



# An Analysis of Comparative Efficacies of Various Insecticides on the Densities of Important Insect Pests and the Natural Enemies of Cotton, *Gossypium hirsutum* L.

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## ABSTRACT

Field studies were undertaken to assess the influence of insecticidal treatments on sucking and chewing insect pests and their natural enemies in cotton crop. Experiments were conducted to find out the effects of monocrotophos 36% SL and endosulfan 35% EC insecticides on the incidence of harmful insects and the beneficial insects. The data on the incidence of sucking pests were recorded on three leaves (top, middle and bottom canopy) per plant by randomly selecting five plants from each replicate. Similarly, observations on the populations of natural enemies were taken from whole plant basis at weekly intervals. The practice implemented for assessing infestation of chewing pests involved estimating of injury due to all kind of bollworms recorded on shoots, squares, flowers and bolls at regular intervals. Study displayed both the tested insecticides at their recommended doses statistically showed better control of the insect pests as compared to the control, and the pest infestations ranged 3.33-7.00 whiteflies, 0.55-1.99 jassids and 3.99-11.33 aphids per leaf; 2.88-6.22% bollworms damage; and 2845.3-2433.0 kg yield ha<sup>-1</sup>. The beneficial insects viz., coccinellid beetle (*Coccinella septempunctata* [Linnaeus]), common green lacewing (*Chrysoperla carnea* [Stephens]), hover fly (*Eupeodes confrater* [Wiedemann]) and bigeyed bug (*Geocoris ochropterus* [Fieber]) were not so severely affected in the treated and control fields and no statistical differences noted in their densities. Concludingly, decline in abundance of pests and safety of natural enemies by tested pesticides may have important implications for the control of harmful insects in cotton areas and such chemicals can encourage biological control in an agricultural land.

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### Authors' Contributions

MS designed the experiments. M. Sattar recorded the data. Both authors wrote the articles.

### Key words

Cotton, sucking insect pests, bollworms, beneficial insects, insecticides.

## INTRODUCTION

The economy of Pakistan is principally based on agriculture and cotton *Gossypium hirsutum* (L.), is the most exceedingly prized cash crop, which has a major input for food, agriculture and textile industries. Amongst the four provinces of Pakistan, the Punjab province which is a land of five rivers is major cotton cultivated area of the country. All parts of the cotton plant are very useful in our daily life. The most important parts of the cotton are the cotton seed and fiber or lint (Sarwar *et al.*, 2013). However, in terms of yield, cotton is at the distant position locally than in the advanced countries of world. Within Pakistan, there are a lot of practicable reasons for low cotton yield including low literacy rate of farmers, lack of advanced technologies, higher intensity of insect and pest attacks, high price of pesticides, and adulteration in pesticides. Thus, cotton crop yield cannot be attributed to just one or two factors but, there are certain factors

including those which are controlled by the growers, for instance, availability of the pesticides and certain decisions that are in the domain of individual farmer, such as choice of the pesticides (Ahmad and Sarwar, 2013). The quality and productivity of cotton is deteriorated by the invasions of insect many pests. Several insect pests are responsible for causing yield reduction in cotton either directly through sucking cell sap or else by means of eating different parts of plant (Sattar and Abro, 2011). Cotton is a very sensitive crop in terms of pest complex being attacked by different insect pests from germination to final picking (Sarwar, 2013 a). There are 162 species of insects that have been recorded as pests of cotton. Among them, 15 species are of major significance due to their occurrence in serious appearance. The pest complex in cotton includes sap feeders, soft and delicate stem feeders, and a large group of lepidopteron insects which cause serious damage to cotton by direct feeding as well as by transmitting various diseases (Abou-Elhagag, 1998).

