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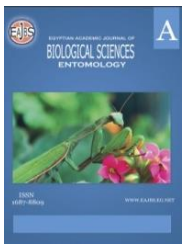

Evaluation of the Effectiveness of Some Synthetic Insecticides Against Cotton Bollworm, *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae)

Mohammad Razinataj[1], Mahmoud Jokar[1*], Taghi Darvish Mojeni[1], Parisa Heravi[1], Kianoosh Haghnama[2] and Payam Abravan[2]

1- Cotton Research Institute of Iran, Agricultural Research, Education and Extension Organization (AREEO), Gorgan, Iran
2- Agricultural Jahad Organization of Golestan Province
E.mail: m.jokar@areeo.ac.ir

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ABSTRACT

Cotton bollworm, *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae), is one of the most important and key pests of cotton in Iran. This study was carried out with the aim of investigating the efficacy of several different insecticides on cotton bollworm in three regions of Golestan province, Iran, in a completely randomized design with 4 replications and 7 treatments. Experimental treatments include: Proclame-Fit® 150 g/ha, Profenofos® 2.5 lit/ha, Cypermethrin® 150 ml/ha, Indoxacarb® 250 ml/ha, Karvin® 1.5 lit/ha, Fenpropathrin® 1 lit/ha and control (water without insecticide). Samplings unite of cotton bollworm larvae was 10 cotton plants per plot which were recorded the number of immature pests per plant at the before spraying, 3, 7, and 14 days after spraying. The larval mortality of treatments was modified by the Henderson-Tilton formula to determine the efficiency percentage. According to the results obtained in Bandar-e Gaz, Proclame-Fit® and Karvin® had the highest long-term effect 50.85% and 59.86%, respectively, and Profenofos® had a suitable short-term effect with 74.82% mortality percentage. In Gonbad-e Kavous, Proclame-Fit®, Profenofos® and Karvin® with 96%, 94.33 % and 80% have shown a suitable lethal-short-term effect on cotton bollworm larvae. In Ramian, Proclame-Fit®, Profenofos ® and Karvin ® showed the highest short-term effect on cotton bollworm larvae, 83.18 %, 88.97 % and 88.37%, respectively. Based on the results, to control cotton bollworm, Proclame-Fit ® and Profenofos® are recommended as appropriate insecticides with the recommended doses.

INTRODUCTION

that has a wide range of crop hosts such as cotton (*Gossypium hirsutum* L.), corn (*Zea mays* L.), sesame (*Sesamum indicum* L.), hemp (*Cannabis sativa* L.), tomato (*Solanum lycopersicum* L.), pea (*Pisum sativum* L.), sorghum (*Sorghum bicolor* L.), beans (*Phaseolus sp.*), sunflower (*Helianthus* sp.), soybeans (*Glycine max* (L.) Merr.) and peanut (*Arachis hypogaea* L.) in Iran (Fallahnejad-Mojarrad *et al.*, 2017). In order to use various pesticides to control pests in cotton fields and damage natural enemies of pests in the

ecosystem, therefore a combination of control methods is recommended to keep this pest population under the economic threshold (Soleimannejad *et al.*, 2010).

