Minufiya J. Agric. Res. Vol.40 No. 1(2): 179 - 186 (2015) "http://www.mujar.net"

EFFECT OF VERTIMEC®, A MICROBIAL INSECTICIDE ON THE PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* (SAUNDERS) B- BIOLOGICAL STUDIES AND LIFE TABLE PARAMETERS

Dina A. Ahmed
Bollworms Dept., Plant Protection Research Institute, ARC, Dokki, Giza, Egypt.

(Received : Sept., 16, 2014)

ABSTRACT: *The toxicity and biological effects of sub-lethal concentrations of the microbial insecticide vertimec (product of Streptomyces avermitilis-Avermectin-1.8% w/v) on pink bollworm (PBW), Pectinophora gossypiella larvae were evaluated under laboratory conditions. The effects of vertimec on some biological activities of PBW larvae were recorded . The tested compound prolonged the larval period (21.97 days) than the control (17.49 days). Also, the larval weight of the 2nd instar larvae was affected, where the average weight was 2.78 mg in control, while it was significantly decreased to 0.47 mg in larvae treated with vertimec. In contrast, weight of the 4th larval stage was significantly increased in vertimec treatment (28.86 mg) . The pupal duration, pupal weight and pupal mortality were not significantly affected, whereas the pupation percentage was inhibited due to the larval treatment. Obviously, the earlier treatment of newly hatched larvae of PBW with vertimec was extended to the produced moths. Vertimec gave 87.06 % moth emergence compared with the control (98.36%). Sex ratio was directed to the male side (66.41%). In addition, vertimec affected the oviposition periods, where adult longevity and fecundity of the emerged females had low reproductive capacity compared to control. Furthermore, vertimec affected the five main parameters associated with a fertility life table (the generation time (T), net reproductive rates (R_O), doubling time (DT), intrinsic rate of increase (r_m) and finite rate of increase (e^{rm}). In conclusion, vertimec treated PBW larvae had the lowest of population growth parameters as indicated by the long developmental time (42.67 days), low net reproductive rate (20.24 ♀/♀), and low survival of immature stages as reflected in a lower value of r_m (0.07 ♀/♀/day). Generally, vertimec proves to be an effective bio-insecticide against developmental stages of PBW and could be an excellent fit into IPM/ICM programs on cotton plants by the Ministry of Agriculture after successful field experiments.*

***Key words** : Biology, Pink bollworm (PBW), Pectinophora gossypiella , life table,*

INTRODUCTION

Pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gellichidae) is a major pest of cotton in the world. The indiscriminate use of insecticides has caused a number of ecological, economical, social and political problems. Hence there is a growing necessity and interest in the use of materials with new modes of action for management of crop pests. One of such pesticides with new mode of action is avermectin B1 (abamectin), a natural product by the soil microorganism, *Streptomyces avermitilis.* Avermectin B1 has demonstrated activity against a range of insect pests, especially lepidopteran insects. It has been shown to exhibit growth regulating activity, inhibit feeding (Beach and Todd 1985 and Abo El-Ghar *et al.* 1994) and adversely affect the reproduction of some insects (Putter *et al.*, 1981).

This study aimed to evaluate the latent effects of vertimec against the PBW. It involved the sublethal effects of the previous compound on some biological aspects and life table parameters of the insect.

MATERIALS AND METHODS

Rearing of *P. gossypiella*:

Newly hatched larvae of *P. gossypiella* were obtained from a colony maintained in the Bollworms Department Laboratory, Plant Protection Research Institute, Ministry of Agriculture, Dokki, Giza for several

generations at 27 ± 1°C and 75 ± 5% relative humidity (RH). Larvae were reared on a modified artificial diet as described previously by Abd El-Hafez *et al.* (1982).

Microbial formulation:

Formulation of *Streptomyces avermitilis,* vertimec [Avermectin 1.8% w/v emulsifiable concentrate; Merck Sharp & Dohme Research Laboratory (MSDRL)] was used in the present investigation. It contains at least 80% of avermectin B_{1a} (C_{48} H_{72} O_{14}, MW: 872) and not more than 20% of avermectin B_{1b} (C_{47} H_{70} O_{14}, MW: 858).

