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FIELD EVALUATION FOR EFFICACY OF CONVENTIONAL INSECTICIDES AND INSECT GROWTH REGULATORS AGAINST SPOTTED BOLLWORMS, *EARIAS* SPP. OF COTTON

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ABSTRACT

Spotted bollworms (SBW) are important pests of cotton. Its larvae bore into the growing shoots, flower buds, flowers and bolls of cotton resulting in considerable losses in quality and quantity. Field studies were conducted to evaluate the insecticidal toxicity of four conventional insecticides (deltamethrin, cypermethrin, bifenthrin and chlorfenapyr) and four insect growth regulators (IGRs) (chlorfluazuron, pyriproxyfen, methoxyfenozide and buprofezin) against SBW. Cotton variety, BH-167 was sown in Randomized Complete Block Design (RCBD) with three replications at the farm area of The Islamia University of Bahawalpur, Pakistan. The percentage bolls infestation and population reduction was calculated at 3 and 7 days after treatment (DAT). Deltamethrin showed comparatively better results with minimum percentage bolls infestation (4.35% and 1.82%) and maximum percentage reduction in SBW larvae population (64.4% and 100.0%) at 3 DAT and 7 DAT, respectively. Deltamethrin also gave prominently significant results for increase in seed cotton yield (2043.2 kg/ha). It was also observed that insecticides were found most effective on both 3 DAT and 7 DAT as compared to the IGRs. However, the effect of IGRs against SBW was enhanced at 7 DAT as compared to their effect at 3 DAT. Taken together, deltamethrin was found most effective against SBW with a significant increase in the seed cotton yield.

Keywords: Cotton, Efficacy, Insect growth regulators, Insecticides, Spotted bollworms

INTRODUCTION

Cotton, *Gossypium hirsutum* L. (family Malvaceae) is one of the major cash crop of Pakistan and is also known as silver fiber (Gill and Dhawan, 2006). It is a main earning source of foreign exchange and occupies the largest portion after wheat. The millions of farmers are dependent on this crop along the entire value chain from weaving to textile, clothing exports, good production and utilization in the country (Hashmi, 1994; Lohar, 2001; GOP, 2013). After U.S.A and China, Pakistan is ranked third largest producer of lint in the world and comes at fifth position in cotton utilization (Skorburg, 2002). Cotton provides fiber to the farmers and its seed provides edible oil and cake for the cattles. The seed oil has high poly unsaturated fats and high level of antioxidants (Mallah *et al*., 1997).

The yield of cotton in Pakistan is still lower than cotton growing countries (Ahmed, 1999). Insects are important in agriculture due their beneficial as well as destructive aspects (Javed *et al.,* 2013; Suhail, *et al.,* 2013). Insect pests are considered as the leading threat and hurdle in improving cotton production. It is predicted that about 20-40% losses take place annually due to different insect pests of cotton (Mallah *et al*., 1997; Abbas, 2010). Spotted bollworms (Noctuidae: Lepidoptera) are one of the major chewing insect pests of cotton among 148 already recorded insect pests on cotton crop in Pakistan (Leclant and Deguine, 1994; Mohyuddin *et al.,* 1997). Spotted bollworms (*E. insulana* and *Earias vitella*) are serious pests of cotton that can cause huge loss (19-20%) from germination to maturity of the crop (Kamaluddin, 1994).

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SBW attacks on cotton crop at early stage and cause top boring at the time of boll formation. The larvae bore into the young bolls, flower buds and terminal shoots of young plants. The characteristic symptom is the bore hole with larval frass presence at the entrance. Terminal shoots dry up and withers away when the larvae bore into the pre squaring plants. Feeding holes in squares and on bolls are seen with or without larvae. However, holes are blocked with the excreta of larvae. Premature dropping or opening of the attacked bolls is common after SBW infestation. One larva bears the potential of destroying a number of bolls before it reaches pupation. Infested bolls produce poor lint resulting in low economic yield and lower prices in the market (Atwal, 1994). SBW can exhibit up to 11 generations in single year under the favorable conditions (Shanower and Romies, 1999).

