COMPARATIVE EFFECTIVENESS OF *BACILLUS THURINGIENSIS* AND LANNATE AGAINST *SPODOPTERA LITTORALIS*

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SUMMARY: Application of Dipel 2x at a rate of 250 g/g was effective against the larvae of Spodoptera littoralis (1st to 4th instars), while larvae in older stages (5th and 6th instars) were more resistant. Lannate was highly effective against either young or old larvae. The addition of potassium carbonate to Dipel increased the larval mortality. In Sharkia governorate, the yield of soybean increased significantly when the infested areas were treated once by either Dipel 2x or Lannete with 1.113 fold increase compared with the control. In Monoufia governorate, an obvious increase in soybean yield was also recorded when soybeans were treated three times with Dipel 2x or Lannete but the fold of increase was 2.031 -2.066 times compared to the control. This difference in yield give a higher net profit to the farmer exceeding the costs of spray applications.

Key Words: B. thuringiensis, Lannate, S. littoralis.

INTRODUCTION

The Egyptian cotton leaf worm *Spodoptera littoralis* Bosid. is considered as the major pest in a wide range of cultivation including cotton, corn, soybeans, peanuts and vegetables. This pest is widely spead in Egypt as well as in other Middle East countries in addition to temperate zones in Asia and Africa. The need for a new safe and effective insecticides became necessary nowadays after the increase of environmental pollution and insect resistance to chemical insecticides. Salama and Foda (2) discovered a highly promising strain of the microbial control agent, *Bacillus thuringiensis* var. *entomocidus* that was highly effective against larvae of *S. littoralis*. Later, Salama *et al.* (4-6, 10,12) carried out detailed studies on the effect of *B. thuringiensis* on *S. littoralis*. In addition, attempts to increase the activity of the *B. thuringiensis* preparations were carried out and was found to be improved by the addition of a phagostimulant as well as protectants from U.V. irradiation (1,13,14). On the other hand, the safety of *B. thuringiensis* and its effect on some parasites and predators has been extensively studied by Salama *et al.* (3) and Salama and Zaki (3,7-9,11).

The purpose of the present work is to evaluate the efficacy of some preparations of *B. thuringiensis* to control larvae of *S. littoralis* on soybean cultivations under field conditions as compared to conventional chemical insecticides.

MATERIALS AND METHODS

Two locations in two governorates were selected for the present study. The following data summarize all information concerning the selected areas and the agricultural practices adopted.

Location and practices adopted in Sharkia governorate

In Sharkia governorate- Abou-Hammad, a soybean field of 3 feddans was used for spraying Dipel 2x against *S. littoralis* larvae. Plantation of soybean was carried out on April 14th using Clark variety. 35 kg of seeds were used/feddan after mixing with *Rhizobium* bacteria. Irrigation was carried out as follows: heavy irrigation for plantation of the seeds; light irrigation after one week; on the 6th of May, and then every 15 days. Fertilization

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was carried out using 150 kg of superphosphate on May 5th. A 60 unit of N_2 was added, i.e., 15 units on May 5th, 30 units on May 20th, and 15 units on June 5th. Two rows of maize were planted between each 10 rows of soybean.

The area (three feddans) of soybean plants was divided into 30 plots each of about 420 m^2 (one feddan=4200m^2). Two treatments were carried out as follows: Dipel 2x (250 g)+ 20% molasses and 1% starch (as sticker) /feddan; and Lannate 90% at the recommended rate at 300 g/f. Untreated plots were kept as control. Each treatment replicated in 10 plots. The Turbair fox sprayer was used for spraying Dipel 2x (8 liters spray/f), and the Knapsack sprayer was used for spraying Lannate (200 liter spray/f). The Turbair fox is a powerful and versatile sprayer, fitted with a robust high quality 2 stroke petrol engine with easy starting and proven reliability. A big capacity fan moves a large volume of turbulent air at a relatively low speed. It is capable of given good cover on three crops up to 15 feet high, without causing damage to young seedlings. Up to three feddans can be sprayed in one hour.

Location and practices adopted in Monoufia governorate

In Monoufia governorate, an area of 10 feddans cultivated on May 10th with soybeans, was selected. All agricultural practices were essentially the same as in Sharkia governorate.

Sight treatments were carried out using the following rates per feddan:

1. Dipel 2x (150 gm).
2. Dipel 2x (150 gm) + molasses 20%.
3. Dipel 2x (250 gm) + molasses 20%.
4. Dipel 2x (150 gm) + Lannate 90% (150 gm).
5. Lannate (300 gm).
6. Dipel 2x (150 gm) + potassium carbonate (150 gm).
7. Dipel 2x (250 gm).
8. Dipel 2x (250 gm) + potassium carbonate (150 gm).

