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Review Article

Management of Cotton Boll Weevil (*Anthonomus grandis*) through Application of Different Tactics

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Abstract

Cotton (*Gossypium hirsutum*) is an important fiber crop for agrarian sector and the development of textile industry throughout the world. Cotton boll weevils (*Anthonomus grandis*) eat all the buds of the plants and destroy any cotton boll that the plants manage to produce by eating and laying their larvae inside cotton bolls and squares. They can mature from egg to adult in less than 3 weeks. As a result, every year they produce 6 - 7 generations and thus consume cotton throughout the growing season. The farmers can use various biological, cultural and chemical practices (depending on production type) which can reduce pest infestation on farms. The methods and practices such as early planting, appropriate fertility, weed management program for stimulating rapid plant development, early-maturing varieties, stalk destruction after harvest (which eliminates plant host for pest reproduction), crop rotation, weevil traps, pheromones, insecticides based on bacteria Bacillus thuringiensis and chemical insecticides based on various active substances use for the management of cotton pests. The best method for the control of boll weevil is the use of biological fauna which prove fruitful for weevil management. The climate change or sunlight is helpful in the population reduction of Cotton boll weevils.

Keywords: Cotton; Cotton Boll Weevils; Biological; Chemical; Sunlight

Introduction

The cotton boll weevil or Mexican cotton boll weevil (*Anthonomus grandis Boheman*) (Curculionidae: Coleoptera) is a damaging pest of cotton bolls in various cotton producing countries especially America faced problem by the attack of this pest. Its attack has found on tropical and subtropical region of the world and is attracted to plant volatiles of its host [1-3].

It is a native pest of Mexican and American regions and has been first reported from the Texas in 1892. The larvae attack on different parts of the cotton, feeds inside the square, floral buds which causes severe damage to cotton crop (Degrande, 1998). Owing to its attack on cotton plant parts such as square and fruits, production was significantly reduced and losses has increased if no proper management practices are applied [4]. Several factors such as temperature and relative humidity build up the weevil populations and increase its infestations on cotton fields (Rummel., *et al*. 1977).

Many management practices have been adopted in the past to control its population to reduce the infestation. Several insecticidal applications, pheromone, natural agents and many cultural practices will minimize the insect attack. However, farmers relay on the chemical-based products to suppress this pest population but this control strategy is insufficient to control the pest [5,6], and these insecticides are costly may cause harmful impact on environments and the non-target hosts. Several bio-products and insecticides are no provided efficient results against boll weevil, however some other control measures; use of traps such as pheromone trap [4], use of natural enemies (Pallini., *et al*. 2006) and IPM practices [7] for the control of this pest.

The alternative approach is the entomopathogenic bacteria *Bacillus* spp., and entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*) applied alone or suitable integration may help to control *A. grandis* minimize its infestations. The Bacillus thuringiensis is good and potential biological control agent against *A. grandis*. and insecticidal cry protein are produced by EPF bacterium [8]. Most of the parasitoids from the Braconidae family [9] and some entomopathogenic fungus [10,11] are good alternatives against this pest. These management approaches will necessary to adopt in various countries which facing problems by this pest attack and also save cotton crop as well as native host of this pest.

Distribution

The *A. grandis* is found in Southern Texas where it was first reported in 1892 and spread to South eastern America in 1922 and Southern Mexican regions and Guatemala. *A. grandis* was spread from United states to Haiti (1832); Cuba (1870); Venezuela (1949); Colombia (1950); Brasil (1983); Argentina (1984); Argentina (1993); Paraguay (1994) and Bolivia (1997) [12-14], then to Africa, Caribbean, North and Central America, and Europe and now this pest has found in all over the world.

Host plants

Cotton is a major host plant and other hosts are weeping love grass (*Eragrostis curvula*); Gallini cotton (*Gossypium barbadense*); shrubby Althaea (*Hibiscus syriacus*); Lind Heimer prickly pear (*Opuntia lindheimeri*); Honey Mesquite (*Prosopis glandulosa*); Portia tree (*Thespesia populnea*).

Biology and life cycle

White legless larvae of *A. grandis* ranges from 5.6 to 8.1 mm long with robust and thick abdominal segments, curved at posterior end. The brownish yellow color head round and broad with 1 pair ocellus. Larvae feed inside the squares until they covert into pupal stage. Pupae are white in color and body ranges from 6.6 to 7.4 mm in length. The weevil is reddish brown 5.5 to 8.0 mm long, hairy antennae, elytra coarsely punctate-striate, snout is slender, straight abdomen.