Chemical insecticides are considered as the most rapid and effective method to control cotton bollworms. The threat of SBW to cotton arouses the importance of its effective control with these agrochemicals. The steps employed for the management of insect pests especially the application of synthetic insecticides and their continuous evaluation is necessary (Wahla *et al.,* 1998). There are varying amount of insecticides which are using regularly for controlling cotton bollworms including SBW (Gupta *et al.,* 2005). Pesticides are comparatively better option to avoid economic damage to this high value crop (Shanower *et al.,* 1994). However, chemicals pesticides may cause health hazards, environmental pollution, resistance development in insects, resurgence of new insect pests and toxicity to natural biological agents (Croft, 1990; Bhati *et al.,* 1993; Horowitz *et al.,* 1993; Ahmad *et al.,* 2001; Gill and Garg, 2014). In parallel to conventional insecticides, insect growth regulators (IGRs) also got importance due to their unique mechanism of action, potential effect against specific insect pests and low toxicity to the environment as well as the natural biological agents (Biddinger and Hull, 1995; Oberlander *et al*., 1997; Karim *et al.,* 1999; Javaid *et al.,* 1999; Dent, 2000; Tunaz and Uygun, 2004). Thus, IGRS may also facilitate the biological management of cotton insect pests by disrupting the molting, physiology and biochemical process of the insects (Smet *et al*., 1990; Schenker and Moyses, 1994; Oberlander *et al*., 1997; Naranjo *et al*., 2004; Sohrabi *et al*., 2012).

Keeping in view the severity of SBW infestation on cotton crop, present study was designed to evaluate the comparative toxicity of conventional insecticides and insect growth regulators against SBW.

MATERIALS AND METHODS

The study was conducted at the farm area of the Islamia University of Bahawalpur in randomized complete block design (RCBD) with three replications. A cotton variety (BH-167) was sown in May, 2012 with plot size of 3.75 x 5.40 m, plant-to-plant distance of 22.5 cm and row-to-row distance of 2.5 ft. All standard agronomic practices were applied equally in all the treatments throughout the whole duration of the crop. Four conventional insecticides (deltamethrin, cypermethrin, bifenthrin and chlorfenapyr) and four IGRs (chlorfluazuron, pyriproxyfen, methoxyfenozide and buprofezin) were tested against SBW (Table 1). Knap sack sprayer (Syngenta) was used to spray the insecticides at their recommended doses when the population reached the economic threshold level (ETL; 3 small larvae or 5 eggs or 5 both per 25 plants) (Ahmad, 2000). Five plants were selected randomly from each plot for observing larval population and number of infested bolls. The larval population was counted by opening the infested flower buds, flowers and bolls a day before treatment and 3, 7 days after treatment (DAT). The percentage reduction (increase or decrease) in SBW larvae population was calculated by using the following formula (Fleming and Retnakaran, 1985).

$$\%\ \text{population reduction} = \frac{\text{Pre-treatment population} - \text{Post-treatment population}}{\text{Pre-treatment population}} \times 100$$

The percentage bolls infestation and seed cotton yield was calculated by using the following formulas:

$$\%\ \text{bolls infestation} = \frac{\text{No. of damaged bolls}}{\text{Total no. of bolls}} \times 100$$

Seed cotton yield = Yield per plot /Plot Size × 10,000 (1 hectare = 10000 m^2)

STATISTICAL ANALYSIS

Statistix 8.1 software was used to analyze the data statistically with Fisher's analysis of variance (ANOVA) and least significance difference (LSD) test at 5 % probability level (Steel *et al*., 1997).

RESULTS

Bolls infestation

Percentage bolls infestation was highly significant in all treated plots at 3 DAT ($F = 393.86$, $P = 0.0000$) and 7 DAT ($F = 892.00$, $P = 0.0000$) as compared to control plots (Table 2). However, bolls infestation gradually decreased from 3 DAT to 7 DAT in all the treatments. In contrast, highest percentage bolls infestation was observed in untreated plots (Table 3). Deltamethrin gave prominent reduction in bolls infestation from 3 DAT to 7 DAT as compared to all other tested treatments (Table 3).

