International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 10 [2] June 2019 : 118-125

[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA REVIEW ARTICLE

DOI: .10.15515/iaast.0976-4828.10.2.118125

Pest Diversity in Cotton Crops and Its Biocontrol Mechanism for Red Cotton Bug – A Review

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ABSTRACT
The diversity of pest population in theoretical ecology has led to the emergence of testable conjectures with the application of biological control and agroecosystem management. The main focus of the reviewin this area has been deliberately put forward to attain a predictably stable pest population (below the basic threshold level) in crop systems. The increase in pest diversity in croplands led to the serious impact on the abundance and efficiency of natural enemies, which depend on a habitat complexity for sources of alternate nectar and pollen, prey/hosts, shelter, nesting and overwintering sites. Plant diversification of agroecosystems can result in increased environmental opportunities for natural enemies as predators to control insect pests and, consequently results in the improved biological pest control. Red cotton bug, which is predominantly, increases its population in cotton plants. Thenymphs and adults feed on flower buds and on closed or partly-opened cotton bolls. They bore through the cotton fibres and feed on the seeds exploiting the essential nutrients of the cotton crop. The best way to eradicate the natural pests in the crops is to introduce natural predators to the insect prey as a biocontrol mechanism.
Key words : *Pest diversity, Cotton, Red cotton bug, Biological control and Predators.*

Received 24.02.2019 Revised 08.03.2019 Accepted 11.04.2019

CITATION OF THIS ARTICLE
Vijaya Priya. S.,Bhuvaneswari. R., Kala. K.,Sudhakar. S.,and Gopinath, L. R. Pest Diversity in Cotton Crops and Its Biocontrol Mechanism for Red Cotton Bug – A Review.Int. Arch. App. Sci. Technol; Vol 10 [2] June 2019: 118-125

INTRODUCTION

Pest diversity in crop plants

The great majority of these insects are of little or no economic significance so far as cotton is concerned, and no doubt some of insect pests, are collected on the cotton plant, which have not been observed to feed on it. It is not deliberately known, in case of many of the other plant species, whether they are able to complete their life cycle on cotton. A considerable proportion of those recorded are general feeders, particularly amongst the locusts and grasshoppers, leaf-eating beetles, lepidopterous caterpillars, and bugs that suck the contents of developing balls, and many of those cannot be regarded as specific pests of cotton, but only as sporadic, casual or accidental visitors to the crop (1). The geographic area rather than the individual homogeneous field may provide an appropriate unit for pest-management research [2].

Some species are referred as secondary pests, that is, they are attracted to and feed upon the products of decay or fermentation following the attacks of other insects of disease organisms according to a survey [3]. A few other candidates are pests identified in the stored cotton seeds. Only about 150 species of insects that occur on cotton in tropical

Africa are mentioned [4), rather less than one-third of the number were recorded, and it may be taken that the remaining species have not shown to be of economic importance to the crop (5).

Cotton production plays an essential role in the economic development of many countries, and any crises that decrease the production of this commodity can adversely affect the developing countries. In almost all cotton-producing countries of the world, insect pests and crop diseases are considered as the major factors that contribute to a decrease in cotton production. The key to maintain a "modern" agricultural system capable of meeting the cotton production needs of a country without unduly damaging the agricultural resource base which makes a better understanding of the ecological consequences of any crop production technique. The most important pests of a crop plant are often insects that are associated with the plant species in its uncultivated, wild state. It happens that the species of *Gossypium* to which the cultivated cottons belongs do not occur in the wild state, with the possible exception of *G. herbaceum* (as race africanum) in Africa, and the other, wholly wild, species of *Gossypium* are plants of arid regions, and have only a restricted fauna associated with them.

The presence of similar pest species, particularly heliothines, mirids, aphids, spider mites and thrips across the systems worldwide is striking. These pests are largely polyphagous. Production systems containing more specialized pests such as the boll weevil (*Anthonomous grandisgrandis*), pink bollworm (*Pectinophora gossypiella*), Red cotton bug (*Dysdercus cingulatus)* generally experience more severe pest problems than those without such specialized pests (6). The production environment of the cotton fields influences the arthropod community. Tropical pests such as pink bollworm are nowhere found in the northern temperate regions of America. In the humid environments of Brazil and the US, the boll weevil causes severe problems in the cotton crops (7).