The latent effect of vertimec LC_{50} on *P. gossypiella* :

Biological studies:

In this assay, newly hatched larvae were fed on diets containing LC_{50} of vertimec (recorded previously after 2 days (Ahmed, 2014). Three replicates of each assay (400 larvae /replicate) were applied. After two days, the survivors in each assay were transferred to clean glass vials (2 X 7 cm) containing control diet and held at 27 ± 1°C and 75 ± 5% RH. Larvae of control bioassay were fed on control containing water instead of tested material. Larval stage as well as pupation and adult emergence were estimated. After moth emergence, ten replicates each contained 5-pairs/cage of emerged moths that appeared morphologically not impaired were used to measure the reproductive potential of the insects in each assay. Laid eggs were counted daily & kept under the same conditions and the percentage of hatchability was estimated.

Life table parameters:

To compare the biotic potential under the conditions of the experiment, life table parameters [generation time (T), net reproductive rates (R_o), doubling time (DT), intrinsic rate of increase (r_m) and finite rate of increase (e^{rm})], were calculated according to Birch (1948) using Life-48 basic computer program (Abou-Setta *et al.*, 1986). The age specific female fecundity (M_x) and the rate of survival (L_x) were graphically illustrated (Figure 1).

Statistical analysis:

Analysis of variance (ANOVA) was conducted on all data using Costat computer program software. Means were compared by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

1. Effects of vertimec LC_{50} on some biotic potential of *Pectinophora gossypiella* :

1.1. Larval and pupal stages:

The obtained results in Table (1) show that vertimec exhibited some biological activities on PBW larvae treating as 1st instar with the vertimec LC_{50}. It can be noted that the tested compound prolonged the larval period (21.97 days) than the control (17.49 days). Also, the larval weight in the 2nd instar larvae, was affected, the average weight was 2.78 mg in control while, the average weight decreased significantly to 0.47 mg in larvae treated with vertimec. In contrast, 4th larval weight was significantly increased in vertimec treatment (28.86 mg) in comparison with control (22.89 mg). As a result of larval treatment, the pupal duration and weight were not significantly affected (8.27 days & 20.61 mg, respectively) as compared with the control (8.04 days & 22.40 mg, respectively). The results also clearly indicated that the pupation percentage was inhibited due to the larval treatment. The inhibition in pupation percentage was 42.32%. On contrary, pupal mortality was not affected according to the vertimec treatment since it recorded 3.27%. This value was 1.64% in the case of control. Similar observation on other insects was obtained by Wright *et al.* (1985), Abo El-Ghar *et al.* (1994) and Youssef (2006). This could be due to the inhibit feeding activity of vertimec as mentioned by Putter *et al.* (1981), Beach & Todd (1985) and Abo El-Ghar *et al.* (1994).

Table (1): Effect of LC_{50} vertimec on larval and pupal aspects of *P. gossypiella*

Treatment	Larval period (days) ± SD	Larval weight (mg) ± SD		Pupation% ± SD	Pupal Period (days) ± SD	Pupal weight (mg) ± SD	Pupal Mortality% ± SD
		2nd	4th				
Control	17.49[b] ± 2.25	2.78[a] ±0.36	22.89[b] ± 2.25	86.68[a] ± 4.98	8.04[a] ± 1.22	22.40[a] ± 2.52	1.64[a] ± 0.94
Vertimec	21.97[a] ± 2.53	0.47[b] ± 0.09	28.86[a] ± 2.55	50.00[b] ± 0.00	8.27[a] ± 0.98	20.61[a] ± 1.64	3.27[a] ± 6.60
LSD (5%)	0.25	0.34	2.61	3.15	0.24	3.28	5.28

Means followed by the same letter at each column are not significantly different at P= 0.05.

1.2. Adult stage:

Obviously, the earlier treatment of PBW larvae with vertimec was extended to the produced moths. Results obtained in Table (2) show that, the treated 1st instar larvae of PBW with vertimec gave 87.06% of moth emergence as compared with the control (98.36%). Vertimec treatment did not affect adult's percentage malformations and the survival rates as compared with the control (3.11, 5.18%) and (48.37, 47.42 %), respectively. Concerning the sex ratio, it was notable that the vertimec affected considerably sex ratio, where it directed to the male side (66.41%).

