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EFFECT OF NOVEL INSECTICDES ON *HELICOVERPA ARMIGERA* (LEPIDOPTERA: NOCTUIDAE) ON SEED CROP OF BERSEEM (*TRIFOLIUM ALEXANDRINUM* L.) AND THEIR IMPACT ON SEED YIELD

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ABSTRACT

Six novel insecticides from the new chemistries - Marshal (lufenuron), Runner (methoxyfenozide), Spintor (spinosad), Emamectin (emamectin benzoate), Coragen (chlorantraniliprole) and Belt (flubendamide) - were evaluated for efficacy in a controlled field experiment against an active infestation of *Helicoverpa armigera* (Hübner) larvae on berseem seed crop at the Fodder Research Institute, Sargodha during 2016-17. The data was recorded before the treatments were applied, then 3, 5, 7 days after treatment. Treatments with percent mortality greater than 75% were considered to be effective controls. Percent mortality was 96% for emamectin, 95% for spinosad, and 94% for belt at 3 d posttreatment. Percent mortality was; 94% for spinosad; 90% for belt; and, 89% for emamectin at 5 d posttreatment. Percent mortality was 82% emamectin and 78% mortality for spinosad at 7 d posttreatment. All other treatments had percent mortality estimates of less than 75%. It is concluded that emamectin, spinosad and belt are suggested to be used on berseem seed crop against *H. armigera* for better management since among the treatments in the trial efficacious control was found at 3, 5 and 7 days posttreatment. The maximum seed yield i.e. 3.19, 3.09 and 3.04 mounds per acre was obtained, where these insecticides were applied compared to 1.38 mound per acre in the nontreated control.

Keywords: Berseem SB-11, Seed crop, Novel insecticides, *Helicoverpa armigera*, Improved crop yield, Pakistan

INTRODUCTION

Egyptian clover, or berseem, *Trifolium alexandrinum,* is the chief leguminous forage crop in Pakistan (Karishnamurthi, 1959) mainly grown for green fodder. It is very nutritious, palatable (FAO, 2011) and a high-yielding fodder crop (Clark *et al*., 1992) that is well adopted in Pakistan (Chaudhry *et al*., 1994). It is cultivated in the Rabi season and therefore known as a cool season clover (Rethwish *et al*., 2002). Berseem is one of the most important leguminous forages in the Mediterranean region and the Middle-East (Sardana and Narwal, 2000: De-Santis *et al*., 2004). It can be grown by direct cropping, mix cropping or in crop rotation. It also serves as a trap crop for natural enemies to attract and enhance the predators and parasitoids of pest (Wagan *et al*., 2015). As a legume, it increases the soil fertility and also reclaims saline soils, particularly in the rice growing areas (Khalil and Jan, 2000). Berseem is the rich and cheapest source of protein for livestock. Its forage is superior to other grasses in protein and mineral contents (Laghari *et al*., 2000). In green fresh form, berseem contains about 10 % total digestible nutrients and 2.2% digestible crude protein and is rich in protein composing 23% of the biomass on a dry matter basis (Randhawa *et al.,* 2009). Berseem has regenerative capability and during its growing season it gives several cuttings and provides nutritious, palatable and succulent forage for livestock (Gul *et al.,* 2011). Berseem normally gives 4-6 cuttings (Graves *et al.,* 1996) and also it is capable of 5-7 cuts of succulent forages (Khan *et al.,* 2012). In Pakistan, berseem becomes major rabi fodder crop and also known as the 'king of fodder'. It is the largest cattle fodder grown in the country, 88% of which grows in Punjab, 9% in Sindh, 2% in the KPK and 0.5% in Balochistan (Anonymous, 2007). Improvements in livestock production totally rely on the proper supply of quality and quantity of feed (Amanullah *et al*., 2005). Economical and quality seed can be obtained after fodder, seed yield depends

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upon various factors such as the weather, cutting gap and insect-pests (Randhawa *et al.,* 2009). The crop is attacked by a number of insect pests but gram pod borer, *H. armigera* is one of the destructive pests of seed crop of berseem. The larvae feed on flower-buds, and developing seed heads of berseem. It is not only pest of berseem but it has many host plants. For example, in Pakistan, tomato fruit losses due to *H. armigera* are 32 - 35% (Latif *et al.,* 1997), 53% (Inayatullah, 2007), 70% (Abbas *et al.,* 2015). Severity of the pest incidence can be judged from the fact that in Pakistan 80% of the total insecticides are used to overcome this pest (Shaheen, 2008).

