status and Extent of damage

The *Helicoverpa sp.* cause considerable economic losses to the agricultural and the horticultural crops. Both the quantity and the quality of the major agro-products like cotton, all pulses, sorghum etc and the horticultural products like the tomato, chilli, capsicum, okra, brinjal etc. are greatly damaged by this pest. The first, second and third instar larvae initially feed on the foliage but after the flower emergence they mostly feed on the flower and flower buds, after the fruit emergence the fully grown larvae mainly feed the inner part of fruit by inserting their head and where their body is in hanging position. The American bollworm attacks the plant in all stages and feeds on the leaves, flowers, and fruits. The damaging of flowers leads to the low amount of the fruit settings and then those fruits are also destroyed then we can say that the whole crop loss and the adults also feed on the nectar of the cotton flower.

Existing practices to check the infestation of the *Helicoverpa armigera*

Because of its high mobility, survival rate under adverse conditions, capacity to complete several generations in a year and ability to develop resistance against insecticides, its management is very difficult. Being polyphagous in nature, it causes damage to several crops but economic damages occur in cotton.

Monitoring

The monitoring of American bollworm is been done through pheromone trap. In the Integrated Pest Management (IPM), monitoring is one of the major components. Monitoring helps us to check the pest population in the field and also to understand the major factors behind the increase of the pest population which eventually helps to forecast its incidence in the field. Pheromone trap with the sex pheromone 'Helilure' is used to trap the male insects and after that from the pre designed models prediction of the numbers of the larvae is done. The ETL level of this pest is one egg or one larva per plant. It has been seen that the number of the trapped moths is in the pick in the two times of the year once in the April-May and another one is in December – January (Patil, Goyal1, Chitgupekar, Kumar, & El-Bouhssini, 2017). So in the cotton crop we can see an emergence from the pest from the seedling stages.

Cultural methods

Sowing time : Sowing cotton at the optimum time is one of the most important factors affecting crop yield. Weather factors such as temperature, wind speed, sunshine hours plays an important role in regulating the population of *Helicoverpa armigera*. Temperature helps in the growth of the larvae and rainfall and the humidity inhibit the growth. Early sowing is very effective process to control the pest and reduce the damage percentage (Garg 1990; Choudhary et al 2015; Parmar et al 2015).

Crop rotation : It is one of the key factors to control the American bollworm because it has been seen that if we directly cultivate the cotton crop right after the pulses then the infestation is more due to the pupae in soil. Also in single set of cultivation they got resistant to pesticides also so variation in the crop cultivation is very important.

Deep ploughing : The pupal stage of the *Helicoverpa armigera* mainly happens in the soil so the deep ploughing expose the hibernating pupae in the sunlight which helps to destroy them.

Trap crop : Trap crop is another important factor. We can use trap crop to reduce the infestation of this pest on the main crop. Trap crop is nothing but another host plant of that same pest we planted in the edges so that the pest attacks in that crop not the main crop. By this method we actually gets good amount of grains from the main crop.

Host plant resistant : Growing such varieties which are resistant to the pest or which are tolerant to some extent of the pest infestation or those which are less attractive to the pest for their oviposition is one greatest method of management of the pest in the regional area. (Kennedy et al 1987; Fitt 1988) Some resistant varieties are LD-135, L- 1245, Sujata, Abadhi, and LK- 861.

Mechanical method

Hand picking : Hand picking and destruction is one of the key management work done by the any farmer. If one can observe any larvae hanging from the bore hole of the cotton bolls pick it by your hand and destruct them in the fire or kill them.

Pheromone trap : Pheromone trap with the sex pheromone Helilure trap the male moths of the field which helps in monitoring and also control the next generation of the pest.

Biological control

Using the natural things to control the pest population is called biological controls. It includes the entomophagous insects, pathogens, predators, parasitoids, plant derived products etc.

Neem-based pesticides : Parts of the neem plant is used to make pesticides which are very effective against the insects. Pest has developed resistance against chemical pesticides hence this can be used as substitute of those insecticides. As well as it is plant product and does not leave any harmful residue to the crop plant which is very good for our health and also the farmer's health (Boeke *et al* 2004). Paul 2007, added neem based pesticides names in his list of pesticides.

Bacteria : *Bacillus thuringiensis* is the bacteria we are using in India. *Bacillus thuringiensis* is discovered in Japan in 1901 by Ishiwata, officially described by Berliner in 1915, isolated from Mediterranean flour moth in province of Thuringia in1911 and hence the name. It's a gram positive, aerobic bacterium, contains parasporal body (known as crystal) that is proteinaceous and possesses insecticidal properties. The parasporal body comprises of crystal and is tightly packed with proteins called protoxins or endotoxins. In India strain – Kurstaki, HD-1 is used to control the bollworm.

Virus : Most of the species of the cotton bollworm have at least some degree of the infestation of the Nuclear Polyhedrosis virus or NPV. IN India HaNPV is used against the *Helicoverpa armigera.* NPV is an obligate pathogen. The virus consists of a proteinaceous polyhedral occlusion body inside which the various or virus rods are embedded. Due to alkaline gut juice, the viruses are liberated, which attack nuclei of cell tissues, fat-bodies, tracheal matrix, haemocytes, ganglia, and brain.

Fungi : In the list of the entomopathogenic fungi *Beauveria bassiana* causes some infestation of some species of the bollworm.

Parasitoid : Ecto parasitoid wasp like *Habrobra conhebetor* (Hymenoptera, Braconidae) and endo-parasitoid like *Trichogramma* sp. (Hymenoptera, Trichogrammatidae) is used as the parasitoid of the *Helicoverpa armigera*. Like *Trichogramma chilonis* is used as the egg parasitoid. (Husain & Hasan, 2020).

Predator : In India *Chrysoperla carnea* is used as the insect predator of the *Helicoverpa armigera.* But other than some birds like house sparrow, black drongo, mynah etc helps naturally to control the boll worm.

Chemical control

In India for the management of the bollworm heavy use of the insecticides has been noticed and for which gradually the pest develops resistance to the most of the popular insecticides. We know that the chemical control is fastest way to control the pest we also have to keep in mind that the excessive use of the chemicals are very harmful for the environment. So proper use of the chemical insecticide with the combination of others helps to control the pest effectively and also the insect will not develops resistance so easily.

Flubendiamide 480 SC @ 75 ml/ha is found the best treatment for the minimum population of *Helicoverpa armigera* (Singh et al 2015). Chowdary et al 2010, reported that Chlorantraniliprole was effective against the okra fruit borer. Indoxacarb and Flubendiamide were found the next best treatment after the Rynaxypyr. Indoxacarb 0.01% is the most effective treatment for the bollworm.(Shinde et al 2015). Except this there are some other insecticides which are commonly used like in the early stages of the larval growth apply endosulfan 35 EC @ 0.2 l/ha. And during the maturation stage we can either apply phosalone 50EC 2.5 l/ha, quinalphos 25 EC 2.0 l/ha. Except this we can also use the Thiodicarb 75 WP 1.0 l/ha.

Conclusion

It is concluded through present review paper that the *H. armigera* is a major pest and also a big problem for the farmers cultivating cotton. The population of *H. armigera* can be controlled by the proper study of its life cycle and effect of the environment factor on it because it will help the experts for a successful pest prediction. Pest forecasting is an important component of the IPM which helps to reduce the frequency of application of the pest management measures and chemicals as well as the cost of cultivation.

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