The mated females began laying eggs 2.00 and 2.42 days after emergence of control and vertimec moths, respectively. Regarding the oviposition periods, results cleared that it differs significantly and averaged 13.68 & 16.0 days, respectively. On the other hand post-oviposition period did not differ significantly than control. It recorded 3.18 & 3.71 days for control and vertimec treatment, respectively (Table 3).

In comparison with control insects, the adult longevity was significantly affected when newly hatched larvae were fed on diet containing vertimec LC_{50}. Adult longevity of PBW male and female moths resulted from vertimec treatment were 22.38 & 20.77 days, respectively. These values were significantly higher than those achieved with control insects (16.42 & 15.62 days for male & female, respectively) (Table 3).

Data in Table (4) revealed that fecundity of the produced adults was significantly affected by the vertimec treatment. The average number of eggs was 208.36/untreated ♀, this value significantly decreased to 151.87 eggs/♀ emerged from vertimec treatment. The same trend was obvious in the case of the average of egg hatchability% since it reached 78.86% in the case of untreated PBW. While, it decreased significantly to reach 71.95% following treatment with vertimec. According to incubation period of PBW eggs, eggs hatched after 4.15 & 4.77 days in the control and vertimec treatment, respectively (Table 4). Our results are in conformity Wright *et al.* (1985) and Lopez *et al.* (2011).

Beach & Todd (1985) and Abo El-Ghar *et al.* (1994) showed that vertimec inhibit insect feeding activity. Reduction in feeding may reduce normal development, weight gain, fecundity and increase mortality (Van Duyn, 1971). Present experiment showed that Vertimec prolonged the life cycle and decreased larval and pupal weighs of PBW. Sequentially, all these effects, known to decrease fecundity.

2. Effects of Vertimec on PBW life table parameters:

2.1. Survival rate and fecundity:

The rate of survival (L_x) and the female progeny produced per female (M_x) for each age interval (x) are shown in Figure (1). Survival rate (L_x) parameter was almost the

same in vertimec treatment and control. In vertimec treatment it ranged between 0.12 to 0.48 times as compared with the control values which ranged between 0.1 to 0.47 times. On the other hand, daily fecundity of PBW (M_x) parameter in adults emerged from control larvae ranged between 0.0 to 12.37 ♀/♀ the highest M_x was 12.37 ♀/♀. In the case of vertimec treatment it ranged between 0.0 to 4.88 ♀/♀ the highest (M_x) was 4.88 ♀/♀.

Table (2): Effect of treating newly hatched larvae with LC_{50} vertimec on adult stage of *P. gossypiella*

Treatment	Moth emergence ± SD	Malformed moth ± SD	Survival rate* ± SD	Sex ratio% ± SD	
				♂	♀
Control	98.36^{a} ± 0.94	3.11^{a} ± 2.28	47.42^{a} ± 0.75	51.08^{b} ± 4.41	48.92^{a} ± 4.41
Vertimec	87.06^{a} ± 31.22	5.18^{a} ± 3.63	48.37^{a} ± 3.30	66.41^{a} ± 28.47	33.59^{b} ± 28.26
LSD (5%)	20.49	3.16	2.09	10.73	13.72

Means followed by the same letter at the same column are not significantly different at P= 0.05.
* Survival rate = (Normal moth/total larvae)*100

Table (3): Pre-oviposition, oviposition , post-oviposition and adult longevity periods of *P. gossypiella* resulted from treated newly hatched larvae with vertimec LC_{50}.

Treatment	Pre-oviposition Period ± SD	Oviposition Period ± SD	Post-oviposition Period ± SD	Adult longevity (days) ± SE	
				♂	♀
Control	2.00^{b} ± 0.00	13.68^{b} ± 3.09	3.18^{a} ± 3.26	16.42^{b} ± 0.18	15.62^{b} ± 6.96
Vertimec	2.42^{a} ± 0.67	16.00^{a} ± 6.45	3.71^{a} ± 3.62	22.38^{a} ± 0.19	20.77^{a} ± 7.37
LSD (5%)	0.19	0.35	2.06	2.81	2.01

Means followed by the same letter at each column are not significantly different at P= 0.05.