Various arthropod species and beneficial insects can be found in cotton fields attacking several pests species. Such predaceous insects live on cotton plants, feed on their arthropods prey and have traditionally been

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successful in suppressing their populations. Beneficial arthropods affect the ecosystem in the sense that they are entomophagous arthropods of insect pests and enhance pollination (Isaacs *et al.*, 2009). A number of parasitoids and predators have been reported feeding on insect pests of cotton. For example the most important and common groups of predatory insects are big eyed bugs, *Geocoris ochropterus* (Fieber) (Lygaeidae: Hemiptera), damselflies, *Ischnura* sp., (Coenagrionidae: Odonata); lady beetles, *Coccinella septempunctata* Linnaeus (Coccinellidae: Coleoptera); green lacewings, *Chrysoperla carnea* (Stephens) (Chrysopidae: Neuroptera); ants (Formicidae: Hymenoptera); wasps, *Ichneumon* sp., (Ichneumonidae: Hymenoptera), spiders, Jumping sp., (Salticidae: Araneae) and predaceous mites *Neoseiulus cucumeris* (Oudemans) (Phytoseiidae: Acarina). These beneficial species have an immense biocontrol potential and attack the egg, immature and adult stages of most pest species (Gloria and John, 1999; Omkar and Pervez, 2003). Multiple chemical applications are often required for crop management and insect control throughout the growing season in cotton. Pesticides exert a variety of effects on natural enemies, of which the most frequently reported is acute toxicity (Ruberson *et al.*, 2004; Sattar *et al.*, 2011; Sarwar and Sattar, 2013; Khalid *et al.*, 2015). Thus, the conservation of natural enemies in the cotton field is of urgent need. The insecticides affect the behavior and biology such as fecundity of the predators. There is a positive correlation between predator and pest populations (Sarwar, 2014; Sarwar *et al.*, 2009, 2010, 2012). Toxicity of chemicals highly influences this relationship by killing preys and predators (Wilson *et al.*, 1998). Farmers mostly rely on pesticide sprays to control insect pests and the repeated use of pesticide sprays is dangerous for the target and non targeted fauna. Target insect pests exhibit resistance but non targeted insect especially the predatory fauna become extinct due to the lethal effects of insecticides (Trumper and Gyenge, 1998). The damage to cotton has become more serious and frequent because insecticide sprays directed against insect pests normally kill most natural enemies, such as ladybeetles and lacewings that are major predators of cotton pests (Sattar *et al.*, 2011; Sarwar, 2013 b). Field studies were undertaken to assess the influence of insecticidal treatments on predators and insect pests in cotton crop under experimental conditions which can be equally or more important for integrated pests management.

## MATERIALS AND METHODS

### *Experiment field*

Experiments were conducted at the investigational

field of Sindh Agriculture University, Tandojam, in District Hyderabad. Study determined the effects of organophosphorus monocrotophos 36% SL (Manufacturer, Cia-Shen Company Limited, China) and chlorinated hydrocarbon endosulfan 35% EC (Manufacturer, Shenzhen King Quenson Industry Co., Ltd., Guangdong, China) insecticides on the incidence of cotton's sucking and bollworm insect pests, and the beneficial insects. The site is located at an altitude of about 26 m above sea level with a latitude of 25° 25' 28" N and 68° 32' 25" E. A cotton variety 'NIAB-Karishma' used in the experiments was taken from Plant Protection Division, Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. Geographic coordinates of Faisalabad, is latitude: 31° 25' 00" N, longitude: 73° 04' 59" E and elevation above sea level: 186 m. The cotton variety used on relative effects of different insecticides on the abundance of major insect pests and their predators, was grown in the field area free from weeds. The field was ploughed and leveled accurately and divided into various sections according to treatments. The field trial was sown in four replications in complete randomized block design. The seed sowing @ 6 kg ha<sup>-1</sup> in the field was undertaken by hand on first week of May, 2006 during summer season at a distance of 45 cm from plant to plant and 90 cm row to row distance. The experiments were arranged adopting standard agronomic practices and compulsory intercultural operations such as irrigation, fertilizers and weeding were carried out properly.

