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Sensitivity of Lepidopterous Larvae to Recombinant Products of *Bacillus thuringiensis* as a Bioinsecticide Agent

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Abstract: The present study was conducted on sensitivity of transgenic bacteria that express one or a few toxins from *Bacillus thuringiensis* (*Bt*) were obtained in this study through conjugation between different eight *Bt* strains from different serovars agent. Products from 28 transconjugants were screened for larvicidal activity against *S. littoralis*, containing naturally occurring combinations of spores and crystal proteins, as well as, each of one product alone. *Bt* products containing cry + end from some transconjugants resulting significant mortalities over their mid-parents in the second and fourth instars of F_1 generation attributed to synergistic interactions. In the fifth and sixth instar of F_2 generation, endospores caused significant mortalities effect than other bacterial preparations, indicating that recombinant *Bt* strains can not only produce asporogenous strains of *Bt* but can also improve the toxicity of the crystal. Spores increased mortality and reducing the weight of surviving larvae by interacting with individual *Bt* toxins. The results indicated that cry + end plays a critical role in delaying the development of resistance to *Bt* products. Emberyo mortality percent due to cry + end reached to 45.0, 30.83 and 19.37 in F_1, F_2 and F_3 generations respectively, although which due to endospores reached up to 40.83, 32.08 and 23.75 among three generations, respectively. This study assumed that the absence of spores in *Bt* toxin expressing transgenic plants and bacteria would accelerate evolution of pest resistance. Strategy of conjugation induced recombinant bioinsecticide used in this study was able to induce strains containing a unique combinations of cry genes conferring a wider activity spectrum than that of their parental strains.

Key words: *Bacillus thuringiensis*, bioinsecticide, larvicidal activity, mortality, recombinant products, transconjugants

Introduction

Biological pesticides based on the soil microbe *Bacillus thuringiensis* (*Bt*). Berliner are becoming increasingly important for pest management (Entwistle *et al.,* 1993). Each of the numerous strains of *B. thuringiensis* produces a characteristic set of insecticidal crystalline proteins. For example, the HD-1 strain of *Bt* subsp. *kurstaki* produces toxins Cry IAa, Cry IAb, Cry IAc, Cry IIA and Cry IIB (Abbott, 1992). Each of these toxins is effective only against certain species of insects (Höfte and Whiteley, 1989). In contrast with many conventional insecticides, *Bt* is harmless to humans and most other nontarget organisms (Entwistle *et al*., 1993). Genes that encode toxins in *Bt* have been transferred to and expressed in corn, cotton, potatoes and many other plants to create transgenic varieties (Peferoen, 1992). The usefulness of *Bt* and transgenic plants that produce *Bt* toxins will depend on how long pests remain susceptible to the toxins (McGaughey and Whalon, 1992). Gonzalez *et al.* (1982) demonstrated that most δ-endotoxin genes are located on large plasmids, which either are self-transmissible or can be transferred from a donor to a receptor strain in a conjugation-like process. Since most strains of *Bt* carry and express more than one δ-endotoxin gene, their spectra of insecticidal activity depend upon the combination of individual δ-endotoxins present in their parasporal crystal. Further success of such strategies to improve the usefulness of *Bt* insecticides depend upon the availability of suitable δ-endotoxin genes.

During spoulation *Bt* synthesizes crystalline inclusions composed of one or several insecticidal proteins (known as δ-endotoxin or Cry proteins) that form a large family of related proteins. The target of these toxins is the brush border membrane of the larval midgut epithelial cells (Sanchis *et al*., 1994) and it is now generally accepted that the δ-endotoxins act by opening or by forming new specific ion-selective channels or non selective pores in the midgut cells of susceptible insects. Thereby, the toxins destroy the osmotic balance across the cell membrance causing swelling and eventual lysis of midgut epithelial cells.

Transconjugational products of *Bt* are based on combinations of two δ-endotoxin proteins that together expand the activity against insects that are not affected by either of the toxic proteins when expressed alone. This combination was produced by transconjugation of a plasmid bearing a gene of one *Bt* subspecies into the cells of another subspecies of the microbe (Carlton *et al*., 1990). Using this strategy, commercial products have been developed that are active against both lepidopterans and coleopterans or with a widened host range against lepidopterous pests. This study shows the results to observe the pathological effects of *Bt* new recombinant products against *Spodoptera littoralis*. This finding leading to development new more efficient recombinant isolates of *Bt* against lepidopterous pests. The present study was investigated the capabilities of three *Bt* formulations (crystals, endospores and crystals + endospores). The relative effect of selection by single or multiple toxins of *Bt* on the development of resistance was achieved.