Arid production systems throughout the world generally experience crop damage with spider mites (*Tetranychus spp*.). Beneficial Species associated with the different worldwide cotton production systems is similar. Most of the common predators of cotton include true bugs (*Geocoris, Orius*, and *Nabis spp*.), lacewings (*Chrysopa spp.),* spiders and various predatory beetles (especially the *Coccinellidae*). Parasitic species of the *Ichneumonidae, Braconidae, Trichogrammatidae,* and *Tachinidae* are common in all fields. In US, *Formicidae* are important predators of some cotton insects. *Phytophagous mirids* and thrips are recognized as important predators of *Lepidoptera* and *spider mites*, respectively, in most of the cotton production areas. In Australia, cotton fields are strictly monoculture, and the lack of ecological diversity could be the major cause of pestproblems because the food, hosts, prey, and hibernating or overwintering sites of most of the natural enemies of the pestsare reduced, thereby identifying pests and limiting the natural biological control (8).

The insect fauna associated with cotton is rich and diverse. However, more than one thousand species found on cotton, only 10 or a dozen are significant potential pests. They are either pests of the fruiting parts (flower buds or squares, flowers, and the developing seed capsules or bolls) – causing excision of these parts from the plant, consuming the seeds and destroying or staining the fiber – or they are leaf feeders, root feeders or sucking pests, attacking particularly young shoots and developing leaves. There are monophagous species, almost restricted to the genus *Gossypium (Anthonomus, Diaparopsis*), oligophagous feeding on plants in the family Malvaceae and closely related families (9). The heliothinelepidopteran species complex (*Heliothis virescens, Helicoverpa armigera*, Helicoverpa zea) is considered as the most dangerous, attacking numerous other cultivated plants which are often associated with cotton in a range of cropping systems.

It is remarkable that sucking pests (Miridae and Pentatomidae) are considered as key pests in the mid-south and southeast states of the US cotton belt, even though traditionally it was the progressive migration of the boll weevil from equatorial humid regions which was the main determinant of phytosanitary interventions.The development of the pest complex of cotton to the diversity of these systems of culture across the globe and cautions prudence when attempting generalizations about the abundance of cotton. Cotton is basically a weak competitor with weeds, particularly during emergence and the early vegetative stages, as a result of its C3 metabolism. Weeds can thus cause severe losses to the quality and quantity of the harvest (10). It is for this reason that manual weeding is one the major constraints of the small-scale cotton farmer, while large scale operations have recourse to chemical herbicides. One hundred weed species are recorded which directly or indirectly helps insect pests that are associated with cotton, but only a dozen of these are responsible for significant yield losses. Weeds and insects of foreign origin are the most common and dangerous, as they are frequently more competitive in the absence of their natural control factors.

Impact of different pests on Cotton

Cotton (*Gossypium hirsutum L.*) is the most important cash crop in almost all countries, which is cultivated on 3.12 million hectares in India and Pakistan and is the source of large amount of economic value. In spite of large acreage, yield of seed cotton is very low because of severe pest complex in the cotton balls. The cotton bollworm *Helicoverpa armigera* (Hubner), pink bollworm *Pectinophora gossypiella* (Saunders), spotted bollworm *Eariasvittella* (Fab.), tobacco caterpillar *Spodopteralitura* (Fab.) and the whitefly *Bemisiatabaci* (Genn.) are major pests of cotton that have the potential to reduce yields by 20–80% (11).

Important sucking insect pests are *jassid Amarascadevastans* Dist. (Hemiptera: Cicadellidae), whitefly, *Bemisiatabaci* (Genn.) (Hemiptera: Aleyrodidae), cotton thrips, Thrips*tabaci Lind.* (Thysanoptera: Thripidae) and cotton aphid, *Aphis gossypii* Glover (Hompotera: Aphididae), red cotton bus, cotton stainer etc.. These insect pest inhabit the cotton plant and in due course of its growth, it becomes insecticide resistance and has received much considerable attention (12). However, there are only few data on changes in insecticide susceptibility in other important insect pests of cotton in India *.H. armigera, P. gossypiella, E. vittella* and *Spodopteralitura* in cotton explore the resistance activity to even chemical pesticides such as carbamate (methomyl) and organophosphate (quinalphos and monocrotophos) and infect damage to the cotton crops.