Treatments were carried out three times, on June 17th, July 15th and August 19th, 1988. Harvest took place on September 15th. Larvae of *S. littoralis* were counted on 100 plants before treatments and then 5 and 10 days after each treatment. Each treatment was replicated in five polts. The yield was estimated. The Knapsack sprayer was used in Monoufia for both Lannate and Dipel 2x and its combination, using 200 liter/f.

RESULTS

1. Results in Sharkia governorate (1987)

Effect on the population of larvae

To asses the effect of Dipel 2x in comparison to the chemical insecticide, Lannate, the numbers of egg batches, egg batches as well as counts of different instar larvae of *S. littoralis* were recorded before and after each treatment. Appropriate controls were run simultaneously. Results are shown in Table 1. Application of Dipel 2x and Lannate (W.P.) resulted in a marked decrease in the population of *S. littoralis* after one week of the treatment compared with the untreated plots (control). The average number of egg batches and hatches in the plots treated with Dipel 2x was 1.5 ± 0.34/10 plants (0-3), while in plots treated with Lannate, it averaged 0.5 ± 0.15/10 plants; this is compared with an average of 4.6 ± 0.49/10 plants in the untreated plots. Also, the average number of 1st and 2nd instars was 9.3 ± 2.62 and 1.1 ± 0.67 larvae/10 plants after Dipel and Lannate treatments, respectively, compared to an average of 100 ±13.02 larvae/10 plants in the control.

The number of 3rd and 4th instars averaged 18.9±1.27 larvae/10 plants in untreated plots (13-27). This number significantly decreased to an average of 4.5±0.64 and 1.7 ± 0.45 larvae/10 plants after Dipel and Lannate treatment. The average number of the 5th and 6th instars in untreated plots was significantly higher being 4.4±0.56 larvae/10 plants in the control untreated plots, compared to an average of 1.3 ± 0.27 and 0.3 ± 0.027 larvae/10 plants after Dipel and Lannate, respectively.

Table 1: Numbers of different instar larvae of *S. littoralis* on soybean plants in Sharkia governorate before and after treatment.

Treatment	Average no. of egg batches and hatches ± s.e.	Average no. of 1st and 2nd instar larvae ± s.e.	Average no. of 3rd and 4th instar larvae ± s.e.	Average no. of 4th and 6th instar larvae ± s.e.
Before treatment	5.3 ± 0.67 (2-9)	93.8 ± 10.56 (39-150)	15.9 ± 2.24 (6-33)	2.0 ± 0.68 (0-6)
Dipel 2x	1.5 ± 0.34 (0-3)	9.3 ± 2.62 (0-25)	4.5 ± 0.64 (0-6)	1.3 ± 0.27 (0-3)
Lannate	0.5 ± 0.15 (0-1)	1.1 ± 0.67 (0-6)	1.7 ± 0.46 (0-4)	0.3 ± 0.027 (0-3)
Unteated	4.6 ± 0.49 (3-7)	100 ± 13.02 (61-222)	18.9 ± 1.27 (13-27)	4.4 ± 0.56 (3-7)

Effect on predators

Three of the active and commonly known predators in the Egyptian fields were recorded during the present investigations, these are: the rove beetle, *Paederus alfierii* Koch, which is very active against the eggs and larvae of the cotton leaf worm (Kemal, 1951); the lady bird beetle, *Coccinella undecimpunctata* R., which is always found with the cotton leaf worm infestations feeding on eggs and small larvae; the lace wing chrysopid predator, *Chrysoperla carnea*, which is also found on the soybean plants. Direct counts of these three predators were made before and after treatments. Table 2 summarizes the results. Before spraying, the averages of the three mentioned predators, *P. alferii*, *C. undecimpunctata* and *C. carnea* were 29.9 ± 1.38, 11.8 ± 1.04 and 17.5 ± 1.39 individuals/10 plants. Seven days after application, the average population of the predators was found almost constant in the untreated areas, being 26.8 ± 2.22, 13.9 ± 1.69 and 17.1 ± 1.98 individuals/10 plants for *Paederus*, *Caccinella* and *Chrysoperla*, respectively. In plots treated with Dipel, the predator *Paederus* was not affected (24.7 ± 2.65 individuals/10 plants), while *Coccinella* and *Chrysoperla* showed a significant decrease in their population being 9.6 ± 1.12 and 12.2 ± 0.75 individuals/10 plants. A high significant reduction of the three predators, however, was recorded after spraying with Lannate (Table 2).