To overcome gram pod borer growers spray various chemicals alone, as well as in combinations, without confirming their compatibility on their own experience, without any consultation of agriculture experts to get the maximum production on their farms. The irrational use of chemicals controls pests and also is detrimental to insects that prey on the pests, such as predators and parasitoids. As a result, the crop may come under stresses and leading to yield reductions (Wagan *et al*., 2014). Numerous pesticide resistance problems have been created in areas where the injudicious chemical poisons are applying for pest control (Rueda and Shelton, 1995). For judicious use and cost reduction scientists always trying to screen the best chemicals against *H. armigera*. For example, Saini *et al.* (2013) used chlorantraniliprole and indoxacarb against *H. armigera* and reported that both chemicals significantly reduced the larval population significantly. Similarly, Abbas *et al.* (2015) tested nine novel insecticides with modern chemistries and found that volium flexy and delegate gave maximum mortality of *H. armigera.* The objective of the current research, reported herein, was to measure the efficacies of selected novel insecticides against *H. armigera* on seed crop of berseem to provided information for making better management decisions and improving seed production.

MATERIALS AND METHODS

A field trial was conducted at Fodder Research Institute, Sargodha- Punjab Pakistan on variety SB-11 of berseem that was left for seed production after last cutting on 31st March, 2017. The experiment was conducted in a Randomized Complete Block Design (RCBD) with six insecticides viz., Spintor 480SC (spinosad) (Jaffar Brother) enterprises Pvt. Ltd @ 100 ml, Coragen 20SC (chlorantraniliprole) FMC United Pvt. Ltd., manufactured by Dupont, USA @ 62.5 ml, Marshal 5EC (lufenuron) (FMC) @ 500 ml, Runner 280SC (methoxyfenozide) (Dow Agro Sciences) @ 250, Emamectin 1.9 EC (emamectin benzoate) (R.B. Awari) @ 500 ml and Belt 48SC (flubendiamide) Bayer Crop sciences @ 50 ml/acre along with a nontreated control in field trial during 2017 and with three replications and a plot size of 3x5 m. After the last cutting, the crop was regularly observed to measure the larval abundance of *H. armigera* at 3 days interval. When the attack of young larvae of the insect was observed in the field, the crop was subjected to insecticide spray. For determination of quantity of water, calibration was done by spraying water in the nontreated plots. Spraying was done with a manually operated hand knapsack sprayer @ 250 liter per hectare. All the insecticides were sprayed after 5.30 PM to save pollinators, especially, honey bees. Before the application of each insecticide, the spray machine was cleaned thoroughly with clean water to avoid insecticide mixture. The spray was repeated after 10 days when the larval population started increasing again. Seed yield of berseem was recorded from each plot and then converted into acre. Larval population was recorded before and after treatment from one square meters from each plot in different treatments. Percent mortality was calculated by using the below mentioned formula:

$\%M=100 \times (N_{bs} - N_{as}) \div N_{bs}$ where,

%M - Percent mortality; N_{bs} - Insect abundance before spray; N_{as} – Insect abundance after spray

Statistical analysis

The data was subjected to analysis of variance (ANOVA) using Statistix version 9 (www.statistix.com/free trial.html) (Lawes Agricultural Trust Rothamsted Experimental Station, Rothamsted, UK). The means were separated by LSD.

RESULTS

Percent mortality of *H. armigera* during 2016-17 after 1st spray

Percent mortality three days after spray

The data on the effectiveness of various insecticides for the control of *H. armigera* three days after spray revealed a highly significant differences (F=327.26; df=6, 12; P<0.01) (Table 2) between treatments. The maximum mortality of the pest was observed in those treatments where Belt, Spinosad and Emamectin were sprayed having 93, 92 and 92 percent mortality of the pest, respectively, and these were statistically similar. Coragen and Runner were significantly less efficacious with 67 and 61 percent mortality, respectively. The lowest morality of 35 percent was observed in those treated with Lufenuron.