Achieving appropriate insecticides against larvae of cotton bollworm has been reported by many researchers all around the world. Carneiro et al., (2014) calculated the percentage mortality of *H. armigera* by laboratory bioassay to confirm the efficiency of insecticides from different chemical groups. The results demonstrated that Chlorpyrifos and Spinosad were effective against the third instar of *H. armigera* larvae in both ways on contact and ingestion. Flubendiamide, Acephate, Methomyl, *Bacillus thuringiensis*, Dimethoate, Chlorantraniliprole and Fipronil had good responses to control of *H. armigera* (Carneiro et al., 2014). A field trial was evaluated the efficacy of insecticides including Fastac®, Spinosad, Indoxacarb, Diazinon, Runner®, and Lambda-cyhalothrin in Ethiopia and reported that the application of Indoxacarb (Avaunt® 150 SC) 0.3 Lha−1 or Spinosad (Tracer® 480 SC) 0.15 Lha−1 three times with a week interval can be advised for *H.armigera* management (Mihretie *et al.*, 2020). In two case studies, on common insecticides against cotton bollworm in Golestan, *Carbaryl* and *Avaunt*® compared to Larvin® and Endosulfan had the greatest effect on the control of cotton bollworm (Mojeni, 2005) and in another research, Endosulfan, and Thiodicarb had the greatest effect on cotton bollworm (Mojeni, 2019). Widely usage of synthetic insecticides could develop resistance, therefore the use of a virulent strain of HaNPV in combination with recommended larvicide of Spintoram and Emamectin benzoate was tested in the field. The combination of HaNPV with Spintoram and Emamectin benzoate 100% reduced the larval population as compared to Emamectin benzoate and HaNPV alone (Abid et al., 2020). Comparative study of the *H. armigera* susceptibility to conventional insecticides showed The susceptibility of third instar *H. armigera* and *H. zea* larvae to Indoxacarb, Methomyl, Spinetoram, and Spinosad and showed Spinetoram and Methomyl exhibited the highest acute toxicity against *H. armigera* (da Silva et al., 2020). The main purpose of current research is assessed the *H. armigera* susceptibility on ordinary insecticides in the world.

MATERIALS AND METHODS

Locations of the study area were selected in three different regions with different weather and geographical features including Bandar-e Gaz (lat: 36.7750° N, long: 53.9462° E; MASL= -21m), Ramian (lat: 37.0147° N, long: 55.1403° E; MASL=226m) and Gonbad-e Kavous (lat: 37.2407° N, long: 55.1597° E; MSAL= 40m). The study was carried out on Goleatan®, a commercial cotton cultivar, in a Randomized Complete Block Design with 4 replications and 7 spraying treatments. Experimental plots included 10-meter planting lines with 80×20 cm planting system. spraying treatments included Proclame-Fit ® at 150 g/ha, Profenofos® 2.5 lit/ha, Cypermethrin® 150 ml/ha, Indoxacarb® 250 ml/ha, Karvin® 1.5 lit/ha, Fenpropathrin® 1 lit/ha and control (water without insecticide). for sampling schedule, one day before and 3, 7, and 14 days after foliar application, 10 cotton plants were selected from each plot and recorded the number of immature stages (larval) of the *H. armigera* per plant. All data were analyzed using the Kolmogorov–Smirnov normality test. Subsequently, the data were transformed by $\sqrt{x} + 0.1$ and submitted for statistical analysis. The efficiency of each treatment in controlling cotton bollworm was modified using Henderson-Tilton formula (Henderson and Tilton, 1955), the mean of the treatments was compared with The one-way analysis of variance (ANOVA) with Duncan's multiple range test by SAS® software (Razaq *et al.*, 2005).

RESULTS AND DISCUSSION

The final results of pesticide evaluation were evaluated for statistical significance of different pesticides. After checking the normality of the data by Kolmogorov-Smirnov

test at 5% probability level, the transformed data were used for Statistical analysis. Statistical grouping of different treatments was performed by ANOVA and the results are presented in Tables 1, 3 and 5. Insecticide-performance was evaluated by modifying the mortality rate with Henderson-Tilton equation in Tables 2, 4 and 6. According to the results of the evaluation of various pesticides in Bandar-e Gaz in 2019, the modified larval mortality (compared with the control treatment) of Karvin® 74.82% and Profenofos® 70.62% showed the highest short-term effect (3 days after spraying) for cotton bollworm (Table 3). On the other hand, the lowest mortality rate of cotton bollworm larvae was recorded on Cypermethrin® -7.69% and Fenpropathrin® 11.7% for short-term effects in Bandar-e Gaz field. For the middle-term effect (14 days) at Bandar-e Gaz Indoxacarb®, Karvin® and Proclame-Fit® could control about 50% of larval stage. As mentioned in Table 1, the mortality rate of immature of *H. armigera* showed statistically different at sequential time periods. So, on the fourteenth day (after applying different treatments), a significant difference was observed between different insecticides (Table 2). Based on the results of various insecticide tests in 2019 in Bandar-e Gaz region, the initial effective treatments were Karvin® and Profenofos® beside for long-term control were Indoxacarb® and Proclame-Fit®. The reliable point is the ineffectiveness of the two insecticides Cypermethrin® and Phenopropatrin® in controlling cotton bollworm larvae.