Under the present cultivation of cotton production in the U.S., the bollworm, *Heliothiszea* (Boddie), and the tobacco budworm, *H. virescens*, may account for as much as 50% of all losses in yield attributable to insect damage. These pests are distributed throughout the cotton belt and, although generally considered as secondary pests of cotton, they commonly achieve primary status if natural controls are diminished by insecticides applied for the primary pests. The problem of *Heliothis spp.* on cotton is worsening, primarily because of the continuing development and spread of insecticide resistance among populations of the tobacco budworm. This pest has long been highly resistant to organochlorine and carbamate insecticides (13) and had become generally resistant to the organophosphorus (OP) insecticides that have served as the primary means for the chemical devastation of cotton pests (14)

A brief review on reproductive nature of Red Cotton Bug

One of the important attributes of insects is their immense reproductive potential. Insect reproduction includes mating behaviour, oviposition behaviour, fecundity and fertility. Phytoconstituents present in many plants can easily challenge any of these aspects of insect reproduction. Many of the secondary metabolites present in plants adversely alter the fecundity and fertility of insect pests (15). Therefore, studies pertaining to influence of plant extracts in insect reproduction are important in integrated pest management. The pest inflicts considerable damage to standing crops of cotton and other malvaceous plants in many parts of the world including India.

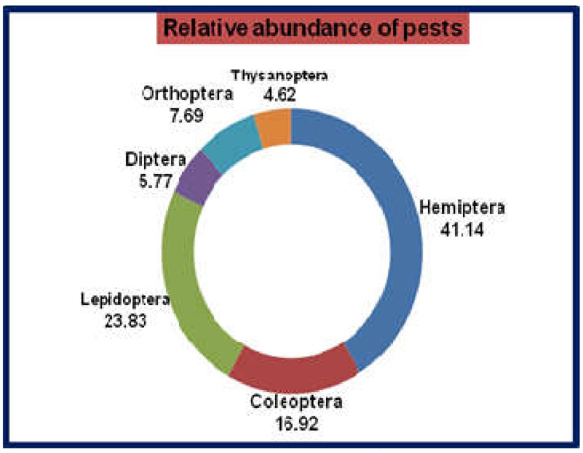
Both, the nymphs and the adults suck sap from the developing seeds, which thus lose the oil contents and germinating capacity. *Dysdercus koenigii* has high reproductive potential when they inhabit crops according to its necessity. The females lay eggs in batches throughout their reproductive life; a single female may lay up to seven egg batches. Each egg batch contains about 100-150 eggs (16). Studies reported on *Catharanthus roseus, Ocimum sanctum* and *Lantana camara* extracts were restricted mainly to their larvicidal activity. Adverse effects of the plant extracts on fecundity and fertility of *D. koenigii* were less extensively explored. Moreover, the solvents used for the extraction in the earlier studies were highly toxic. Ethanol extract treatment of *Lantana camara* also influenced the reproductive bioactivities of the adults. However, the effects were less intense in comparison to *Catharanthus* and *Ocimum*. The number of egg batches laid per female in treatments with 2.5% and 1.25% were 32% and 26% lesser than control groups of insects taken from cotton fields (17).

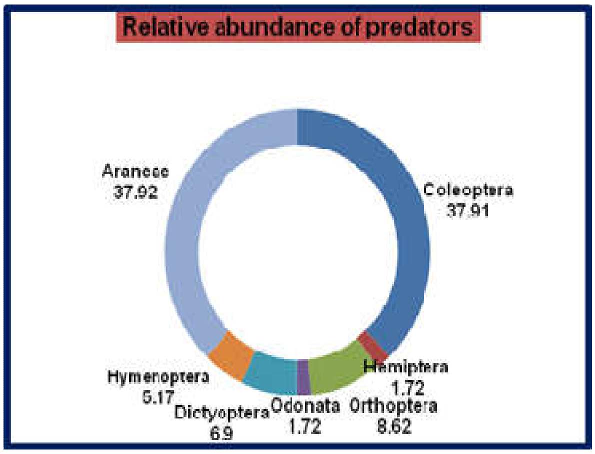
The *Hemiptera* constitute a large and very diverse order with a wide variety of reproductive adaptations. One suborder, the *Homoptera* (all plant-feeding insects), displays a number of reproductive specialisations, the endocrinology of which is comprehended at certain point of time. Much attention was paid on the Heteroptera, which includes both terrestrial and aquatic species. While most species are plant feeders, there are many which have taken up a predaceous habit, and a few of these have become blood feeders. The control of ovulation and oviposition had much attention in the *Heteroptera*. In the *pyrrhocoridiphitalim bata,* Nayar [18] has shown that oviposition is induced by injections of blood from ovipositing females, by implanting neurosecretory cells from the parts intercerebralis, or by injection of mature but unlaid eggs. Based on the histological studies of cerebral neurosecretory cells, Nayar proposed that mature ovaries secrete a hormone which in turn causes the secretion of a neurosecretory hormone which stimulates contractions of the oviducts leading to oviposition.