On 3 DAT, the least bolls infestation with deltamethrin was 4.35% followed by bifenthrin (5.80%), cypermethrin (6.63%) and chlorfenapyr (7.54%). Chlorfluazuron was least effective after control with high bolls infestation (17.37%). But in comparison with other tested IGRs, chlorfluazuron exhibited higher bolls infestation (17.37%) followed by buprofezin (13.21%), methoxyfenozide (11.31%) and pyriproxyfen (10.04%) (Table 3).

On 7 DAT, deltamethrin still remained effective with least bolls infestation (1.82%) followed by cypermethrin (4.57%), bifenthrin (5.32%) and chlorfenapyr (6.36%). Chlorfluazuron remained less effective after control with high bolls infestation (12.68%). Among all tested IGRs, pyriproxyfen showed better results for bolls infestation (7.69%) followed by buprofezin (9.46%), methoxyfenozide (10.30%) and chlorfluazuron (12.68%). The data also exhibited that IGRs were less effective at 7 DAT as compared to all insecticides.

However, the better toxic effect of IGRs was observed at 7 DAT as compared to their effect at 3 DAT (Table 3).

SBW Population

Percentage reduction in SBW population was highly significant at all treated plots at 3 DAT (F = 41.07, P = 0.0000) and 7 DAT (F = 84.65, P = 0.0000) as compared to untreated plots (Table 4). The SBW larvae population reduction gradually increased from 3 DAT to 7 DAT in all the treatments except control where no reduction was observed (Table 5). Among treatments, deltamethrin proved the most effective against SBW from 3 DAT to 7 DAT as compared to all other tested treatments (Table 5).

On 3 DAT, the highest population reduction with deltamethrin was 64.400% followed by cypermethrin (58.87%), bifenthrin (53.53%) and chlorfenapyr (44.43%). Chlorfluazuron showed zero reduction in SBW larvae population as observed in untreated plots. Among all tested IGRs, pyriproxyfen and methoxyfenozide exhibits better results (35.53%) against SBW followed by buprofezin (30.53%) and chlorfluazuron (0.00%).

On 7 DAT, deltamethrin remained at the top for its effectiveness with highest SBW population reduction (100.00%) of SBW followed by cypermethrin (93.33%), bifenthrin (55.53%) and chlorfenapyr (55.53%). Untreated plots showed zero reduction but chlorfluazuron gave better result (50.00%) at 7 DAT as compared to its zero effect at 3 DAT against SBW. But in comparison with other tested IGRs, chlorfluazuron exhibits better results against SBW (50.00%) followed by pyriproxyfen (35.53%), methoxyfenozide (35.53%) and buprofezin (30.53%). The data revealed that IGRs required more time to be effective against SBW as compared to conventional insecticides. Thus, the comparison between conventional insecticides and IGRs revealed that insecticides were found effective on both 3 DAT and 7 DAT. However, IGRs gave better performance at 7 DAT as compared to their effect at 3 DAT (Table 5).

Seed Cotton Yield

There was significant variation in seed cotton yield among all the tested treatments (F = 74.05, P = 0.0000). The highest seed cotton yield was recorded in deltamethrin treated plots (2043.2 kg/ha) followed by cypermethrin (1706.7 kg/ha) and bifenthrin (1648.2 kg/ha). It was also noticed that the yield was comparatively more in plots treated with insecticides than IGRs treated plots (Table 6). Perhaps, the slow action of IGRs against SBW might be the possible reason for such difference in the yield (Table 6).

Table 1

Insecticides used against SBW on cotton crop.

Common Name	Trade Name	Type/Category	Company	Dose/acre
control		Water		
deltamethrin	Deltamethrin	Insecticide	Agri plus	250 ml
cypermethrin	Arrivo	"	FMC	250 ml
bifenthrin	Bifenthrin	"	Agri plus	200 ml
chlorfenapyr	Chlorfenapyr	"	Agri plus	320 ml
chlorfluazuron	Prade	IGRs	FMC	350 ml
pyriproxyfen	Pyriproxyfen	"	Agri plus	250 ml
methoxyfenozide	Runner	"	Arysta	200 ml
buprofezin	Buprofezin	"	Agri plus	600 gm

Table 2

ANOVA comparison for cotton bolls infestation for various insecticides.