Effects on soybean yield

Application of Lannate or Dipel agains *S. littoralis* on soybean plants gave the highest yields being 865 ± 31.08 and 835.8 ± 39.48 kg/f, respectively. The yield obtained from the untreated plots was significantly lower (659.4 ± 44.10 kg/f), compared with the treated plots.

2. Results in Monoufia governorate

Effect on population of the larvae

In these experiments, total larval counts were made before treatments and also 5-10 days after each treatment. Data presented in Tables 3 and 4 show that the use of Dipel (150 gm) combined with molasses 20%, caused the highest larval mortality which was also obtained after application of Lannate (300 gm/f) in the first treatment on

Table 2: Effect of Dipel 2x and Lannate on the predators associated with *S. littoralis* on soybeans in Sharkia (1987).

Treatment	Average no. of P. alfierii ± s.e.	Average no. of C. undecimpunctata ± s.e.	Average no. of C. carnea ± s.e.
Before treatment	29.9 ± 1.38 (22-38)	11.8 ± 1.04 (7-19)	17.5 ± 1.39 (8-23)
Dipel 2x	24.7 ± 2.65 (11-36)	9.6 ± 1.12 (4-15)	12.2 ± 0.75 (10-16)
Lannate	0 0	0 0	0 0
Untreated	26.8 ± 2.22 (14-35)	13.9 ± 1.69 (7-23)	17.1 ± 1.98 (6-28)

Table 3: Larval mortality of *S. littoralis* after different treatments on soybeans in Monoufia governorate.

Treatment (per feddan)	%Larval mortality after		
	First Application	Second Application	Third Application
B.t. 150 gm	38.7	36.3	13.6
B.t. 250 gm	73.0	66.1	54.0
B.t. 150 gm + molasses 20 %	54.4	52.2	21.3
B.t. 250 gm + molasses 20 %	72.0	61.0	74.1
B.t. 150 gm + Lannate 150 gm	56.5	54.8	67.4
Lannate 300 gm	78.9	76.5	70.6
B.t. 150 gm + K_2CO_3 150 gm	42.1	34.5	39.0
B.t. 250 gm + K_2CO_3 150 gm	82.4	62.3	73.9

June 17th. On the other hand, application of Dipel (150 gm) alone or combined with 100 gm Lannate, caused lesser effect on *S. littoralis* larvae 5-10 days after application. Counts of larvae in plots treated with Dipel at a high rate (250 gm combined with 20% molasses) remained significantly low.

After the second application on July 15th, Dipel (250 gm/f) gave the highest larval mortality (66.1%) compared with Lannate (76.5%). Dipel (250 gm) combined with K_2CO_3 caused 62.3% larval mortality, while Dipel (250 gm) combined with 20% molasses caused 61% mortality. A combination of Dipel at a low rate (150 gm) with Lannate (100 gm) caused 54.8% mortality (Table 3). In the third application on August 19th, a combination of Dipel (250 gm) with either molasses (20%) or K_2CO_3 (150 gm) were as effective as Lannate (300 gm), used singly.

Effect of treatments on the yield

Data in Table 5 indicate that the highest yield of soybean was obtained from plots treated with Dipel ath the rate of 250 gm combined with either 20% molasses or K_2CO_3 (150 gm) being 1790 and 1750 kg/f after Lannate treatment. The lowest yield was obtained from plots treated with Dipel at the rate of (150 gm) being 975 kg/f compared with an average of 847 kg/f in the control untreated areas.

From the foregoing data, it appears that Dipel 2x (250 gm/f) was as effective as Lannate (300 gm/f) in controlling *S. littoralis* on soybean cultivations. When the treatment was applied once, the larval population was significantly reduced. Judged from counts made after seven days and the resulting yield, was significantly higher compared to the control areas, but the fold of increase was 1.133 times

Table 4: Effect of different treatments on the population of larvae of *S. littoralis* on soybeans in Monoufia governorate.

Treatments	Avera e no. of larvae / 10 plants								
	First treatment			Second treatment			Third treatment		
	Before treatment	5 days	10 days	Before treatment	5 days	10 days	Before treatment	5 days	10 days
B.t. 150 gm	15.0	9.2	11.2	33.0	21.0	13.5	55.00	47.4	48.4
B.t. 250 gm	20.0	4.5	8.2	34.9	11.8	11.3	48.1	22.1	22.9
B.t. 150 gm + molasses 20 %	18.0	8.2	8.8	22.0	10.5	9.1	53.3	41.9	34.4
B.t. 150 gm + Lannate 150 gm	23.0	10.0	12.4	40.1	18.1	23.2	49.2	16.1	15.7
Lannate 300 gm	18.0	3.8	6.4	25.1	5.9	7.9	50.4	14.8	18.6
B.t. 150 gm + K_2CO_3 150 gm	3.9	2.3	18.0	23.0	15.0	20.1	53.7	32.7	35.0
B.t. 250 gm + K_2CO_3 150 gm	17.0	3.0	6.0	22.0	8.7	9.9	54.2	14.1	26.7
Control	25.0	28.6	22.6	28.7	43.0	40.3	73.5	71.8	65.3

Table 5: Data on soybean yield obtained after different treatment (3 times) in Monoufia.