### *Experiment technique*

The field experimental designed included subsequent treatments of pesticides and each treatment was replicated three times: - T1= Monocrotophos insecticide, T2= Endosulfan insecticide, as and when required at the rate of 0.70 and 0.75 kg. a.i./ha, respectively, each dissolved in 225 liters of water/ ha, and T3= Without pesticides given (control). For each treatment, the insecticide was combined with water to simulate a concentration that could be applied on crop and sprayings for experiment were done by using a knapsack sprayer when whichever plant per replicate was infested by any of the target pests. The experiment was conducted under river irrigated system and data on predators and insect pests parameters in cotton from randomly selected plants were recorded initially at 60 days after crop sowing.

### *Sampling populations of harmful insects*

Each treatment field was sampled every 1-2 days after insecticide treatments, and each sample consisted of field counts on incidence of sucking pests, infestation of chewing pests and occurrence of natural enemies by the

random selection of plants. The data on the incidence of sucking pests were recorded on three leaves per plant selected from the top, middle and lower portion (Sarwar, 2013 b), viewing by the naked eye or under a magnifying glass at weekly interval. The methodology used to establish the pest infestation for different sucking pests, such as whiteflies *Bemisia tabaci* (Gennadius) (Aleyrodidae: Homoptera), jassids *Amrasca biguttula* (Ishida) (Cicadellidae: Homoptera) and aphids *Aphis gossypii* Glover (Aphididae: Homoptera) was similar as the description given above.

The method adopted for assessing infestation of chewing pests involved estimating of injury due to all kind of bollworms recorded on shoots, squares, flowers and bolls at regular intervals. For pink *Pectinophora gossypiella* (Saunders) (Gelechiidae: Lepidoptera) and spotted bollworms *Earias insulana* (Boisduval) or *E. vitella* (Fabricius) (Noctuidae: Lepidoptera), the field scouting methodology was counting the numbers of larvae per 20 plants within a group of 5 plants by moving in between the plant rows in diagonal direction across the field.

#### *Sampling populations of natural enemies*

The populations of natural enemies were observed on whole plant at regular intervals and their adults, larvae and pupae were identified (Sarwar, 2013 a). The technique included sampling of five randomly selected plants in each replicate of a treatment and counting number of predatory enemies *i.e.*, lady bird beetles, green lacewings, hover flies and bigeyed bugs, and data were collected and recorded.

#### *Yield estimation*

At the end of crop season, when the crop attained complete maturity, cotton was picked up and yield of all individual pickings was summed up together to determine the total yield of each treatment. The season mean crop data recorded after final harvest were calculated, and converted and expressed into kg ha<sup>-1</sup>.

#### *Data analysis*

All the data gathered on weekly basis were analyzed by using Statistics computer software package 8.1 Version. Descriptive statistics (Mean, Least significance difference, Sum and Standard error), and ANOVA models were used for representation of the results and interpretations of conclusions.

## RESULTS

The data collected by surveying the effects of both the tested insecticides at their recommended doses

statistically showed superior control of the insect pests as compared to the control, while a good survival of natural enemies observed in treated and untreated fields that did not differ significantly (Tables I, II).

#### *Populations of insect pests*

Investigations on the seasonal population dynamics of sucking insect species complex in cotton fields indicated that pest's density on cotton increased drastically in untreated crop, almost certainly due to none insecticide sprays. Incidence of whiteflies in treated cotton was reduced by 3.33 and 3.77 populations per leaf, respectively, in monocrotophos and endosulfan treatments in comparison to control field (7.00 per leaf). Also the monocrotophos and endosulfan treatments had less infestation of jassids (0.55 and 0.73 populations per leaf, respectively) in comparison to control field (1.99 per leaf). The populations of aphid were also found significantly ( $P < 0.05$ ) lower in fields where insecticides were applied on cotton. Populations of 3.99 aphids per leaf were found in monocrotophos treatment against the endosulfan showing some sort of 4.33 (differences were non significant) and 11.33 mean population, respectively, in unsprayed field.