Management strategies

Cultural control

Many cultural practices combined with other practices are helpful to suppress the *A. grandis* populations. The scientists in Texas performed an experiment, integration of high soil temperature with dry conditions can dehydrate the young weevil and reduce germination to develop volunteer cotton, cotton sticks were destroyed by stalk puller to remove larvae and pupa [15]. Trap crop should be installed around the cotton field to provide alternate host for minimize the pest attack. In summer, cotton should be planted on sloped beds in an east-west which may help to provide fallen squares by high soil temperature, the larvae will kill inside squares. In case of autumn, plant growth regulars can be used to eradicate the remaining bolls and squares during late September. Destroy the hiding place of this insect during the diapause period to reduce its survival in winter.

Host-Plant resistance

The main mechanisms of host-plant resistance to insect pests are categorized as antibiosis, antixenosis and tolerance [16]. The resistance type antibiosis is a mutual interaction of host-plant and insect causes physiological or developmental disabilities in insect. In other type of resistance antixenosis. insect can be attracted to or repelled from host plant. The resistant cultivar (*Tamcot Sphinx*) against the boll weevil was identified by El-Zik and Thaxton in 1996. But in recent, need to identify resistant cultivar against this pest, Therefore, further studies are needed to understand plant defense mechanisms against *A. grandis*.

Pheromone

The male weevil produces volatile substance (pheromone) in their frass, serve as aggregation pheromone, attract both sexes (male and female) (Hedin., *et al*. 1969, 1979). For field trapping and monitoring of *A. grandis*, a pheromone name grandlure use in trap as a lure. It is produced commercially for use in the pheromone trap at the early season when the first insecticide can be applied trap should installed [17]. Trapping of weevils is a best strategy to capture and suppress the populations [18], however combined with other management strategy may reduce the infestation level and minimize pest populations.

From the 9 states of United states *A. grandis* was eradicated by pheromone trap to protect these areas from this pest attack [19].

Teague and Tugwell [20], transplanted cotton, baited with 10mg weevil pheromone and sprayed with ULV malathion applications twice a week, was three weeks earlier in development than the commercial crop and continued to be attractive to boll weevils even after the commercial crop began fruiting. The researches have shown that this aggregation pheromone is capable of attracting both sexes of boll weevils from as far as 500 feet.

Chemical control

Several insecticidal applications have been used in pest for the control of *A. grandis*. In USA, during 1994 and 1995, different group of insecticides organophosphate, carbamate and pyrethroid were tested against *A. grandis*, among these group pyrethroids provided efficient results as compared to others. Martin., *et al*. [21] collected A. grandis from the 11 locations of USA, Louisiana to perform bioassays with 11 different insecticides. No such evidence of field resistance was found against tested insecticides and maximum LD50 value was obtained from cypermethrin and malathion. Spurgeon., *et al*. [22] checked the efficacy of insecticides against the boll weevil in laboratory and significant mortality was observed after 24 hours to 72 hours.

In between the pesticides Fipronil provided maximum mortality after treatment application. Malathion was applied against boll weevil in Texas and Mississippi during the 1995-96 (Jones and Wolfenbarger, 1997) and obtained significant results. The foliar insecticidal treatments were applied to Bt and non-bt cotton to evaluate effects on target and non-target organisms. The Bt cotton provided more yield and lint as compared to non-bt cotton [19]. Less toxic and environmentally safe insecticides including Pymetrozina which demonstrates physiological effects upon the boll weevil [23]. The IGR's lufenuron is a best option to control the A. grandis by inhibiting chitin synthesis [24].

In Argentina, Chemical application combined with cultural control measures are used for the control of *A. grandis* [25], which are efficient combination for cotton growers to get better results. But some disadvantages which are facing farmers, such as too expensive, harmful to non-target hosts, reduction of natural enemies, development of resistant insects the increase of production costs. No efficient control obtained by insecticides against *A. grandis* [26]. Therefore, alternative methods are finding to control the pest attack and reduced its infestations. Integration of biological control agents with insecticides are good alternative to suppress the pest populations and solve the resistance problems.

Biological control

Biological control of *A. grandis* or other *Anthonomus* species has been studied in various countries. The entomopathogenic fungi *B. bassiana* and *M. anisopliae* has been considered good biological control agents against many insect pests. Both species of EPF was collected from cotton field to evaluate their entomopathogencity against *A. grandis* in Brazil (Sao Paulo). Mortality was achieved after 7 days of treatment. Oliveira., *et al*. [1] achieved effective results against the adults of *A. grandis* by *M. anisopliae*. Nussenbaum and Lecuona [27], recovered the *B. bassiana* and *M. anisopliae* and checked their pathogenicity against *A. grandis*. They screened out the best EPF strains from 28 isolates of *M. anisopliae* and 66 of *B. bassiana* against boll weevils. Both *B. bassiana* and *M. anisopliae* soil borne facultative EPF are cosmopolitan anamorphic genera [10,11], and provided promising control against many insect pests of certain crop which are economically important [28].