Materials and Methods

Insects: Eggs of *Spodoptera litura* were collected from cotton fields in Kafr El-Sheikh Governorate through the summer season of 2001. Bioassay technique was assayed against 4 days old larvae according to Dulmage *et al.* (1971).

Bacterial strains and media: *Bacillus thuringiensis* standard strains (Table 1) were used in this study. These strains were supplied by United States, Department of Agriculture, National Center for Agriculture, Utilization Research, Peoria, Illinois 61604, USA and were incubated on T_3 medium (l^{-1}: 3 and 2 g tryptose, 1.5 g yeast extract, 0.05 M sodium phosphate [pH 6.8] and 0.005 g $MnCl_2$) according to Travers *et al.* (1987), until sporulation was complete. All strains were grown on L agar (per liter: 10 g tryptone, 5 g yeast extract, 5 g NaCl and 15 g agar, according to Travers *et al.*, 1987) at 30°C until they sporulated.

Separation of crystals and endospores: Bacteria were grown in petridishes or in suspension cultures. The spores were collected from nutrient agar washed three times in ice-cold distilled water. Pellets (spores and crystals) were resuspended in small volumes of distilled water. The bacterial suspension cultures were prepared as follows. Loopfuls from bacterial colonies with spores and crystals were transferred to 1 ml of distilled water. Heat-Shocked (70°C for 30 min) suspensions were transferred to 250 ml of PWYE medium (5% peptone, 0.1% yeast extract, 0.5% NaCl, pH 7.5) and incubated at 30°C for 8 to 15 h with shaking at 180 rpm. Two milliliters of the PWYE culture was used to inoculate 1 of T_3 medium and was incubated at 30°C for 3 to 4 days with shaking at 180 rpm, at least 90% of bacterial cells were lysed releasing spores and crystals after this incubation. Spores and crystals were collected by centrifugation (10.000xg for 10 min). Pellets were washed 3 times with ice-cold distilled water, and final pellets were resuspended in 20 ml of water and stored at -4°C. To purify crystals from spores and cellular debris, samples were sonicated on a vibra cell sonicator (Sonics and Materials Inc., Danbury, Conn.) for 60s at 70W and were centrifuged on discontinuous sucrose density gradients (79% (w/v) sucrose) at 15.000xg for 2 h. Crystal bands and spore pellets were purified by three centrifugations and washed with distilled water. Final pellets were resuspended in small volumes of distilled water and stored at -4°C (Karamanlidou *et al*., 1991).

Bioassay technique: Eggs from a field population of *Spodoptera litura* were collected from cotton fields in July 2001 without insecticide selection pressure, surface treated with *Bacillus thuringiensis* (crystals + endospores, endospores and crystals) as described by Ignoffo *et al.* (1968). Susceptibility levels to bioinsecticides were evaluated among two generations. The bioassay procedure exposed groups of early-fourth-old larvae. The appropriate dose was applied by using a micropipette to dispense 100 µl of the suspension on 4 g of diet cotton leaf surface (Ignoffo and Boening, 1970). This drop was evenly distributed over the diet surface with a sterile glass rod and the surface was air-dried. Mortality was recorded daily. Surviving larvae from each replicate were pooled and weighted. Four g of cotton leaves were added daily to each breeding bottle and consumed leaves were calculated. Generally, six replicates consisting of 12 larvae/replicate was used (Ignoffo *et al*., 1977). Mortality of pupae that formed was recorded. Generations were maintained separately (Wirth *et al*., 2000). Evaporated water from the cotton leaves through 24 h of feeding larvae was subtracted from the residual fed leaves before recording the weight of residual leaves, to calculate the consumed fed leaves/larvae day.

Mating procedure: Conjugation between strains of *Bacillus thuringiensis* is accompanied by nonpheromone-induced and protease-sensitive co-aggregation between donor and recipient cells. Further, the genetic basis of this aggregation system has been shown to reside on pXO16, a 2000 kb conjugative plasmid. Strains that have the opposite genetic markers were used in mating experiments, donor and recipient cultures were grown to mid-log phase in PWYE medium. For mating, 1 ml of recipient was added to a new PWYE medium followed immediately by 1 ml of the donor. The inoculated medium was rolled gently (5 min) to mix the inoculum and incubated at 30°C for 4 h. Aliquots were then spread onto PWYE agar plates containing the appropriate selection of antibiotics. After an overnight incubation, transconjugant colonies were picked up and transferred to PWYE slant agar medium. This methodology was carried out according to Krasovsky and Stotzky (1987). Two isolates of transconjugants were used in this work among 14 matings carried out in this study. Two different recombinants from each mating were used in bioassay experiments (Table 2).

