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Population Dynamics of Predatory Insects and Biological Control of Cotton Pests in Pakistan

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Abstract: Biological control is the most important component of IPM because a number of pests of a crop, remain under natural control if crop is unsprayed. Many natural enemies such as predatory beetles, bugs, lacewings and spiders have been recorded in cotton fields in Sindh Pakistan, but their potential value has been widely exploited in cotton pest management due to lack of techniques to conserve and maximize both their abundance and effectiveness.
During 1999 cotton season population dynamics studies were carried out to observe the beneficial insects under sprayed and unsprayed conditions at Sakrand Sindh. Three spray applications were given in sprayed block with Dimethoate 40 EC, Thiodan 35 EC and Tracer 480 SC against sucking and bollworm complex of cotton. Predators appeared 10 days after germination of cotton plant. The species observed during the season were i.e. chrysopa, orius, geocoris, spiders, coccinellids, Zanchius and campylomma. The numbers of predators ranging from three to fifty six thousand in unsprayed plot and 0.7 to 8.9 thousands in sprayed block. These predators were active throughout the cotton season with a peak population during July and August.

Key words: Cotton pests, population dynamics, predators, Biological control

Introduction

Cotton occupies a vital role in the agrarian economy of Pakistan. It provides raw material to the domestic textile and the other subsidiary industries employs millions of hands and earns substantial amount of foreign exchange. Textile, the most important industry of Pakistan is wholly dependent on the production of raw cotton within the country. Cotton plant with its green leaves, many large open flowers, nectaries on every leaf and flowers and large number of fruits seems to specially attract the insect pests under natural condition. Different types of insects with chewing and sucking habits attack the crop causing serious damage, which can result in partial or total failure of the crop. They do not only lower the yield but also impair the quality of the fiber. It is estimated that in Pakistan 20 to 40 percent of the total crop is lost every year due to the insect pests (Zahoor A. 1999). The control of cotton pests largely depends on the use of insecticides that created the problems, such as development of resistance in pests, resurgence of secondary pests, environmental pollution and health hazards. Van Steenwayk *et al.* (1975) observed that season long application of insecticides in cotton field resulted in the destruction of beneficial insects thus accelerating the emergence of secondary pests.

The country at present imports over 10 billion of pesticides annually through registered Firms alone. About 90% of these are being used on cotton (Ingram *et al.* 1989). Thus there is a need to develop alternate methods of pest control. Among the alternative methods biological control seems to have great potential in terms of profitability, safety for humans and animals, for environment and for the sustainability of agricultural activities. It requires the knowledge of biology, ecology, phenology and behavior of the pests and their natural enemies.

Biological control is the most important component of IPM because a number of pests of a crop, remain under natural control,. The strategy should be to attempt control of serious pests without disturbing the natural control that is already existing. The introduction and conservation of parasitoids in cotton fields can prove a good base for any sustainable integrated pest management programme. Egg parasitoids belonging to the polyphagous genus *Trichogramma* have contributed a lot in natural control of many lepidopterous pests (Stinner, 1977) Mass rearing of *Trichogramma* is relatively inexpensive and can be reared on eggs of Angoumois grain moth, *Sitotroga cerealella* (Oliv.). Mark *et al* (1983), Ganev (1977) reported that the common chrysopid can be multiplied by laboratory rearing.

Some important cotton pests are: thrips *Thrips tabaci* (lind) *Scirtothrips dorsalis* (Hood) Jassid *Empoasca devastans* (Dist.), whitefly *Bemisia tabaci* (Gennadius), mite *Tetranychus urticae*, aphids *Aphis gossypii* (Glov), spotted bollworm *Earias vittella* (Fabricius), Spiny bollworm *Earias insulana* (Boisduval), pink bollworm *Pectinophora gossypiella*, (Saunders), American bollworm *Helicoverpa* armigera (Hubner) and armyworm *Spodoptera litura* (F.)

Pink bollworm *Pectinohora gossypiella* (Saunders): A large number of parasitoids and predators have been reported from the pink bollworm. Thompson (1946) and Herting and Simmonds (1975) reported about 147 species of parasitoids and predators feeding on it. Greathead (1966) reported about 25 species of its natural enemies from Africa. Cheema *et al* (1980a and 1980b) reported 28 species of parasitoids and 63 of predators from Pakistan. However most of the predators are polyphagous.

In Pakistan besides augmentation of endemic species such as *Apanteles angaleti* Muesebeck, *Bracon gelechiae* Ashmead (Braconidae), *Elasmus johnstoni* Ferr. (Elasmidae) and *Goniozus sp.* (Bethylidae), exotic parasitoids *Bracon platynotae* (Cushman) from Mexico, *B. kirkpatricki* Wilknson. From East Africa *Chelonus blackburni* Cameron (Brachonidae) from Hawaii, *Bracon brevicornis* Wesmeal from Egypt and Sudan and *Exeristes roborator* (Fabricius) (Ichneumonidae) from Greece, Egypt and Kenya can be tried in Pakistan (Mohyuddin ,1991).