Percent mortality five days after spray

The data on the effectiveness of various insecticides for the control of *H. armigera* 5 d after spray revealed significant differences (F=107.54; df=6, 12; P<0.01) (Table 2) between treatments. The percent mortality was 89% for Emamectin, 88% for Spinosad and 84% for Belt and these three were not significantly different. Significantly lower percent mortality was found in Coragen at 63%. Very low percent moralities were found in the Runner treatment at 34% and the Lufenuron treatment at 37%.

Percent mortality seven days after spray

Significant differences (F=298.03; df=6, 12; P<0.01) (Table-2) were found between treatments regarding mortality of the pest 7 d after the spray. Percent mortality at 7 d post treatment was 80% for emamectin and 75% for spinosad and these treatments were found to be the most effective insecticides resulting in maximum mortality of the pest and are statistically similar followed by Belt, Runner and Coragen with 31, 29 and 29 percent mortality, respectively. Minimum mortality of the pest was recorded in those treatments where Lufenuron was sprayed having 11 percent mortality of the pest.

Percent mortality of *H. armigera* during 2016-17 after second spray

Percent mortality three days after spray

The data reveals that significant differences (F=142.53; df=6, 12; P<0.01) (Table 3) were found between treatments regarding percent mortality of *H. armigera* 3 d after second spray. The results indicate that Emamectin, Spinosad and Belt resulted in 100%, 97% and 96% mortality and were the most effective insecticides and are statistically similar. Coragen have 67 percent mortality of the pest. Minimum mortality of *H. armigera* was recorded in those treatments where Lufenuron was sprayed having 29 percent mortality of the pest.

Percent mortality five days after spray

Significant variances (F=641.99; df=6, 12; P<0.01) (Table 3) were found between treatments in mortality estimates for *H. armigera* 5 days after the second spray. The results indicate that high mortality of 100%, 97% were recorded in the Spinosad and Belt treatments, respectively. Emamectin caused 89% mortality, Lufenuron caused 47% mortality, and Runner caused 35% mortality of the pest.

Percent mortality seven days after spray

Variations (F=225.13; df=6, 12; P<0.01) (Table 3) were found to be significant between treatments regarding mortality of *H. armigera* 7 d after the second spray. The results indicated that, 84% and 80% mortality in the Emamectin and Spinosad, respectively. Significantly lower mortality was found in the Coragen, Runner and Belt treatments with 32%, 32% and 31% mortality, respectively. Lowest mortality of *H. armigera* was recorded in those treatments where Lufenuron was sprayed at 11%.

Cumulative average percent mortality of *H. armigera*

The data on the effectiveness of various insecticides for the control of *H. armigera* on cumulative basis 3 d after spray revealed a highly significant differences (F=252.03;df=6, 12;P<0.01) (Table 4) between treatments. The maximum mortality of the pest was observed in those treatments where Emamectin, Spinosad and Belt were sprayed having 96%, 94% and 94% mortality of the pest, and these are not statistically different. Coragen caused 67% mortality of the pest. The least morality of the pest at 32% was observed in the Lufenuron treatment.

Significant differences (F=721.43; df=6, 12; P<0.01) (Table 4) was recorded between treatments after 5 d posttreatment. The maximum mortality of the pest was observed in those treatments where Spinosad and Belt were sprayed having 94% and 90% mortality of the pest followed by Emamectin at 89% mortality and these are statistically similar. Lufenuron had 42% mortality and the lowest morality of the pest at 34% was observed in the Runner treatment.

Significant differences were found between treatments at 7 d posttreatment (F=708.82; df=6, 12; P<0.01) (Table 4). The maximum mortality of *H. armigera* was observed in those treatments where Emamectin was sprayed having 82 percent mortality of the pest followed by Spinosad having 78 percent mortality of the pest. The insecticides Belt, Coragen and Runner have the same percent mortality at 31 percent. The lowest percent mortality was found at 11% was in the Lufenuron treatment

Graphical presentation regarding yield of Berseem seed crop

Berseem seed yield was estimated at 7.98, 7.73, 7.60 and 7.18 mound per hectare was recorded in the Spinosad, Belt, Emamectin and Coragen treatments, respectively. Lufenuron and Runner treatments had seed yields of less than 7 mound per hectare. Minimum yield was recorded in control at 3.45 mound per hectare (Fig.1).