Table 1: Statistically time-laps on the efficacy of different insecticide to control cotton bollworm by ANOVA in Bandar-e Gaz region in 2019.

Source Sampling days	***df***	**MS**	***F***	***P-value***
Day 3	6	73.59	4.01	0.01*
Day 7	6	26.99	2.75	0.04*
Day 14	6	17.85	2.13	0.01*

* Significant difference between experimental treatments with 95% probability level with Duncan's multiple range tests.

Table 2: Effect of several insecticides applied as foliar treatment against larvae of cotton bollworm, during the 2019 cotton seasons in Bandar-e Gaz (mortality rate was modified by Henderson and Tilton, (1955) formula).

Treatments	**Mean number of live larvae of cotton boll worm in treatment plots in time periods**				**Percentage of initial mortality (Days 3)**	**Percentage of mortality due to residual insecticides in treatments**		**Average reduction**	**Average reduction due to residual (%)**
	Pre- treatment	Days 3	Days 7	Days 14		Days 7	Days 14		
Cypermethrin ®	12	14	8	8	-7.69 c	-51.51 c	-233.33 ab	-142.42	-97.51
Indoxacarb ®	11.66	7	1	1.33	44.61 ab	81.92 a	45.14 a	63.21	57.01
Karvin ®	14.66	4	2	2	74.82 a	70.24 ab	34.54 a	52.39	59.86
Profenofos ®	14.66	4.66	2	6.33	70.62 a	70.24 ab	-107.27 ab	-18.51	11.19
Fenpropathrin ®	15.33	14.66	6	3.66	11.7 bc	19.36 abc	-14.78 ab	2.29	5.42
Proclame-Fit ®	12.33	8.66	1	1.66	35.13 ab	82.3 a	35.13 a	58.71	50.85
control	16	17.33	7	3.33	-	-	-	-	-

The same letters show a non-significant difference between insecticides based on Duncan test on each sample day is given at the level of 5%. Negative percentages indicate the ineffectiveness of insecticide, which was considered null (+0.1) in statistical analyzes.

The results of several insecticides on immature of *H. armigera* in Gonbad-e Kavous showed no significant difference in larval population between different treatments during sampling days (Table 3). Mortality percentage corrected by Henderson-Tilton equation, Profenofos 74.33% showed the highest initial effect (Table 4). Regarding the medium-term effects caused by residues on the plant surface, the insecticide Proclame-

Fit® showed the highest mortality rate of 82.5% along with Profenofos® 76.72%. Based on the results of various insecticides tests in 2019 in Gonbad-e Kavous, the suitable treatments were Proclame-Fit® and Profenofos® insecticides.

Table 3: Statistically time-laps on the efficacy of different insecticide to control cotton bollworm by ANOVA in Gonbad-e Kavous in 2019.

Source Sampling days	*df*	MS	F	*P-value*
Day 3	6	545.34	0.4	0.86 ^{ns}
Day 7	6	534	0.85	0.54 ^{ns}
Day 14	6	575.86	0.54	0.76 ^{ns}

^{ns}: non-Significant difference between treatments on sampling days.

Table 4: Effect of several insecticides applied as foliar treatment against larvae of cotton bollworm, during the 2019 cotton seasons in Gonbad-e Kavous (mortality rate was modified by Henderson and Tilton, (1955) formula).

Treatment	Percentage of initial mortality (Days 3)	Percentage of mortality due to residual insecticides in treatments		Average reduction	Average reduction due to residual (%)
		Days 14	Days 7		
Fenpropathrin ®	54.83 ns	57 ns	38 ns	47.5	49.94
Karvin ®	59.16 ns	80 ns	57.5 ns	68.75	65.55
Indoxacarb ®	40.66 ns	78.33 ns	54.5 ns	66.41	57.83
Cypermethrin ®	51.33 ns	71.33 ns	49.83 ns	60.58	57.5
Profenofos ®	74.33 ns	94.33 ns	61.5 ns	77.91	76.72
Proclame-Fit ®	70.33 ns	96 ns	81.16 ns	88.58	82.5
control	-	-	-	-	-

^{ns}: Non-significance difference between treatments on sampling days based on Duncan test is given at 5% level.