Table (4): Potentiality of *P. gossypiella* produced moth's *P. gossypiella* resulted from treated newly hatched larvae with vertimec LC_{50}.

Treatment	Eggs/female ± SE	% Hatchability ± SE	Incubation Period ± SE
Control	208.36^{a} ± 1.58	78.86^{a} ± 0.28	4.15^{b} ± 0.38
Vertimec	151.87^{b} ± 4.37	71.95^{b} ± 0.6	4.77^{a} ± 0.99
LSD (5%)	18.35	2.99	0.35

Means followed by the same letter at each column are not significantly different at P= 0.05.

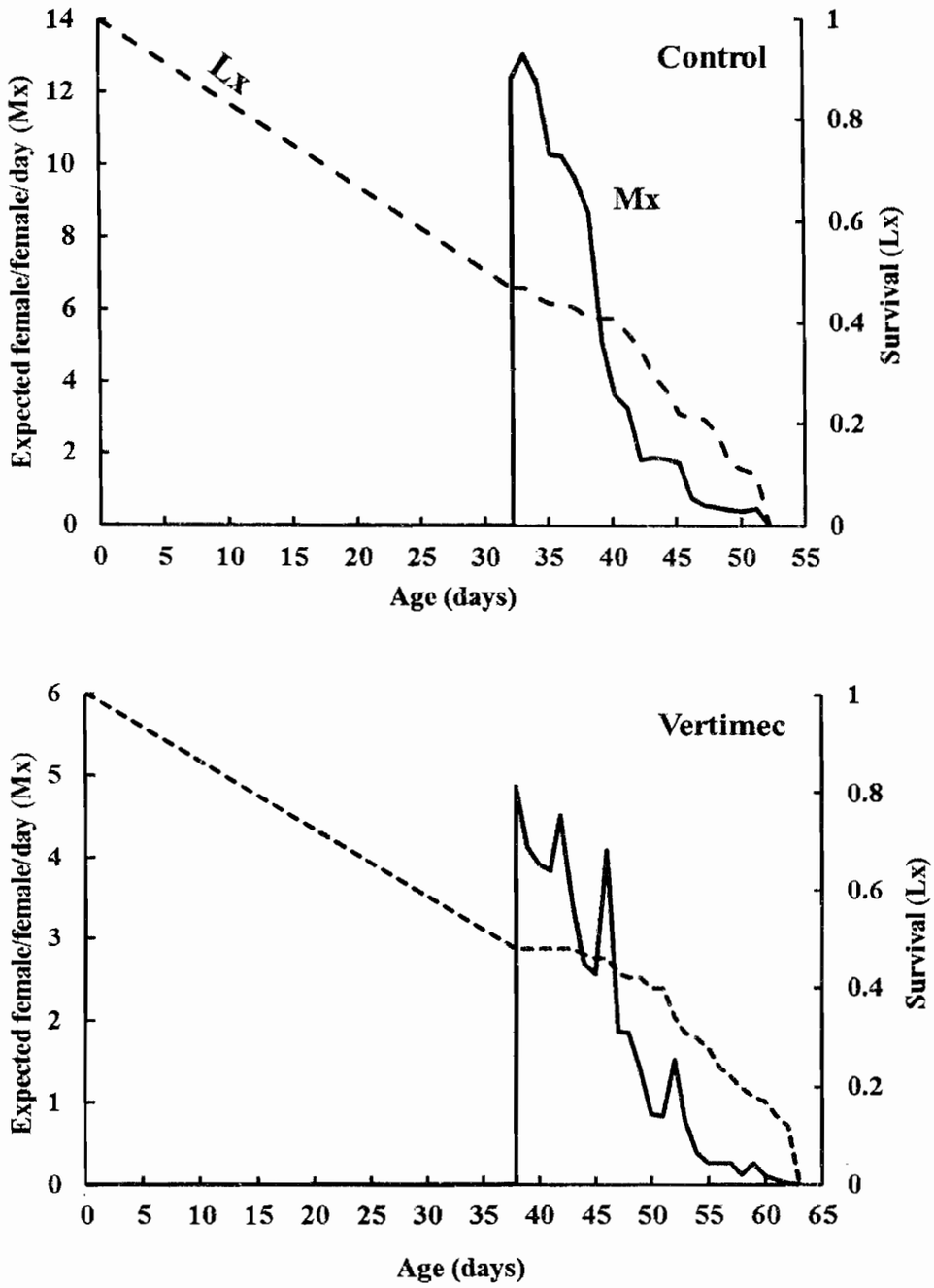

Figure (1): Survival rate (L_x) and fecundity (M_x) of control and vertimec treatment of *P. gossypiella*