Bioinsecticides and their mode of action: Crystals + endospores, endospores and crystal protein of bacterial insecticides used in these test included both wild-type and recombinant strains grown in liquid medium. All separated bioinsecticides are divided to three types, the first consisted of crystal-spore mixtures, but the second consisted of endospores and the third consisted of crystal protein. The *Bt* crystals must undergo a complex cascade of biochemical reactions before they become active against susceptible insects. Firstly, the crystals must be dissolved in an alkaline midgut milieu and the presence of certain enzymes to yield a biologically inactive protoxin of 130-135 kDa in molecular weight. Secondly, again in a stepwise chain of reactions, a 65 kDa toxic fragment is proteolytically cleaved from the protoxin. This fragment, commonly referred to as the activated toxin, binds to receptors located on the epithelium of the insect midgut. The receptor-bound toxin then induces pore formation leading to lysis of the midgut, which results in the death of the insect. For induction of death of a susceptible insect, binding and pore formation are essential. However, all steps preceding pore formation are equally crucial for determining the specificity of the *Bt*-proteins in killing insects (Gonzalez *et al.*, 1982) (Fig. 1).

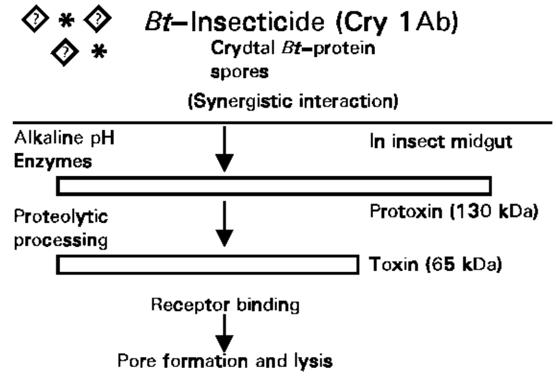

Fig. 1: Differences *Bt*-insecticides and Bt-plants

Table 1: Bacterial strains used in this study

Strains	Designation
Bacillus thuringiensis serovar *alesti*	S_1
Bacillus thuringiensis serovar *thuringiensis*	S_2
Bacillus thuringiensis serovar *kenyae*	S_3
Bacillus thuringiensis serovar *kurstaki*	S_4
Bacillus thuringiensis serovar *entomocidus*	S_5
Bacillus thuringiensis serovar *darmastadiensis*	S_6
Bacillus thuringiensis serovar *galleriae*	S_7
Bacillus thuringiensis serovar *israelensis*	S_8

Table 2: Matings between *Bacillus thuringiensis* strains that have the opposite genetic markers related resistant or sensitive to antibiotics