		(3 DAT)			(7 DAT)		
Source of variation	**Degree of freedom**	**Mean squares**	**F-value**	**P-value**	**Mean squares**	**F-value**	**P-value**
Replication	2	0.5604			0.0429		
Treatment	8	89.1752	393.86	0.0000***	86.2103	892.00	0.0000***
Error	16	0.2264			0.0966		
Total	26						
CV		4.43			3.58		

Probability level at 5%, P ≤ 0.001***, DAT = days after treatment, CV = Coefficient of Variation

Table 3

Percentage bolls infestation in plots treated with insecticides.

	%age boll infestation	
Treatments	**(3 DAT)**	**(7 DAT)**
control	20.47 cd	20.04 a
deltamethrin	4.35 h	1.82 I
cypermethrin	6.63 g	4.57 h
bifenthrin	5.80 g	5.32 g
chlorfenapyr	7.54 f	6.36 f
chlorfluazuron	17.37 b	12.68 b
pyriproxyfen	10.04 e	7.69 e
methoxyfenozide	11.31 d	10.30 c
buprofezin	13.21 c	9.46 d
LSD	0.8236	0.5381

Means sharing the common letters are not significantly different at P = 0.05, DAT= days after treatment, LSD= Least Significant Difference

Table 4

ANOVA comparison of Percentage reduction in SBW population.

		(3 DAT)			(7 DAT)		
Source of variation	**Degree of freedom**	**Mean squares**	**F-value**	**P-value**	**Mean squares**	**F-value**	**P-value**
Replication	2	0.34			95.90		
Treatment	8	1651.63	41.07	0.0000***	2899.70	84.65	0.0000***
Error	16	40.22			34.25		
Total	26						
CV		17.57			11.55		

Probability level at 5%, P ≤ 0.001***, DAT= days after treatment, CV = Coefficient of Variation

Table 5

Percentage reduction in SBW larval population at 3 and 7 DAT of different insecticides.

	%age population reduction	
Treatments	**(3 DAT)**	**(7 DAT)**
control	0.00 d	0.00 d
deltamethrin	64.40 a	100.00 a
cypermethrin	58.87 a	93.33 a
bifenthrin	55.53 a	55.53 b
chlorfenapyr	44.43 b	55.53 b
chlorfluazuron	0.00 d	50.00 b
pyriproxyfen	35.53 bc	35.53 c
methoxyfenozide	35.53 bc	35.53 c
buprofezin	30.53 c	30.53 c
LSD	10.98	10.13

Means sharing the common letters are not significantly different at P = 0.05, DAT = days after treatment, LSD= Least Significant Difference

Table 6

Effect of different treatments on the seed cotton yield (kg/hectare).

Treatments	Seed cotton yield (Kg/ha)
control	1046.8 f
deltamethrin	2043.2 a
cypermethrin	1706.7 b
bifenthrin	1648.2 b
chlorfenapyr	1438.6 c
chlorfluazuron	1188.2 e
pyriproxyfen	1419.2 c
methoxyfenozide	1296.4 d
buprofezin	1218.9 de
LSD	107.81

Means sharing the common letters are not significantly different at P = 0.05, , LSD= Least Significant Difference

DISCUSSION

The data exhibited the percentage boll infestation and larvae population reduction after application of different treatments. The effect of these treatments on the seed cotton yield was also evaluated. Results regarding effectiveness of deltamethrin and cypermethrin for SBW larvae population and bolls infestation are partially supported by a comparative study that reported the minimum damage to squares with deltamethrin. The minimum larval population was observed with spinosad followed by deltamethrin and cypermethrin (Khan *et al*., 2007).The findings of Brar *et al.* (1998) and Chauke *et al.* (1998) are in agreement of our findings regarding the prominent results of cypermethrin up to 7DAT. Ali *et al.* (2005) reported the contrast results where lowest numbers of SBW were found with bifenthrin and cyhalothrin at 2 DAT. The moderate effect of bifenthrin up to 7 DAT against SBW is in confirmatory with Aslam *et al.* (2004) .Deltamethrin was the most effective against SBW larvae population up to 7 DAT which is in agreement with the findings of Samuthiravelu and David (1990). It is partially in accordance with a study where mixture of deltamethrin with endosulfan proved to be more effective against cotton bollworm complex at 7 DAT (Dhawan and Simwat, 2001). Deltamethrin and cypermethrin used alone or in mixture remains effective against SBW larvae population which is reported by previous studies (Hamed *et al.,* 1997; Khan *et al.,* 2000; Misra *et al.,* 2002; Daud and Mushtaq, 2012).