Studies were conducted by Nazir *et al.* (1996) on the significance of pheromones and parasites for the control of cotton bollworm to evaluate the efficacy of pheromones in conjunction with innundative releases of *Trichogramma chilonis* to control the three major species of cotton bollworms i.e. Pink bollworm, *Earias insulana* and *E. vittella*. These studies indicated that pheromones and parasites are more effective in controlling the pink bollworm than spotted bollworms. Nazri *et al.* (1998) in an other laboratory study

observed the potential of *Trichogramma chilonis* to parasitize the eggs of cotton bollworms. Studies indicated that *Trichogramma chilonis* parasitized the eggs of pink, spotted and spiny bollworms but the parasitism was significantly higher in pink bollworm than in spotted and spiny bollworms eggs.

Heliothis *Heliocoverpa armigera* (Hubner): Greathead (1966) reported 57 species of parasitoids and 9 of predators from Africa have listed its natural enemies in Africa. Mohyuddin (1989) reported eight species of parasitoids from Pakistan. Mohyuddin (1989) has recommended 16 species of parasitoids for introduction in to Pakistan. These include *Banchopsis ruficornis* (Cameron), *Enicospilus sp.* Communis Szepligeti, *Heteropelma scaposum* (Morley), *Hyposoter didymator* (Thungberg) (Ichneumonidae); *Apanteles kazak* Telenga, *Bracon brevicornis* Wesmael, *Cardiochiles nigricollis* (Cameron), *C. nigriceps* Vierick, *C. trimaculatus* (Cameron), *Microplitis croceipes* (Cresson), *M. demolitor* Wilkinson (Braconidae); *Arachytas marmoratus* (Townsend), *Carcelia illota* Curran, *Eucelatoria bryani* Sabrosky, *Goniophthalmus hali* Mensil (Technidae); *Telenomus sp.* nr. triptus Nixon.

Spiny bollworm *Earias insulana* (Boisduval)
Spotted bollworm *Earias vittella* (Fabricius)

27 species of parasitoids have been reported from spiny and spotted bollworm in Pakistan. Some of these are common with the pink bollworm. Greathead (1966) reported 44 species of natural enemies from Africa. Some of these that could be considered for introduction include *Agathis aciculata* (Brues) (Braconidae) from East Africa and Ivory Coast, *Netelia parvulas* (Szep.) (Ichneumonidae) from Malawi and *Strobliomyia* (Actia) *nana* (Curr.) (Tachinidae) from Uganda.
In case these pests assume serious pest status, inundative releases of *Trichogramma sp.* (Trichogrammatidae) can be tried for their control Mohyuddin (1991).

Jassid *Amrasca devastans* (Distant): No work has been done on its natural enemies in Pakistan. An unidentified chalcid has been reported parasitising its eggs by Afzal and Ali (1983). Different unidentified species of spiders have been observed hunting adults and nymphs of jassid (personal observations).
In India Subba Rao *et al* (1968) reported six species including *Anagrus empoascae* (Doz.), *Arescon enocki* Subba Rao and Kaur, *Erythelus empoascae* Subba Rao, *Lymaenon empoascae* Subba Rao and *Stathynium empoascae* Subba Rao (Mymaridae) and *Oligosita sp.* (Trichogrammatidae) parasitising up to 66% egges of *Amrasca devastans*. Sharma *et al* (1971) reported *Chrysopa sp.* and *Brumus sp.* feeding on this jassid, aphid and whitefly on cotton. Subba Rao *et al* (1965) reported *Geocoris tricolor* (Fabricius), *G. jucundus* (Fabricius), an unidentified spider and erythraeid mite preying on it.

