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Role of Biocontrol Agents in Cotton Ecosystem

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SUMMARY

Among all the environment friendly methods, perhaps the use of biocontrol agents in biological control of pests ranks first. Several biocontrol agents (parasitoids, predators and pathogens) are known to attack cotton pests. India is a very rich source of diverse biotic agents spread throughout the country. Biological control is perhaps one of the oldest methods of pest management. Agencies involved in biological control of cotton pests include arthropod natural enemies (parasitoids, predators, predatory mites and spiders), insect pathogens (viruses, bacteria, fungi) and avian predators.

INTRODUCTION

Cotton is an important cash crop in India. It is a highly valued commercial crop cultivated for its fiber and oil. Cotton contributes almost 75% of the total fiber consumed in the textile industry. India is the only country where all the four species of cotton are grown. *Gossgpium hirsutum* is a predominant species which covers about 36% of total area under cotton. The productivity of cotton crop in India is less than the world average. The losses due to insect pests is one of the prime reason for low productivity of the crop. The cotton crop is known to suffer from 162 species of insects and mites. Data on crop losses due to cotton pests in India indicate yield losses ranging from 15 to 25% in spite of extensive use of insecticides. The pests of major economic importance in most of the cotton growing tracts in India includes sucking pests (aphid, leaf hopper, whitefly, thrips), bollworms (spotted, *Helicoverpa* and pink bollworm), leaf feeding insects (*Spodoptera*, leaf roller and semilooper) and mites which affect the yield and quality of the crop. Chemical control of cotton pests is one of the most popular methods among the farmers, however excessive use of chemical insecticides has aggravated the pest problem mainly due to the development of pest resistance and depletion of entomophage diversity. The concept of IPM was developed in response to these negative implications of intensive chemical pest control. Among all the environment friendly methods, perhaps the use of biocontrol agents in biological control of pests ranks first. Several biocontrol agents (parasitoids, predators and pathogens) are known to attack cotton pests. India is a very rich source of diverse biotic agents spread throughout the country. Biological control is perhaps one of the oldest methods of pest management. Agencies involved in biological control of cotton pests include arthropod natural enemies (parasitoids, predators, predatory mites and spiders), insect pathogens (viruses, bacteria, fungi) and avian predators.

Egg-Parasitoids:

There are two genera *viz*., *Trichogramma* and *Trichogrammatoidea* which include the egg-parasitoids of many lepidopteran insects. The genus *Trichogramma* has 36 biparental species. It is most commonly encountered in different ecosystem. *Trichogramma* is a bio-agent which has been used world over to suppress lepidopterous insects in many crops including cotton. It can be easily multiplied in laboratory and hence commercially available. Several countries have taken lead in establishing insectaries which are managed by government agencies, cooperatives, private entrepreneurs etc. *Trichogrammachilonis* and *T. achaeae* have been reported as native egg-parasitoids. *T. chilonis* has been reported to be effective against cotton bollworms in the early phase of crop growth. Repeated release of *T. chilonis* reduces infestation of cotton bollworms. First release should be synchronized with the appearance of the pest. In addition to above, *T. brassiliensis* and *T. chilotraea* are also reported as exotic egg-parasitoids on cotton bollworms.

Larval parasitoids:

Rogasali garhensis, *Apanteles angaletis*, *Bracongreeni*, *Parabaenorbata* and *Agathisfabiae* have been recorded as larval parasitoids, whereas *Brachymeria* spp. and *Brachycorphus nyrsei* as pupal parasitoids on spotted bollworm on cotton. Among these, *R. aligarhensis* has been found to cause appreciable mortality in the larvae of *Earias vittella* and has shown tolerance to synthetic insecticides. *Compoletis chlorideae*, *Chelonus* *heliopae* and *Chilonisblackburni* are important larval *parasitoids* of *Helicoverpa amigera*. Similarly, the parasitoids *viz*., *Apanteles angaletis*, *Bracongreeni*, *B.chinensis*, *R. aligarhensis*, *Elasmus johnstoni*, *Chelonu spectiphorae* and *C. blackburni* have been reported as larval parasitoids on cotton pink bollworm, *Pectinophora gossypiella*.