The comparative analysis of field evaluations indicated that monocrotophos and endosulfan treated cotton provided good control of the cotton bollworms. Data illustrated this trend as average square and boll damage of 2.88% and 3.16%, respectively, occurred in monocrotophos and endosulfan treated cotton fields, which were significantly lower than those on unsprayed cotton (6.22% damage) (Table I).

#### *Crop yield*

Untreated control field resulted in lower yield under unsprayed treatment in comparison to treated fields. Highest reduction in yield (2433.0 kg ha<sup>-1</sup>) was observed under unsprayed treatment in comparison to fields treated with monocrotophos and endosulfan (2845.0 and 2830.0 kg ha<sup>-1</sup>, respectively) (Table I).

#### *Populations of natural enemies*

The results revealed that the beneficial insects *viz.*, coccinellid beetle *Coccinella septumpunctata* (Linnaeus), common green lacewing (*Chrysoperla carnea* [Stephens]), hover fly *Eupeodes confrater* (Wiedemann) and bigeyed bug *Geocoris ochropterus* (Fieber) were not so severely affected in the treated and the control fields and no statistical differences noted in their populations. Numbers of coccinellid beetle 2.88 per plant were observed in monocrotophos treatment, whereas, these were only 2.99 and 3.66 beetles per plant in fields sprayed with endosulfan and water, respectively. The

**Table I.- Performance of tested insecticides on cotton for pests' incidence, natural enemies and seed cotton yield.**

Insecticides	Sucking insects density per leaf			Bollworms complex	Yield kg ha <sup>-1</sup>
	White fly	Jassid	Aphid	Average square and boll damage (%)	
Monocrotophos 36% SL	3.33 b	0.55 b	3.99 b	2.88 b	2845.3 a
Endosulfan 35% EC	3.77 b	0.73 b	4.33 b	3.16 b	2830.0 a
Water (Control)	7.00 a	1.99 a	11.33 a	6.22 a	2433.0 b
S. Error	0.439	0.132	0.533	0.325	14.145
LSD Value	1.219	0.368	1.480	0.903	39.272

Means in the column associated with the same letter are not significantly different at Alpha 0.05.

**Table II.- Performance of tested insecticides on cotton for holding densities of natural enemies.**

Insecticides	Densities of natural enemies per plant			
	Coccinellid beetle	Green lacewing	Hover fly	Bigeyed bug
Monocrotophos 36% SL	2.88 a	1.88 a	0.55 a	0.23 a
Endosulfan 35% EC	2.99 a	2.10 a	0.58 a	0.30 a
Water (Control)	3.66 a	2.44 a	0.65 a	0.40 a
S. Error	0.361	0.210	0.075	0.086
LSD Value	1.003	0.585	0.208	0.239

Means in the column associated with the same letter are not significantly different at Alpha 0.05.

foliage-inhabiting natural enemy common green lacewing was not significantly abundant in monocrotophos, endosulfan and untreated control fields (1.88, 2.10 and 2.44 per plant, respectively). Similarly, populations of hover fly were 0.55, 0.58 and 0.65 per plant, respectively, in monocrotophos, endosulfan and untreated control fields. Whereas, natural enemy bigeyed bug had 0.23, 0.30 and 0.40 numbers per plant, respectively, in monocrotophos, endosulfan, and untreated control fields (Table II).

## DISCUSSION

Field experiments on the effects of insecticides imposed on crop yield and number of insects of cotton indicated that cotton pest populations were effectively controlled at a high level, almost certainly due to high densities of ladybeetles, lacewings and predatory bugs populations. The beneficial insects were not so severely affected in the treated and the control fields and no statistical differences noted in their populations. The effects of the insecticides were also tested on the abundance of different predator populations in the prior studies. Our results are comparable to the other results where the influence of insecticides on the viability of entomopathogenic nematodes (Rhabditida: Steinernematidae and Heterorhabditidae) were