Crosses and relevant characteristics of *Bt* strains	Transconjugants	Trans-conjugants designation
$S_1(Ax^s, E^s, R^s, T^r)$ x $S_2 (Ax^r, E^r, R^r, T^s)$	Ax^r, E^r, R^r, T^r	Tr_9
		Tr_{10}
$S_1(Am^s, I^s, E^r, T^r)$ x $S_5 (Am^r, I^r, E^s, T^s)$	Am^r, I^r, E^r, T^r	Tr_{11}
		Tr_{12}
$S_1(I^s, A^r, T^r)$ x $S_7 (I^r, A^s, T^s)$	I^r, A^r, T^r	Tr_{13}
		Tr_{14}
$S_2(I^s, Ax^r E^r, R^r, Ep^r)$ x $S_4 (I^r, Ax^s, E^s, R^s, Ep^s)$	$I^r, Ax^r, E^r, R^r, Ep^r$	Tr_{15}
		Tr_{16}
$S_2(I^s, Am^s, Ax^r E^r, R^r, Ep^r)$ x $S_5 (I^r, Am^r, Ax^s, E^s, R^s, Ep^s)$	$I^r, Am^r, Ax^r, E^r, R^r, Ep^r$	Tr_{17}
		Tr_{18}
$S_2(I^s, Am^r, E^r, R^r, A^r)$ x $S_7 (I^r, Am^s, E^s, R^s, A^s)$	I^r, Am^r, E^r, R^r, A^r	Tr_{19}
		Tr_{20}
$S_2(I^s, T^s, Am^s, Ax^r E^r, R^r)$ x $S_8 (I^r, T^r, Am^r, Ax^s, E^s, R^s)$	$I^r, T^r, Am^r, Ax^r, E^r, R^r$	Tr_{21}
		Tr_{22}
$S_3(Am^s, T^r)$ x $S_5 (Am^r, T^s)$	Am^r, T^r	Tr_{23}
		Tr_{24}
$S_3(Ep^s, B^r, C^r, A^r, T^r, V^r, I^r)$ x $S_6 (Ep^r, B^s, C^s, A^s, T^s, V^s, I^s)$	$Ep^r, B^r, C^r, A^r, T^r, V^r, I^r$	Tr_{25}
		Tr_{26}
$S_3(Ep^s, A^r, T^r)$ x $S_7 (Ep^r, A^s, T^s)$	Ep^r, A^r, T^r	Tr_{27}
		Tr_{28}
$S_4(Ep^s, B^r, C^r A^r, V^r, I^r)$ x $S_6 (Ep^r, B^s, C^s, A^s, V^s, I^s)$	$Ep^r, B^r, C^r A^r, V^r, I^r$	Tr_{29}
		Tr_{30}
$S_4(Ep^s, A^r)$ x $S_7 (Ep^r, A^s)$	Ep^r, A^r	Tr_{31}
		Tr_{32}
$S_5(Ep^s, B^r, Am^r, C^r, V^r, I^r, A^r)$ x $S_6 (Ep^r, B^s, Am^s, C^s, V^s, I^s, A^s)$	$Ep^r, B^r, Am^r, C^r, V^r, I^r, A^r$	Tr_{33}
		Tr_{34}
$S_5(Ep^s, Am^r, A^r)$ x $S_7 (Ep^r, Am^s, A^s)$	Ep^r, Am^r, A^r	Tr_{35}
		Tr_{36}

Ax = Ampielox, B = Benicilline, E = Erthromycin, R = Rifamycin, Am = Amoxil, C = Cefazone, A = Ampicillin, Ep = Epigent, T = Tetracyclin, V = Volven, I = Ibidroxil.

Equations 1-6:

1. Mortalities% = Number of mortality larvae in *Bt* treatment – Number of spontaneous mortality larvae in untreated control experiment/Initial number of surviving larvae in *Bt* treated x 100

$$2.\ \text{Fitness of larvae} = \frac{\text{Number of survivors in } Bt \text{ treatment}}{\text{Initial number of surviving larvae in control experiment}}$$

$$3.\ \text{Weight of surviving larvae (mg)} = \frac{\text{Total weight of all surviving larvae / bottle}}{\text{Number of survivors / bottle}} \times 1000$$

$$4.\ \text{Hatchability percent} = \frac{\text{Number of hatched eggs}}{\text{Total number of initial eggs}} \times 100$$

$$5.\ \text{Embryo mortality\%} = \frac{\text{Number of hatched eggs per treatment} - \text{Number of unhatched eggs in untreated control experiment}}{\text{Total number of initial eggs}} \times 100$$

$$6.\ \text{Fed consumption of leaves (mg) by larvae per day} = \frac{\text{Weight of unconsumped fed leaves after 24 h} - \text{Weight of residual fed leaves per treatment after 24 h}}{\text{Number of surviving larvae}} \times 1000$$

Antibiotic genetic markers: Antibiotics were used for genetic recognize *Bacillus thuringiensis* strains by plate diffusion method, according to Collins and Lyne (1985) with cultures grown to logarithmic growth phase in nutrient broth of PWYE medium. Bacterial suspension was mixed with 18 ml of PWYE agar medium in petri-dishes. Wells (8 mm diameter) were punched in the agar, using a stainless steel borer and were filled with 0.1 ml of the antibiotic concentration. The plates were incubated overnight at 37°C and the diameter of resulting zones of inhibition was measured 3 replicates were used in each plate per each strain (Toda *et al*., 1989). Different antibiotics were used with the concentration of 400 μg ml^{-1} according to Roth and Sonti (1989), they were the products of Hoechst Orients, SAE, Cairo, Egypt.