2.2. Population growth parameters:

The five main parameters associated with a fertility life table are the generation time (T), net reproductive rates (R_O), doubling time (DT), intrinsic rate of increase (r_m) and finite rate of increase (e^{rm}) are shown in Table (5). Concerning the untreated insects (control), the generation time (T) lasted 35.52 days as while this period was elongated to 42.67 days for vertimec treatment. Regarding the net reproductive rates (R_o), it was very clear that the adverse effect was expanded to the produced females. The calculated R_o of PBW at control was 41.43 ♀ / ♀, while it was drastically reduced to be 20.24 ♀ / ♀ for vertimec treatment. At any population, the time of generation doubling (DT) is depending on the intrinsic rate of natural increase (r_m), which is affected by many factors such as the rate of survival, the time of generation, female progeny and females' fecundity. The PBW population had the capacity to multiply (DT) every 6.93 &9.90 days in control& vertimec treatment, respectively (Table 5). Also, the calculated parameters revealed that daily intrinsic rate of natural increase (r_m) recorded 0.10 and 0.07 ♀/♀/day for control and vertimec treatment, respectively. Furthermore, the control insects of the PBW had the finite rate of increase (e^{rm}) (1.11♀/♀/day), this value was lower in case of the vertimec treatment (1.07 ♀ / ♀/ day) (Table 5).

The present study demonstrated that the performance of *P. gossypiella* affected according to the vertimec treatment. In conclusion, vertimec insects had the lowest of population growth parameters as indicated by the long developmental time, low net reproductive rate, and low survival of immature stages as reflected in a lower value of r_m. Beach & Todd (1985) and Abo El-Ghar *et al.* (1994) indicated that the vertimec had a growth regulating activity and inhibit feeding.

Generally, according to the accumulated results of toxicological, biochemical and biological studies of Vertimec on PBW(Ahmed, 2014), this microbial insecticide proves to be an effective bio-insecticide against developmental stages of PBW and can be a possible candidate to be applied on cotton plants by the Ministry of Agriculture after successful field experiments.

Table (5): Effect of Vertimec on life table parameters of PBW, *Pectinophora gossypiella* moths at 27± 1°C and 65-75% RH

Treatment	Mean generation time(T) (days)	Net reproductive (Ro)	Time of generation doubling (DT) (days)	Increase rate	
				Intrinsic rate of natural increase (r_m)	Finite rate of increase (e^{rm})
Vertimec	42.67	20.24	9.90	0.07	1.07
Control	35.52	41.43	6.93	0.10	1.11

REFERENCES

Abd El-Hafez, Alia, A.G. Metwally and M.R.A. Saleh (1982). Rearing pink bollworm *Pectinophora gossypiella* (Saunders) on kidney bean diet in Egypt. Res. Bull., Fac. Agric., Zagazig Univ. 576: 1-10.

Abo El-Ghar, G.E.S., H.S.A. Radwan, Z.A. El-Bermawy and L.T.M. Zidan (1994). Histopatholgoical effects of abamectin, thuringiensin and diflubenzuron on the midgut of *Spodoptera littoralis* (Lepidoptera: Noctuidae) larvae. Bull. Ent. Soc. Egypt. 21: 41-52.

Abou-Setta, M.M., R.W. Sorrell and C.C. Childers (1986). Life 48: A basic computer program to calculate life table parameters for an insect or mite species. Flor. Entomol. 69: 690-697.