It is impossible to have stronger evidence of the red cotton bug that in the eggs of the spider, *Scolopendra* and cockroach, the vacuolar non-fatty golgi vesicles of the youngest oocyte directly give rise to the vacuolar fatty yolk, whereas in *Dysdercus,* the golgi vesicles are fatty even in the earliest oogonia. Indeed, the fatty contents of the oogonial vesicles help researchers amongst other insect pests in distinguishing the cells from the neighbouring nurse cells. The study showed that the herbivore-induced volatiles from cotton can affect pre-copulatory and affect mating behavior of *Spodoptera littoralis*. The induced changes in damaged host plants influences the mating behavior through modulation of female calling behavior, male attraction to females, male and female behaviours during mating. The consequence of herbivore damage on pre-copulatory and mating behaviour in the studies, were parallel to the effect of herbivore damaged plants on oviposition behavior of mated female *S. littoralis* [19].

Analysis of different Bio control methods for cotton crops

There are different approaches to the utilization of natural enemies of insect pests in an agricultural system: preservation and augmentation of existing predators and parasites, and heap rearing of natural predators for field release to minimize the population density of the target insect pests of cotton. Preservation and augmentation of existing predators and parasites in cotton by means of rational application of bio pesticides and crop habitat manipulation can effectively decrease population density of aphids and cotton bollworms (20). In many areas of northern China, intercropping of cotton with wheat is recommended for enhancing naturally occurring biological control of cotton aphids during the early stages of cotton growth (21). Another practice to increase the impact of natural enemies is to use selective biopesticides instead of broad-spectrum insecticides. Mass production of natural enemies has been practiced since 1990. The techniques of quality control in mass production of cotton and field release of natural predators have greatly improved (21).





The use of automation, standardized procedures, and improvements in artificial eggs has revolutionized the availability and utilization of parasitic wasps (22). Industrial technology for commercial production of microbial agents is being gradually adopted and offers substantial improvements over the small-scale procedures have been previously employed .

Augmentations of natural enemies by means of release of *Trichogramma spp.* and *Microplitis* mediator for suppression of cotton bollworm eggs, cotton bug eggs and caterpillars, respectively are recommended when the pest population density exceeds the threshold level [23].
Biopesticides is produced from living organisms (natural enemies) or their products (phytochemicals, microbial products) or byproducts (semiochemicals) which can be used for the management of pests that are injurious to crop plants. Biopesticides such as Bt, nuclear polyhedrosis virus, and *Beauveria bassiana* are also suitable to devastate the pest population (5). After testing biological control of pests, many researchers understood that it was very difficult to effectively control pests solely with natural enemies and biocontrol agents, especially during the season when cotton bollworm, red cotton bug and cotton stainer poses a serious threat. As an alternative, biological control should be one of the imperative mechanism of Integrated pest management. Cotton seed was usually planted in the month of July in rows for about 36-inch centres. An experimental setup was designed with the plots, treated with a tractor-mounted sprayer operated at 40 psi with an output of 36 gpa from 3 hollow-cone nozzles per row. Field plots were 3 rows wide by 50 ft long. Insects damage to buds and bolls were monitored on in the month of September, October by counting insects or buds and bolls on crops in the middle row of the plot (24). The intervention of *Bacillus thuringiensis* in cotton crops to avoid the pest attack and introduce as a genetically modified crop, which is named as *Bt*Cotton regardless of the fertilizers and pesticides.