investigated. Based on the research, it was found that compatibility to chemicals is not only a species-specific, but also a strain-specific characteristic. The *Steinernema feltiae* and *Heterorhabditis bacteriophora* are compatible with azadirachtin and pirimicarb and might offer a cost-effective alternative to pest control (Laznik and Trdan, 2014). This suggests that cotton planting could effectively prevent revival of cotton sucking and chewing pests directly caused by insecticide used for pest control along with protecting the predator populations indirectly effecting the production of a crop by suppressing insect pest populations. Moreover, the treated cotton created severe competition among natural enemies (top significant predators coccinellids, chrysopids, hover flies and bigeyed bugs) indirectly through the removal of adults, eggs, larvae and pupae of insect pests that serve as food sources for predatory arthropods. Insecticide applications directly did not cause considerable reduction in the number of natural enemies that is another important factor regulating their population dynamics. This statement is analogous to the results where earlier finding on nontarget effects of entomopathogenic nematodes on the larvae of the twospotted lady beetle, *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae) and on the larvae of the lacewing *C. carnea* were studied. It was found that the entomopathogenic nematodes under investigation exhibited a pronounced nontarget effect on

the larvae of both predators mentioned (Rojht *et al.*, 2009). The current results also agreed with Nazar *et al.* (2012) who reported that the predator-prey relationships are thought to be among the main factors governing the seasonality and population abundance of most predators in the field.

Field surveys showed that the populations of lacewings, lady beetles, and bugs remained at high densities and no significant differences noted in sprayed and unsprayed cotton throughout the season. Differences among pest's levels revealed that beneficial arthropods definitely played some important role in regulating the number of harmful arthropods (Aslam *et al.*, 1998). Similar results were found in the previous study that toxicity of the insecticides is the prime factor for deterrence of the predators. That might hamper the survival and reproductive potential of the predators and show moderate efficacy on abundance of natural enemies (Amin *et al.*, 2008; Ahmad *et al.*, 2011a; Sattar *et al.*, 2011). Considering this investigation further, it showed the positive effects of pesticides on cotton yield trait and this attribute of cotton was increased significantly due to crop treatments which kept the plants free from severe infestation of sucking and chewing insects and produced the higher yield compared to the untreated control. This is also known for the pests of other crops, for example a comparison of the efficacy of foliar application of two strains of *Steinernema feltiae* (Filipjev) and spraying with thiametoxam for control of the Colorado potato beetle (*Leptinotarsa decemlineata* [Say]) on potato was tested. Observing the population dynamics of the pest, it was became apparent that entomopathogenic nematodes significantly decreased the number of larvae, but no effect on their eggs and adults was confirmed, while thiametoxam showed the best results in general and the highest yield was obtained, while the lowest recorded in the control treatment (Laznik *et al.*, 2010). The present finding further shows similarity with that of Ahmad *et al.* (2011b), who obtained higher seed yield of cotton by protecting the crop from early pest infestation. Our findings also coincide with the results found by Shahid *et al.* (2013) who concluded from the results that predator population can indirectly effect the yield production of a crop by suppressing insect pest populations.

As a concluding point, obvious variations were noticed in both recorded parameters on pest incidence and yield of cotton. Among two pesticides studied, monocrotophos was more efficient in tolerating the adverse effect of pest incidence, whereas endosulfan also showed good responsiveness against pest tolerance. Effects of pesticides treatments on the crop grown were favorable on growth and yield traits. Treatments also did not exert more effects on densities of predatory insects

trait than check replicates. However, pest initiation period was more critical for protecting fruit bodies and yield enhancement traits. Treatments also affected crop more in reducing pest incidence due to differences in chemical constitution of pesticides and environmental affairs. The recorded yield attribute showed significant reduction under high pest incidence at varied growth stages. Pest incidence trait showed significant link with yield, showing that these can be effectively used for field protection of cotton for pest tolerance. The reductions in abundance of insect pests and protection of natural enemies may mitigate crop yield loss and pest control expenditures in cotton cropland. This work demonstrates that such insecticides can promote conservation of biocontrol agents in the cotton field and be able to provide some level of biological control of host insect pests without relying on their colonization from outside of the field.

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