Beach, R.M. and J.W. Todd (1985). Toxicity of avermectin to larval and adult soybean looper (Lepidoptera: Noctuidae) and influence on larval feeding and adult fertility and fecundity. *Journal of Economic Entomology. 78:1125–1128.*

Birch, L.C. (1948). The intrinsic rate of increase of insect populations. J. Anim. Ecol. 17: 15-26.

Ahmed Dina, A. (2014). Effect of VERTIMEC®, a microbial insecticide on the pink bollworm, *Pectinophora gossypiella* (Saunders). A- Toxicological and biochemical studies (Under publication).

Duncan, D.B. (1955). Multiple range and multiple F tests. *Biometrics, 11: 1-41.*

Lopez, J., M.A. Latheef and W.C. Hoffmann (2011). Effect of abamectin on feeding response, mortality, and reproduction of adult bollworm (Lepidoptera: Noctuidae). Southwestern Entomologist. 36:155-166.

Putter, I., J.G. Macconnell, F.A. Preisery, A.A. Haidri, S.S. Ristich and R.A. Dybas (1981). Avermactins: Novel Insecticides, acaricides and nematicides from a soil microorganism. Experimentia. 37*: 963-964.*

Van Duyn, J.W. (1971). Investigations concerninghost plant resistance to the mexicon bean beetle, *Epilachna varivestis* in soybean. Ph.D. Dissertation, Clemson Univ., Clemson, USA: 210 p.

Wright, J.E., J.N. Jenkins and E.J. Villavaso (1985). Evaluation of avermectin B_1 (MK 936) against *Heliothis* spp. in the laboratory and in field plots and against the boll weevil in field plots. *Southwestern* Entomologist. *7: 11-16.*

Youssef, L.A. (2006). Some physiological and histopathological effects of two pesticides against the cotton leaf worm, *Spodoptera littoralis* (Boisd.). Arab Universities. J. Agric. Sci., 14 (2): 803-812.

تأثير المبيد الحيوي فيرتيمك على دودة اللوز القرنفلية *Pectinophora gossypiella*

ب- دراسات بيولوجية ومقاييس جدول الحياة

دينا عبد الظاهر أحمد

معهد بحوث وقاية النباتات - مركز البحوث الزراعية – الدقي- جيزة

الملخص العربى

تم تقييم الآثار السلبية للتركيز السام النصفي للمبيد الحيوي فيرتيمك علي دودة اللوز القرنفلية تحت الظروف المعملية، حيث أدت المعاملة إلى إطالة العمر اليرقي لـ٢١,٩٧ يوم مقارنة بالكنترول (١٧,٤٩يوم)، كما أدت إلي

نقص وزن يرقات العمر الثاني (٠,٤٧ مجم) مقارنة بالكنترول (٢,٧٨ مجم)، في حين زاد وزن يرقات العمر الرابع. كما أظهرت النتائج عدم تأثر كل من العمر العذري، وزن العذاري ونسب موت العذاري في حين انخفضت نسبة التعذر نتيجة المعاملة بالفيرتيمك. كما ظهر واضحا أن تأثير معاملة الفقس الحديث استمر حتى خروج الفراشات حيث انخفض معدل الخروج للفراشات بنسبة (٨٧,٠٦ ٪) مقارنة بالكنترول (٩٨,٣٦ ٪)، كما كانت النسبة الجنسية في صالح زيادة الذكور (٦٦,٤١ ٪)، هذا بالإضافة إلي التأثير علي مدة وضع البيض والخصوبة و فترة حياة الفراشات التي بقيت حية بعد المعاملة والذي انعكس علي القدرة التناسلية للحشرة.

أيضا أثرت المعاملة بالفيرتيمك علي المقاييس الخمس الخاصة بجداول الحياة وهى مدة الجيل (T)، معدل التناسل (R_O)، فترة تضاعف الجيل (DT)، القدرة التكاثرية الموروثة (r_m) ومعدل الزيادة اليومي (e^{rm})، حيث كانت الحشرات المعاملة هي الأدنى في معايير الزيادة العددية كما دل على ذلك طول مدة الجيل (٤٢,٦٧ يوم)، انخفاض معدل التناسل (٢٠,٢٤ أنثي/أنثي)، وانخفاض القدرة التكاثرية الموروثة (٠,٠٧ أنثي/أنثي/يوم).