The analysis of variance of results in Ramian showed a significant difference between the number of live larvae showed and different treatments during sampling days (Table 5). For quantitative studies, time-series estimated with corrected mortality percentage (by Henderson-Tilton equation) are mentioned in Table 6. According to the results of Ramian, showed Karvin® 88.37%, Proclame-Fit® 83.18% and Profenofos® 88.98% showed the highest initial effect. Proclame-Fit 94.57.5% and Profenofos® 100% showed the highest mortality rate based on the residual effect of insecticides. Based on the results of various pesticide tests in 2019 in the Ramian, the efficient treatment was Proclame-Fit® and Profenofos®.

Table 5: Statistically time-laps on the efficacy of different insecticide to control cotton bollworm by ANOVA in Ramian in 2019.

Source Sampling days	DF	MS	F	P value
Day 3	6	5.93	4.45	0.01 *
Day 7	6	5.93	15.58	0 *
Day 14	6	3.35	3.35	0.02 *

* Significant difference between experimental treatments with a 95% probability level.

Table 6: Effect of several insecticides applied as foliar treatment against larvae of cotton bollworm, during the 2019 cotton seasons in Ramian (mortality rate was modified by Henderson and Tilton, (1955) formula).

Treatments	Mean number of live larvae of cotton boll worm in treatment plots in time periods				Percentage of initial mortality (Days 3)	Percentage of mortality due to residual insecticides in treatments		Average reduction	Average reduction due to residual (%)
	Pre-treatment	Days 3	Days 7	Days 14		Days 7	Days 14		
Proclame-Fit ®	8.3	1	0.3	1.3	83.18 a	94.57 a	74.39 a	84.48	84.04
Profenofos ®	7.6	0.6	0	3	88.98 a	100 a	35.46 cd	67.73	74.81
Cypermethrin ®	1.6	2	1.3	3	-74.41 b	-21.87 b	-206.54 d	-114.2	-100.94
Indoxacarb ®	6	1	1	2	76.74 a	75 a	45.5 bc	60.25	65.74
Karvin ®	3.6	0.3	0.3	1.67	88.37 a	87.5 a	24.15 cd	55.82	66.67
Fenpropathrin ®	3	2.6	2.6	2.3	-20.93 b	-30 b	-25.34 d	-27.67	-25.42
control	6	4.3	4	3.67	-	-	-	-	-

Same letters show a non-significant difference between insecticides based on Duncan test on each sample day is given at the level of 5%. Negative percentages indicate the ineffectiveness of insecticides, which was considered null (+0.1) in statistical analyzes.

According to the results, in three different areas was evaluated, Proclame-Fit ®, Profenofos and Karvin® had the highest mortality rate in cotton bollworm larvae. The results were consistent with the results of Bagheri *et al.,* (2017) that the effective treatments were Thiodicarb and Thiodicarb + Cypermethrin, Lufenoron + Emamectin benzoate together with α-cypermethrin + Teflobenzuron to control cotton bollworm. The difference between the present study and the results of Bagheri *et al.,* (2017) was in the Cypermethrin® efficiency. According to this study, Cypermethrin® in all experimental sites showed a low mortality percentage. in agreement with the current research, Abbas *et al.,* (2015) reported Indoxacarb had a better effect against *Helicoverpa armigera* as compared with Delegate® (Spintoram), Volium Flexy® (chlorantraniliprole + thiamethaxim), Fipronil (Grafter®), Proclaim-Fit® (Emamectin benzoate), Pirate® (chlofenapyr) and Lufenuron (lufenuron®), in Pakistan in 2014 and also Mihretie *et al.,* (2020)result's recommended Indoxacarb insecticides for the management of *H.armigera*. In the present study, resistance has not been evaluated, but in a case study on development resistance of Indoxacarb® (SC 15%), Profenfos (EC 50%), Thiodicarb (DF 80%) and Chlorpyrifos (40.8% EC 8) for different populations of cotton bollworm in Gorgan, Moghan and Varamin showed the development of resistance of Thiodicarb in Gorgan (Mosallanejad and Gholami, 2019). Therefore, before any recommendation, development resistance was considered.

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