PATHOGEN	PRODUCT NAME	HOST RANGE	USES AND COMMENTS
BACTERIA			
Bacillus thuringiensis var. *kurstaki* (*Bt*)	Bactur®, Bactospeine®, Bioworm®, Caterpillar	caterpillars (larvae of moths and butterflies)	Effective for foliage-feeding caterpillars (and Indian meal moth in stored grain). Does not cycle extensively in the environment.
Bacillus thuringiensis var. israelensis (*Bt*)	Aquabee®, Teknar®, Vectobac®	larvae of *Aedes* and *Psorophora*mosquitoes, black flies, and fungus gnats	Effective against larvae only. Active only if ingested. *Culex* and *Anopheles* mosquitoes are uncontrolled at general application rates.
Bacillus thuringiensis var. *tenebrinos*	Foil® M-One® M-Track®, Novardo® Trident®	larvae of Colorado potato beetle, elm leaf beetle adults	Effective against Colorado potato beetle larvae and the elm leaf beetle. Like other *Bt*s, it must be ingested.
Bacillus thuringiensis var. *aizawai*	Certan®	wax moth caterpillars	Used only for control of was moth infestations in honeybee hives.
Bacillus popilliae and *Bacillus lentimorbus*	Doom¨, Japidemic¨, Milky Spore Disease, Grub Attack®	larvae of Japanese beetle	The main Illinois lawn grub (the annual white grub, *Cyclocephala* sp.) Is not susceptible to milky spore disease.
Bacillus sphaericus	Vectolex CG®, Vectolex WDG®	larvae of *Culex, Psorophora,* and *Culiseta* mosquitos, larvae of some *Aedes* spp.	Effective against *Aedes vexans* in stagnant or turbid water
FUNGI			
Beauveria bassiana	Botanigard®, Mycotrol®	aphids, fungus, mealy bugs, thrips, whiteflies	Effective against several pests, longevity, and competition with other soil microorganisms remains solved.
Lagenidium giganteum	Laginex®	larvae of most pest mosquito species	Effective against larvae of most pest mosquito species; remains infective in the environment through dry periods.

Consequently, development of biological control strategies for *B. tabaci* has focused, to a considerable degree, on inundative introduction of natural enemies including fungi. The most extensively researched and utilized approach for *B. tabaci* control with fungi relies on the frequent spraying of high doses of infective propagules (25). Fungal pathogens possess incontestable capability to produce helpful management of *B. tabaci* whiteflies under a broader range of conditions than was once commonly believed. Numerous laboratory and field studies have disclosed that the high close humidness conditions needed for development of natural epizootics aren't essentially needed for zymosis. Many pathogens realize adequate wetness for germination and host penetration among the leaf or insect microclimate physical phenomenon. The phenomenon has been demonstrated with respect to infection of whitefly nymphs by *Beauveria bassiana* and *P. fumosoroseus* [25].

Assessment of effective control for red cotton bug

One such effective assessment of effective control for insect pests is the introduction of fungal pathogens for potential control of cotton bugs and whiteflies have focused on all life stages. Although field evaluation is the only way to access the control potential of any predator (26). Insect management programs in cotton-production systems emphasize regulation of pest population growth with natural and alternative control agents, but they differ in the emphasis on non-insecticidal management strategies. In Australia, the commercial Siokra (Cotton) varieties express insect-resistance traits. The role of biological management in Australia is increasing with a growing concern in the conservation of natural enemies and the use of *Bacillus thuringiensis*. Transgenic cotton expressing *B. thuringiensis* with endotoxin proteins represents a major insect control method for better growth. Brazil strongly emphasizes the importance of natural control and recommends inaction levels or no treatment for some pests if beneficial-insect numbers are at critical densities (27). The neurosecretory system of the insect pests treated with insecticide was accompanied by a high accumulation of paraldehyde fuchsin (PAF)-neurosecretory material. *Azadirachta indica,* is a potent insect growth inhibitor. Its physiological and biochemical effects have been studied in hemi- and holometabolous insects.

CONCLUSION

Habitat or environmental manipulation has well-tried another style of conservation and augmentation of natural enemies. Cropping system has been with success altered to reinforce and enhance the effectiveness of a natural enemy. It has been analyzed that parasitoids and predators are noticeably benefited from supply of nectar and also the defence provided by refuges (hedgerows, cowl crops and weedy borders). Observation also suggests that mixed planting and the provision of flowering borders can increase the diversity of habitats and provide more effective shelter and alternative food source to predators and parasites. These natural controls area unit vital and wish to be preserved and thought of whereas creating blighter management connected selections. Implementation of IPM or ecological based pest management relies on the knowledge that, stability in biological systems relies on feedback between organisms. This means that probably damaging species typically area unit ne'er abounding enough to become actual pests.The increasing of biological control strategies due to both ecological beneficiaries including the human health as part of world ecology, has been renewed. The introduction of natural predators by providing a sophisticated environment for survival and emergence of diverse species to the crop plants emerges with a significant result in controlling the insect population affecting the cotton bolls in agro economic countries.

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