The comparative efficacy of synthetic pyrethroids (deltamethrin, cypermethrin and bifenthrin) in present study against SBW and reduction in bolls infestation are endorsed by other studies dealing with synthetic pyrithroids against chewing, sucking insect pest of different crops including cotton (Ahmed *et al.,* 2003; Kaler and Simwat, 2003; Tayyab *et al.,* 2005; Chandra *et al.,* 2010; Ngari *et al.,* 2010). The possible reason for pyrethroid II (deltamethrin) mode of action is its effectiveness against insect through direct contact and ingestion. It has α-cyano group that induces "long-lasting" inhibition of sodium channels. It acts on nervous system through the delay of activation gate for sodium closing. However, pyrethroids can also effect on other ion channels (Burr and Ray*,* 2004; Ray and Fry*,* 2006; Moid *et al.,* 2012).

Pyriproxyfen (juvenile hormone mimic) and methoxyfenozide (ecdyson receptor agonist) significantly reduced the SBW population and bolls infestation. The possible reason might be due to their effect on insect blood cells like other reported insecticides to affect the blood cells in different insects (Iqbal *et al.,* 2002; Zibaee *et al*., 2012). Pyriproxyfen is reported to control many other insect pests of different crops (Darriet *et al*., 2010; Jahan *et al*., 2011). Pyriproxyfen was found more effective than buprofezin (chitin synthesis inhibitor) which is agreement with the findings of Nasr *et al*. (2010), who reported highest mortalities of leaf worm with pyriproxyfen as compared to buprofezin up to 6 days. Pyriproxyfen also significantly lowered the egg production of citrus mealybug as compared to buprofezin (Cloyd, 2003).

Buprofezin was least effective which is in agreement with Gogi *et al*. (2006). Although, chlorfluazuron and buprofezin are chitin biosynthesis inhibitors but both showed different efficacy against SBW at different days. The possible reason might be the different chemical activity of these IGRs, because Chlorfluazuron is a benzoylurea while buprofezin belongs to thiadiazines group of insecticides. The variation in reduction of acetylcholinesterase enzyme (ACHE) activity in response to two chitin biosynthesis inhibitors *i.e.,* buprofezin (thiadiazines) and lufenuron (benzoylurea) is also documented (Badawy *et al.,* 2013). The inhibitory effect of IGRs on ACHE activity is also documented in honeybees (Rabea *et al.,* 2010). Thus, difference in inhibitory effect on ACHE activity might also be the potential reason for variation of efficacy of two IGRs in our study.

The present study elaborated that IGRs were less effective against the bolls infestation and SBW population reduction at 3 DAT but their effect was more promising at 7 DAT. Thus, the insecticides showed effective and rapid results as compared to IGRs. This is partially supported by a laboratory work of Singh *et al.* (1993) who found the minimum effect of IGRs (diflubenzuron) as compared to conventional insecticide (deltamethrin, cypermethrin) against egg hatching of SBW. The reason may be that IGRs take more time than conventional insecticides (Dent, 2000).

Our findings revealed that both insecticides and insect growth regulators showed positive effect on seed cotton yield. However, the plots treated with insecticides gave comparatively better yield as compared to IGRs. The significant increase in yield observed with deltamethrin, cypermethrin and bifenthrin is in partial agreement with the previous studies (Ali *et al.,* 2005; Nasir *et al*., 2008; Ngari *et al.,* 2010).

CONCLUSION:

Taken together, all treatments have significant effect on bolls infestation and SBW population. However, deltamethrin was found comparatively most effective for reduction in SBW population and percentage bolls infestation at 3 DAT and 7 DAT with a significant increase in the see cotton yield. According to the present study, farmers may prefer synthetic insecticides to get quick knock down of SBW population. Since, IGRs were taking more time for its effectiveness. Therefore, inclusion of IGRs in the in integrated pest management program would be a good option for the farmers. Moreover, timely application of IGRs would be the critical factors for the effective management of SBW population.

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