Treatments	Yield/feddan (kg)	Fold increase in yield
B.t. 150 gm/f	975	1.151
B.t. 250 gm/f	1720	2.031
B.t. 150 gm + molasses 20 %	1010	1.192
B.t. 250 gm + molasses 20 %	1790	2.113
B.t. 150 gm + Lannate 150 gm	1000	1.181
Lannate 300 gm	1750	2.066
B.t. 150 gm + K_2CO_3 150 gm	965	1.139
B.t. 250 gm + K_2CO_3 150 gm	1750	2.066
Control	847	-

as compared to the control. When the treatment was applied three times at 4-5 weeks intervals, the reduction in the population of larvae of *S. littoralis* was obvious 5 and 10 days after each treatment. The resulting yield was higher compared to the control with 2.031, 2.113, 2.066 fold increate after treatment with Dipel (250 gm/f), its combination with molasses 20% or K_2CO_3 (150 gm/f), and Lannate (300 gm/f), respectively. Based on these results, it is recommended to spray soybeans three times at 4-5 weeks intervals to control *S. littoralis* on soybeans since this double the total yield. The return profit from the yield increase in higher than the costs of three spray applications.

REFERENCES

1. Bell MR, Romaine CL : Tobacco budworm: Field evaluation of microbial control in cotton using Bacillus thuringiensis and a nuclear polyhedrosis virus with a feeding adjuvant. J Econ Entomol, 73:427-430, 1977.

2. Salama HS, Foda MS : A strain of Bacillus thuringiensis var. entomocidus with high potential activity on Spodoptera littoralis. J Invertebr Pathol, 39:110-111, 1982.

3. Salama HS, Zaki FN, Sharaby AR : Effect of Bacillus thuringiensis Berl. on parasites and predators of the cotton Leafworm Spodoptera littoralis (Boisd.). Z and Ent, 94:498-504, 1982.

4. Salama HS, Foda MS, Sharaby A : Biological activity of mixture of B. thuringiensis varieties against some cotton pests. Z ang Entomol, 95:69-74, 1983.

5. Salama HS, Foda MS, Zaki FN, Khalafallah A : Persistance of Bacillus thuringiensis Berliner spores in cotton cultivations. Z ang Ent, 95:321-326, 1983.

6. Salama HS, Zaki FN : Interaction between Bacillus thuringiensis Berliner and the parasites and predators of Spodoptera littoralis in Egypt. Z ang Ent, 95:425-429, 1983.

7. Salama HS, Foda MS, Zaki FN, Moawed S : Potency of combinations of Bacillus thuringiensis and chemical insecticides on Spodoptera littoralis (Lepidoptera: Noctuidae). J Econ Entomal, 77:885-890, 1984.

8. Salama HS, Zaki FN : Impact of Bacillus thuringiensis Berl. on the predator complex of Spodoptera littorolis (Boisd.) in cotton fields. Z ang Ent, 97:485-490, 1984.

9. Salama HS, Zaki FN : Biological effects of Bacillus thuringiensis on the egg parasitoid, Trichogramma evanescens. Insect Sci Applic, 6(2):145-148, 1984.

10. Salama HS, Foda MS, Sharaby A: Potential of some chemicals to increase the effectiveness of B. thuringiensis against S. littoralis. Z ang Ent, 100:425-433, 1985.

11. Salama HS, Zaki FN : Application of Bacillus thuringiensis Berliner and its potency for the control of Spodoptera littoralis (Boisd.) (Lep., Noctuidae). Z ang Ent 99:425-431, 1985.

12. Salama HS, Foda MS, Sharby A : Possible extension of the activity spectrum of B. thuringiensis through chemical additives . Z. ang Ent, 101:304-313, 1986.

13. Sneh B, Shuster S, Broza M : Insecticidal activity of Bacillus thuringiensis strains against the Egyptian cotton leafworm Spodoptera littoralis (Lep., Noctuidae). Entomophaga, 26:179-199, 1981.

14. Sneh B, Gross S: Biological control of the Egyptain cotton leafworm Spodoptera littoralis (Boisd.) (Lep., Noctuidae) in cotton and alfalfa fields using a preparation of Bacillus thuringiensis sp. entomocidus, supplemented weith adjuvants. Z and Ent, 95:418-424, 1983.

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