DISCUSSION

Cultural, biological and chemical are being implemented globally for the management of *H. armigera* on various crops. But the success of any control measure is judged by the outcome and the most acceptable control strategy is the one that gives appropriate control against the target organism, and saves the crop from economically important injury. Among various approaches of control, chemicals are considered as fast acting control measures. To overcome the *H. armigera* insecticides are considered the only source of quick control measures that save the crop and prevent yield losses and is an important practice of IPM (Gogi *et al.,* 2006). No doubt some chemicals have toxic effects on some non-target organisms, but these are still the best management practices known to save the crop from injury caused by a pest outbreak. In our experiment, six chemicals were tested against *H. armigera* under field conditions, among these chemicals two treatments were found effective against *H. armigera* while four treatments were found to be less effective. Our results suggested that emamectin and spinosad, were found to be the most effective insecticide resulted in significant reduction of *H. armigera* populations even after seven days of spray whereas, flubendamide has effectively control *H. armigera* up to five days as compared to all other insecticides tested. The results agree with of the findings of Randhawa *et al.* (2009) who reported that spinosad is best insecticides for the control of *H. armigera* on seed crop of berseem. Similar results have been achieved by Stanley *et al*. (2009) who reported that the *H. armigera* larvae are highly susceptible to emamectin and spinosad insecticides. Whereas, Fanigliulo and Sacchetti (2008) concluded that emamectin benzoate gave maximum mortality of *H. armigera* on fruits, on cotton (Razaq *et al*., 2005). These insecticides not only gave best control of this notorious pest but also increase in seed yield of berseem was recorded. Similar results were found by Meena *et al*. (2013), who reported that maximum reduction in larval population of *H. armigera* in the treatments where flubendamide was sprayed resulted more yield in chili and cotton crop. In our results flubendamide gave best results up to 5 days after such period its efficacy decreased. The reason could be that flubendamide has a knockdown effect on *H. armigera*. In our experiment, Lufenuron did not gave good efficacy against *H. armigera*. The results did not match with the findings of Khatri *et al*. (2014) who reported that lufenuron and flufenoxuron are effective against *H. armigera*.

CONCLUSION

It was concluded from this study that spinosad and emamectin benzoate are effective, relatively safer choices for control of *H. armigera* on seed crop of berseem. If the crop is infested and is to be managed for production, then these pesticides can be recommended to control the pest population for up to 10 days after treatment. But if the crop has a higher abundance of different lepidopterous pests in different instars or an outbreak is apparent, then flubendiamide would be a better control option because it has knock down effect. Further, by the application of these insecticides, more yields can be obtained. It is strongly recommended that these pesticides should be sprayed after 6.00 PM to save the pollinator fauna that is necessary for seed production.

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Table 1

Information of insecticides with different mode of action against *H. armigera.*

Insecticides		Formulation	Group	WHO hazard classification	IRAC group	Dose (ml /hectare)	Mode of Action
Trade Name	Common Name						
Lufenuron	lufenuron	5EC	Benzoylureas	-	15	500	Inhibitors of chitin biosynthesis, type 0
Runner	methoxyfenozide	280SC	Diacylhydrazines	-	18	250	Ecdysone receptor agonists
Spinosad	spinosad	480SC	Spinosyns	iii	5	100	Nicotinic acetylcholine receptor (nAChR) allosteric modulators
Emamectin	emamectin benzoate	1.9 EC	Avermectins	-	6	500	Glutamate-gated chloride channel (GluCl) allosteric modulators
Coragen	chlorantraniliprole	20SC	Diamides	U	28	62.5	Ryanodine receptor modulators
Belt	flubendiamide	48 SC	Diamides	-	28	125	Ryanodine receptor modulators

Table 2

Mean comparison of percent mortality of *Helicoverpa armigera* on seed crop of berseem after 1st spray in the month of April during 2017.