Predators:

Coccinellids, chrysopids, syrphids, predatory bugs, spiders and insectivorous birds are important biocontrol agents and are known to predate various species of insect pests in cotton fields. Different species of coccinellids and chrysopids predate on sucking pests in cotton. Among the coccinellid predators, the *Cheilomenes* (*Menochilus*) *sexmaculata* (Fab), *Coccinella transversalis* Fab. *C.septempunctata*, *Hippodamia* spp. and *Cryptolaemusmontrouzieri* are potential biocontrol agents of sucking pests and other soft bodied insects. Adults and grubs of these beetles devour their hosts and reduce its population in nature. The coccinellids are found to regulate the population of sucking pests in cotton ecosystem to varied degree. The chrysopids, *Chrysoperla zastrowisillemi* and *Malladabo ninensis* Okamoto are most common aphidophagous insects in cotton ecosystem. Their larvae play an important role in suppressing the population of sucking pests as well as eggs and neonate larvae of lepidopterous pests. The *Chrysoperla* can be mass multiplied in laboratory and hence commercially available for field release. Two to three releases of its larvae (2 to 3 days old) @ 10,000 to 14,000 per ha at weekly interval effectively check the population of host insects (3,6). First release of the chrysopid should be synchronized with the appearance of the pests to obtain its maximum benefits. In addition to coccinellids and chrysopids, different species of predatory bugs and spiders are found as general predators in cotton ecosystem which predate on soft bodied hemipteran pests as well as eggs and early instar larvae of cotton bollworms.

Spiders:

Spiders are the general predators found feeding on leafhopper, whitefly, aphid and few lepidopteran insects in cotton ecosystem. Large numbers of spiders are noticed in cotton crop either hunting the prey (insect pest) or making the web. Some of the species of spiders make webs on the cotton plants and feed on the trapped insects. Spiders are found predating on *H. armigera*, *Spodoptera litura*, *Anomisflava* and *Syleptaderogata* larvae in cotton fields.

Use of selective insecticides:

By and large, all the insecticides used in agricultural crops are toxic to parasitoids and predators of crop pests, but the degree may vary. Therefore, selective use of insecticides resulted in conservation of beneficial fauna. Dust formulations of insecticides are more toxic to arthropod natural enemies compared to EC formulations. Therefore, dust formulations should be discouraged.

Insect pathogens:

Certain viruses, bacteria and fungi are associated with insects. There are many distinct groups of insect pathogenic viruses, but only Baculoviruses have been considered as microbial biocontrol agents. As many as 35 viruses have been reported from different insects. Baculoviruses are classified into three sub-groups i.e. Nuclear Polyhedrosis Viruses (NPV), Granulosis Viruses (GV) and Cytoplasmic Viruses (CV). Among these, the NPV and GV are commercially available for suppression of key pests of economic importance. They are speciesspecific and often highly virulent. The baculo viruses are currently being exploited as biological control agents. It has enormous potential for insect control. NPV has been shown as promising microbial insecticide and is used against *H. armigera*, *S. litura*, *Spilosomao bliquae* and *Amsactaal bistriga*. NPV has been successfully used to control *H. armigera* and *S. litura* infesting cotton. Application of H.NPV (450 LE/ha) and S-NPV (250 LE/ha) during evening hours has been reported for suppression of *H. armigera* and *S. litura*, respectively (2). It affords good control of these lepidopterous pests. NPV has been used either alone or in combination with insecticides. It is desirable to apply NPV during evening hours to avoid adverse effect of UV rays of sunlight on viruses. Insect pathogenic bacteria such as *Bacillus thuringiensis* (B.t), *B. popillae* have been widely accepted pathogens for controlling variety of insects. *Bt* has been commercially produced and extensively used in the management of various lepidopterous pests. Commercial formulations of *Bt* are available in market. The rate of application of *Bt* varies, but normally it is used @ 1.5 to 2.0 kg/ha. There are certain limitations of *Bt* spray formulations such as poor stability under field conditions and frequent applications are required. *Bt* endospores are inactivated when exposed to UV light and half-life is short.

There are over 750 fungal species which are known to attack insects (11). The fungi which attack on insect called entomopathogenic fungi (EPF) *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii* and *Nomuraea rileyi* are important species of EPF. Former three species have been commercialized for producing mycoinsecticides and used in combating pests of cotton.