Whitefly *Bemisia tabaci* (Gennadius): Its natural enemies from various parts of the world have been reported by Greathead and Bennett (1981) and Lopez-Avila (1986). Dan Gerling (1990) reviewed the work done by different researchers and reported that 12 species of mites predators found on *B. tabaci* and are probably important component of most whitefly complexes. He further stated that whitefly predators usually lay their eggs on or near pray population. The larvae of some coccinellids such as *Cryptognatha sp.* and those of the anthocorids, mirids, chrysopids and mites are mobile, moving about the plants in search of prey.
Overview of biological control of *Bemisia tabaci* reported by Carruthers *et al* (1993) from USA. He reported that assessment of natural parasitoids activity is being conducted by a number of individuals from California to Florida. In all study sites, several parasitoids species among the genera *Encarsia* and *Eretmocerus* have been found affecting the SPWF. Apparent parasitism levels ranging as high as 70-90% are cited by various investigators, particularly in insecticide free habitats. Mohyuddin *et al* (1989) reported 11 species of parasitoids from Pakistan. These are *Eretmocerus corni* Haldeman *E. aligarhensis* Khan and Shafee, *E. mundus* Mercet. *Encarsia adrianae* Lopez-Avila, *E. cibcensis* Lopez-Avila, *E. Formosa* Gahan, *E. lutea* (Masi) *E. Mohyuddini* Shafee and Rizvi, *E. Shafeei* Hayat, *E. longifasciata* Subba Rao and *E. partenopea* Masi.
Inayatullah and Goraya (1980) reported parasitization of cotton whitefly on brinjal, lantana and sunflower. Thus the presence of parasitoids population on alternate host plants parasitizing the cotton whitefly would be the most effective factor in the biological control. In addition to classical biological control, pest control can be achieved through augmentation and conservation of natural enemies in Pakistan have been reported by Mohmood and Mohyuddin (1986), Mohyuddin and Hamid (1988).
In Texas, Jones and Rose (1993) have independently found high levels of parasitism on SPWF infesting insecticide free host plants. Jones found *Er. californicus* to be the dominant natural enemy from early spring to early summer; however, *En. pergandiella* was found to dominate on nursery plants in green houses, and on weedy host plants during summer.
Collections of exotic parasitoids of *B. tabaci* are being conducted by numerous investigators over 60 shipments of at least 12 different parasitoid species (10 *Encarsia spp.*, *Er. mundus* and an unknown *Eretmocerus sp.*) have been made from Europe, Africa and Asia. Countries of collection include Austria, Crete, Egypt, Greece, India, Pakistan and Spain.

Predators: In sampling southwestern desert cotton, Hagler and Naranjo, 1993 have identified approximately 25 species of predatory arthropods associated with SPWF populations. Field assessment revealed highest predators densities early in the season with rapid declines associated with pesticide applications for SPWF control. *Chrysoperla carnea* and *Geocoris punctipes* were notable exceptions and were found to increase through the season. Among the most common predators were *Chrosoperla carnea. Geocoris spp.*, *Orius tristicolor* and *Nabis alternatus*.
Legaspi-J.C. *et al* (1994) reported that under laboratory conditions *Chrysoperla rufilabris* were provided with *B. tabaci*, *Aphis gossypii*, an artificial diet, or eggs of *Sitotroga cerealella*, *Helicoverpa zea* or *Manduca sexta* Predator larvae attacked an averageof 532 *B. tabaci* per day, when the prey was mainly eggs. Development of larvae of *Chrysoperla rufilabris* took longer when *B. tabaci*, *A. gossypii* or artificial diet were provided.
Kapadia and Puri (1990) reported from India that *Bemisia tabaci* was observed to be attacked by *Chrysoperla carnea* and six aphelinid parasitoids in cotton fields. In the laboratory, alerodid pupae parasitized by *Encarsia tranvena* were attacked by 3rd-instar larvae of *C. carnea* only in the absence of healthy pupae. They reported from Maharashtra that in a survey of 18 plant species apart from cotton, 5 species supported greater parasitoids activity during the off-season. *Encarsia transvena* and *Eretmocarus mundus* were dominant in the monsoon and winter seasons. While *E. mundus* was abundant on summer food plants of the aleyrodid *Bemisia tabaci* . They reported for

Table 1: Population of natural enemies (Predators) 000/acre in unsprayed cotton field during 1999

Predators	June		July		August		September	
	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30
Orius sp.	0.3	0.8	2.2	6.2	8.5	10.8	5.5	3.3
Campylomma sp.	0.0	0.3	1.5	4.5	6.3	8.5	6.3	4.7
Geocoris tricolor	1.5	2.0	2.9	4.0	4.3	4.5	3.0	2.3
Chrysopa sp	1.2	2.3	3.0	6.5	8.0	4.5	2.3	2.0
coccinella	0.0	0.0	0.3	1.7	0.3	0.3	0.4	0.3
Spiders	0.0	1.8	2.5	3.0	3.5	2.5	1.9	1.4
Zanchius sp.	0.0	2.5	2.3	4.0	10.5	10.5	27.0	30.0
Total	3.0	9.7	14.7	29.9	41.4	56.1	46.4	44.0

Table 2: Population of natural enemies (Predators) 000/acre in sprayed cotton field during 1999