Insecticide Treatment		Mean insect abundance (Number of larvae /m^2 pre-treatment)	Dose /ha. (ml of formulation)	Mean* percent mortality of *H. armigera* on the indicated days posttreatment		
Trade Name	Common Name			3 days	5 days	7 days
Lufenuron 5EC	lufenuron	11.00	500ml	35 d	37 c	11 c
Runner 280SC	methoxyfenozide	7.00	250ml	61 c	34 c	29 b
Spinosad 480SC	spinosad	13.00	100ml	92 a	88 a	75 a
Emamectin 1.9 EC	emamectin benzoate	13.00	500ml	92 a	89 a	80 a
Coragen 20SC	chlorantraniliprole	11.00	62.5ml	67 b	63 b	29 b
Belt 48 SC	flubendiamide	8.33	125ml	93 a	84 a	31 b
Control	-	12.67	-	3 e	2 d	2 d
LSD Value at P< 0.05				5.80	9.96	5.31
F-Value				327.26	107.54	298.03

*Means followed by similar letters and in the same column are not significantly different by LSD at P < 0.05 LSD = Least Significant Difference

Table 3

Mean comparison of percent mortality of *Helicoverpa armigera* on seed crop of berseem after 2nd spray in the month of May during 2017.

Insecticide Treatment		Mean insect abundance (Number of larvae /m^2 pre-treatment)	Dose /100 liter water	Mean* percent mortality of *H. armigera* after indicated days posttreatment		
Trade Name	**Common Name**			**3 days**	**5 days**	**7 days**
Lufenuron 5EC	lufenuron	6.00	500ml	29 d	47 d	11 c
Runner 280SC	methoxyfenozide	7.00	250ml	52 c	35 e	32 b
Spinosad 480SC	spinosad	14.00	100ml	97 a	100 a	80 a
Emamectin 1.9 EC	emamectin benzoate	12.00	500ml	100 a	89 b	84 a
Coragen 20SC	chlorantraniliprole	11.00	62.5ml	66 b	64 c	29 b
Belt 48 SC	flubendiamide	8.33	125ml	96 a	97 a	31 b
Control	-	11.33	-	2 e	2 f	2 d
LSD Value @ 5%				9.74	4.43	6.51
F-Value				142.53	641.99	225.13

*Means followed by similar letters and in the same column are not significantly different by LSD at P < 0.05 LSD = Least Significant Difference

Table 4

Mean comparison of cumulative percent mortality of *Helicoverpa armigera* on berseem seed crop after 1st and 2nd spray during 2017.

Insecticide Treatment		Mean Insect Abundance (& *H. armigera* (Number larvae/m^2) Pre-treatment	Dose ml of formulation /100 liter of water	Mean* percent mortality of *H. armigera* after indicated days posttreatment		
Trade Name	**Common Name**			**3 days**	**5 days**	**7 days**
Lufenuron 5EC	lufenuron	8.50	500ml	32 d	42 d	11 d
Runner 280SC	methoxyfenozide	7.00	250ml	57 c	34 e	31 c
Spinosad 480SC	spinosad	13.50	100ml	95 a	94 a	78 b
Emamectin 1.9 EC	emamectin benzoate	12.50	500ml	96 a	89 b	82 a
Coragen 20SC	chlorantraniliprole	11.00	62.5ml	67 b	63 c	31 c
Belt 48 SC	flubendiamide	8.33	125ml	94 a	90 ab	31 c
Control	-	12.00	-	3 e	2 f	2 e
LSD Value at P<0.05				6.95	4.00	3.56
F-Value				252.07	721.43	708.82

*Means followed by similar letters and in the same column are not significantly different by LSD at P < 0.05 LSD = Least Significant Difference

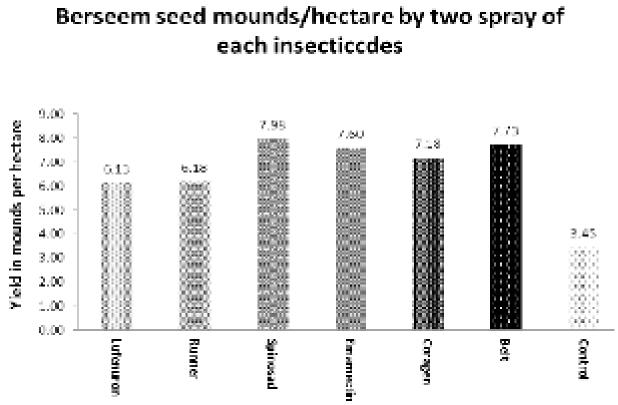

Fig. 1

Berseem seed obtained after the application of insecticides.

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