However, efficiency of microbial agents will increase if possible, combination with other management tactics [29]. Integration of pathogenic fungus with insecticides has provided Synergistics effects against many insect pests. Bleicher., *et al*. [30] performed an experiment to evaluate efficacy of possible combination of *B. bassian* with insecticides and was found promising results against *A. grandis* in Ceara, Brazil. The insecticides (Deltamethrin) low dose with *B. bassiana* provided effective results against *A. grandis*. The synergistic effect has provided by these combinations if low dose of insecticide integrates with fungus. The incompatible combination of products inhibits the activity of pathogens and antagonistic effects have found with lowest pest mortality [28] and resistance problems gain. The chemical and EPF actions vary depending on the species or pathogenic strains, insecticides mode of action and concentrations to be used [31]. Pérez., *et al*. [32] obtained 50% adult mortality of *A. grandis* with 4 indigenous and 3 exotic strains of Pathogenic fungus in Argentina.

The commercial products of *Beauveria* (Naturalis-L) was used by Wright and Knauf [33] to evaluated their effectiveness. Application of conventional and aerial treatments were attempt in Texas, USA in 1991-92. The possible combinations of acephate and bifenthrin with fungus provided efficient results against *A. grandis* and better lint quality was achieved [34]. Many bacterial strains especially *Bacillus thuringiensis* crystals has been found effective against the *A. grandis*. However, experiments showed that *A. gandis* and many other insect pests of cotton, potato and maize can be controlled by bacterials crystal protein [35].

Among many control strategies, it is important to highlight the boil-control with other natural enemies such as parasitoids (Braconidae), *Bracon vulgaris*, provided up to 70% control of *A. grandis* larvae [9]. The classical bio-control have been started in USA during the year 1904 to import the predacious ant species, *Ectatomma tubercuatum* from Guatemala, but it was failed to become established. However, in Peru, *A. vestitus* introduced as parasitoids during 1941-45, but it also failed. In Kenya *Pectinophora gossypiella* parasitoid (*B. kirkpatricki*) was established (Clausen, 1978; Cate, 1985). More investigations were carried to find out the promising parasitoids in Mexico. Consequently, two parasitoids were found *Urosigalphus monotonus* from the family Braconidae which was failed to breed indoors, while other *Catolaccus grandis* from Pteromalidae family was successfully reared and released, but it was failed to established like other parasitoids species. The indigenous parasitoid *B. mellitor* and fire ant *Solenopsis invicta* was used for their establishment and investigated their impacts on hosts. Some scientists attempts have to augmentative release of parasitoids for the control of *A. grandis* in USA Texas, 1991 [36].

The parasitism has been found on 3rd instar larvae of *A. grandis*. It was recorded that *C. grandis* search its host and parasitized them. Slosser., *et al*. [37] recorded that *C. grandis* parasitize the 3rd instar larvae of *A. grandis* and parasitism rate was recorded 65-74% during the year, 1994. In 1992-93, experiment showed that 65-95% and 22-87% mortality was achieved [38]. As comparison to control with treated field the boll weevil survival rate was 72.8-78.2% in control and 0.5-11.8% in treated field was observed. Summy., *et al*. [39] reported that parasitoids *C. grandis* can minimize the boll weevil population up to sub-economic infestation levels. The augmentative release of parasitoids *B. mellitor* and *C. grandis* at high rate (2000-4000 female/hac) was accompanied by a significant increase in densities of the former and a slight increase in the latter. It has been recorded that by the parasitoids released, the maximum mortality being achieved at the early season, as compared to mid-season.

Reproductive control

The boll weevil has been sterilized with diflubenzuron and irradiation. It has been reported that adult weevils sterilized by dipping method (dipped in acetone solutions 0.02% diflubenzuron and 6 k rad of acute irradiation) [40,41]. The obtained results showed that mortality was increased and reduced mating. The sterile male of boll weevil has been released to suppress the population [41-47].

Conclusion

The major goal of this review work was to evaluate the impact of boll weevil on cotton and to evaluate pest management strategies adopted for its management. This review paper provides a useful tool for understanding the boll weevil problem and for suggesting directions for control measures. The measures used must be evaluated in the context of cultural, physical and other control methods designed to reduce initial infestation levels and avoiding pest damage: biological and insecticides should be the solution of current pest. However, other alternatives to pesticides should be explored first, and among them are the use of biological and botanical pesticides gave better control of pest and are ecofriendly.

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Conflict of Interest

Authors have no conflict of interest.

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