Predators	June		July		August		September	
	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30
Orius sp.	0.0	0.0	2.5	3.3	1.2	0.5	0.2	0.0
Campylomma sp.	0.0	0.0	0.0	0.0	2.4	3.0	1.0	0.5
Geocoris tricolor	0.0	0.3	0.5	1.0	0.4	0.3	0.0	0.0
Chrysopa sp	0.0	0.0	2.0	2.2	1.0	0.5	0.0	0.0
coccinella	0.0	0.0	1.3	0.1	0.1	0.8	0.0	0.0
Spiders	0.0	0.3	0.2	0.5	0.3	0.8	0.5	0.5
Zanchius sp.	0.0	0.1	0.5	0.9	2.5	3.0	3.5	4.0
Total	0.0	0.7	7.0	8.0	7.9	8.9	5.2	5.0

the parasitism of *B. tabaci* on different food plants in greenhouse from June 1987 to May 1989. The results suggested that parasitism was highest on cotton and soyabeans. The highest percentage of parasitism was caused by *Eretmocerus mundus*

Aphid *Aphis gossypii* (Glov): Mao *et al.*(1984) from China reported that *Propylea japonica* (Thnb), *Scymnus hoffmanni* (Weise), *Lysiphlebia japonica*(Ashm) and spiders specially *Theridion octomaculatum* Bosenberg and Strand and *Erigonidium graminicolum* (Sund) were collected during a survey in Hunan for natural enemies of *Aphis gossypii* on cotton. The spiders (2.6-26/100 plants) were present from late june to late August and population were relatively unaffected by the weather. Coccinellid populations fluctuated somewhat with the season. Aphid reproduction was inhibited and aphid damage reduced when the ration of total natural enemies to aphids was 1:50, or the ratio of coccinellids to aphid was 1:140.

The characteristics of effective natural enemies: Probably the major advance in biological control during the last decade has been a shift from empirical field assessment of the success of a 'hopeful' introduction to laboratory screening for effectiveness of potential introductions, particularly for the following ecological attributes:

Searching capacity: If a pest is to be kept at low population density, the natural enemy must continue to search rather than emigrate from the area when its host becomes scarce.

Host specificity: In general, host-specific natural enemies respond more precisely to changes in host density than more polyphagous ones. Where, however, the pest population is periodically drastically reduced by other factors, such as harvest of the crop, a more general predator, which can maintain itself on other hosts at such times, may have the advantage.

Potential increase rate: A short development time, large number of generations per year and high fecundity will be particularly useful attributes of a natural enemy to be used against a pest with similar properties, especially if the pest population fluctuates greatly under the influence of weather. Parthenogenesis (as found in Encarsia, the parasite of whitefly) gives the parasite a considerable numerical advantage, as only females of parasitic waps directly perform biological control.

Climatic and niche adaptation: The natural enemy should be able to survive in all the niches and throughout the climatic range occupied by the pest. The relationship of its development and voracity to temperature determines whether it can cause mortality sufficiently early in the pest annual cycle and whether it can avoid being 'outstripped' by the pest.

Ease of rearing: For inundation and even inoculation procedures, it is useful if the natural enemy is easily cultured in the laboratory perhaps on an easily cultured alternative prey or on an artificial food.

Material and Methods

10 acre cotton block sown on second week of May was selected and divided in two portions. In one block three spray applications were given with insecticides Dimethoate 40 EC (First spray), Thiodan 35 EC (Second spray) and Tracer 480 SC (Third spray). The second block of cotton was kept as untreated to see the difference in population of predators in sprayed and un-sprayed cotton. Four stick samples of 52.25" each (1/1000 acre based on a row spacing of 2.5') were selected in a field of approximately 5 acres. All types of predators were recorded from a total plants in the stick sample. Four samples were taken from each field (sprayed and unsprayed) at weekly intervals. Mean fortnightly numbers of predators recorded is given in Tables 1 and 2.

Results and Discussion

Predators were examined both from treated and untreated plots at weekly intervals. Predators number were maximum when population of sucking pests was at their peak in July and August in unsprayed plot. However in insecticide sprayed plo t elimination of all kind of predator species occurred one week after spray. Table 1 and 2.

The observations regarding insect species of predators in sprayed and unsprayed filed were recorded during 1999 are presented in Tables 1 and 2. The results indicated that the predators remained active through out the cotton season with a peak during the month of July and August coinciding with the availability of sucking pest complex in unsprayed plots. However, the number of predators was considerably reduced with the spray of pesticides and thus ineffective for the biological control of cotton insect pest, thus sprays unbalanced the ratio of natural enemies during the above period.

Conclusions: It is becoming essential that pesticide management in cotton includes resistantance i.e. management strategies. Resistance now represents the biggest threat to sustainable cotton production.

Judicious use of pesticides on a need basis, is an important component of cotton IPM; developing practical methods of pest monitoring to establish that need is difficult and is a priority for biological and social science research.

Increasing understanding of the biology and populatio n dynamics of pests and beneficials is gradually improving our ability to introduce preventive measures to keep pests below damage thresholds.

The major focus of the cotton industry is to reduce its dependence on synthetic insecticides for the control of pests in cotton. This can be achieved through the development of alternative pest control strategies which place much more emphasis on the role of beneficial insect.

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