Habitat manipulation:

Plant diversification of agro-ecosystems can result in increased environmental opportunities for natural enemies and subsequently improves biological pest suppression. Increasing plant diversity includes intercropping, mixed cropping, trap cropping, relay cropping and interspersing of some plants which can act as reservoir for natural enemies of crop pests. Such habitat manipulation has great potential to enhance the functional bio-diversity which in turn helps in conservation as well as to encourage the activity of many entomophagous insects. Good number of studies have been made at AAU, Anand regarding the assessment of habitat manipulation in conservation and enhancement of biocontrol agents and thereby to suppress the insect pests in cotton crop. Maize grown as campanion crop on border of cotton field or interspersed @ 10% plants enhanced the aphidophagous insects which in turn suppressed the sucking pests (8). Interspersing of *Cassia occidentalis*Vahl. with cotton @ 6:1 has been advised to cotton growers of Gujarat as such practice enhances the population of *Trichogramma* wasps (5). *Trichogramma* parasitism can be enhanced by sowing *C. occidentalis* in close vicinity of cotton. Similarly, interspersing of flowering plants such as cosmos (*Cosmos bipinnatus*) and zinnia (*Zinnia elegans*) @ 10% plants in cotton fields has been suggested. These plants should be maintained near the cotton crop to attract the natural enemies of insect pests. These beneficial fauna receive nectar, pollens and protection (shelter) from them. Yellow flowered marigold (*Tagetes erecta)* has been used as trap crop to manage the population of *H. armigera* in cotton. It is known to encourage the activity of *Trichogramma* wasps and act as reservoir for the parasitoid.

Intercropping of cowpea or maize with cotton has been suggested as one component of IPM to conserve the natural enemies in cotton crop. Similarly, intercropping of cotton with sesamum and soybean enhanced the population of natural enemies which ultimately reduce the bollworm damage in cotton (4). Conservation of entomophage diversity through establishment of 'Entomophase Park' has been experienced and demonstrated in Gujarat (12). It has diverse plant flora which attract different species of insects which serve as host to friendly parasitoids and predators. The farmers of Gujarat have been advised to establish 'Entomophage Park' in small area of their fields to enhance the biological activity of natural enemies and thereby to suppress the insect pests in nature. Indian senna (*Cassia angustifolia*), a medicinal plant which harbours different species of arthropod natural enemies when interspersed with cotton resulted in reduction of sucking pests (7). Random sowing of *C. angustifolia* in cotton field proved very effective in attracting pierid butterfly, *Catopsilia pyranthe* for egg deposition which served as host for *T. chilonis* and thus resulted into reduction in bollworm damage. Similarly, a waste land weed, *Cassia occidenalis* has been recognized to enhance the population of *T. chilonis*. Growing cowpea in cotton either mixed or intercropping increases the diversity of cropping area and encourages the population of predatory insects like coccinellids and syrphids. Relay crops like maize and sunhemp after cotton supported sizeable population of lygaied predator, *Geocoriso chropterous* and thereby helps the predator to shift cotton in next season.

Improvement in biological traits:

Attempts have been made in searching better strains of natural enemies of crop pests. The development of insecticide resistant strains of natural enemy of crop pests offers great scope in IPM. *T. chilonis* resistant to endosulfan (Endogram) has been evolved for control of cotton bollworm (1). Similarly efforts to develop multiple insecticide tolerant strain of *T. chilonis* utilizing the Endogram strain have resulted in tolerance to monocrotophos and fenvalerate after 34 and 26 generations, respectively. A monocrotophos resistant strain of *Chrysoperlacarnea* has been developed for the first time in Gujarat (9). It has been tested for its cross resistance characteristics and concluded that the strain can resist dimethoate, acephate, phosphamidon and methy-o-demeton (10). It can be integrated for controlling pests to form IPM programme. Temperature tolerant strain of *T. chilonis* has been evolved which gives high parasitism and increased longevity.

CONCLUSION

Considering the beneficial role of bioagents, attempts have been made to integrate it with other methods to manage pest population below ETL level. The IPM technology involving the use of biocontrol agents would provide a better stand for achieving successful pest management on a long term and reaping benefits in terms of safe Agro-ecosystem and thereby sustainable agriculture.

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