Data preparation of bioassays: Mortality was recorded daily and bioassays are dependent on the different parameters according to Zehnder and Gelernter (1995) (Equations 1-6)

***Bt* products affecting mature larvae:** The bioassays are suitable for measuring growth and consumption of larvae fed on natural containing *Bt*. In addition, relative consumption rate is defined as the amount of diet consumed per initial larval weight (Navon, 1993).

Statistical analysis: Data were subjected to analysis of variance procedure according to Steel and Torrie (1960) to estimate the significance of differences between the treated and the reference (untreated) samples at probability level of 0.05 and 0.01.

Results and Discussion

Effect of bioinsecticide on the life of lepidopterous larvae: The bioassay data (Table 3) in the second instar of F_1 generation showed that the bacterial preparation indicating cry + end from transconjugants No. 26 and 33 were all active against lepidopterous larvae, but no strain of any of the others tested was significantly increase mortalities percent. In the second and third instar, the bacterial preparation indicating endospores alone was not active against lepidopterous larvae, but in the fourth instar the preparation from transconjugants No. 12, 23, 25 (7 day) and Tr. 20, 23 (8 days) showed significant mortality percent against lepidopterous larvae. However, crystal preparation from Tr 17 and 22 also demonstrated significant mortalities in the second instar. The results of mortalities percent in F_1 generation indicated that crystals + endospores were all active in the second and third instar, however, crystals alone was more active in the second instar and also endospores alone was more active in the fourth instar. This are in agreement with Akhurst *et al*. (1997), who found that two strains of *Bt* serovar

Table 3: Mortalities of lepidopterous larvae fed on leaves sprayed with different bacterial preparations derived from *Bt* strains and their transconjugants in F_1 generation

	Larval mortality (%) at different days of second instar					
	1			2		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	
Cry						
S_1	2.78	2.78	1.39	9.72	6.94	11.11
S_2	4.17	6.94	1.38	15.27	4.17	4.17
S_3	2.78	8.33	1.39	5.55	8.33	13.88
S_4	5.55	6.66	2.78	11.00	6.94	6.94
S_5	4.17	4.17	0.00	9.72	4.17	1.39
S_6	6.94	8.33	5.55	5.55	6.94	11.11
S_7	2.78	4.17	2.78	9.72	5.55	9.72
S_8	6.94	9.72	4.17	16.67	5.55	9.72
Tr_9	6.94	1.39	1.39	8.33	2.78	1.39
Tr_{10}	5.55	6.94	2.98	9.72	1.39	9.72
Tr_{11}	2.78	2.78	1.39	2.78	2.78	9.72
Tr_{12}	5.55	4.17	0.00	6.94	2.78	4.17
Tr_{13}	4.17	5.55	4.17	8.33	8.33	6.94
Tr_{14}	4.17	4.17	2.78	4.17	2.78	9.72
Tr_{15}	8.33	11.11	5.55	4.17	5.55	8.33
Tr_{16}	6.94	6.94	2.78	9.72	2.78	8.33
Tr_{17}	2.78	6.94	0.00	1.39	4.17	12.50
Tr_{18}	1.39	6.94	0.00	5.55	4.17	2.78
Tr_{19}	5.55	6.94	4.17	4.17	5.55	13.88
Tr_{20}	6.94	9.72	1.39	5.55	5.55	11.11
Tr_{21}	8.33	8.33	4.17	5.72	6.94	11.11
Tr_{22}	9.72	6.94	5.55	9.72	6.94	15.27
Tr_{23}	2.78	5.55	2.78	4.17	5.55	9.72
Tr_{24}	6.94	9.72	1.39	5.55	4.17	6.94
Tr_{25}	6.94	8.33	1.39	11.11	6.94	12.50
Tr_{26}	5.55	6.94	4.17	12.49	6.94	11.11
Tr_{27}	8.33	8.33	1.39	8.33	6.94	5.55
Tr_{28}	6.94	6.94	5.55	9.72	11.11	12.50
Tr_{29}	8.33	4.17	2.78	5.55	6.94	13.88
Tr_{30}	8.33	6.94	1.39	6.94	5.55	12.50
Tr_{31}	11.10	6.94	2.78	11.11	5.55	9.72
Tr_{32}	8.33	8.33	1.39	13.88	6.94	11.11
Tr_{33}	11.10	6.94	2.79	16.66	5.55	6.94
Tr_{34}	9.71	5.55	2.78	9.72	6.94	9.72
Tr_{35}	9.71	4.17	4.17	12.50	4.17	2.78
Tr_{36}	6.94	6.94	1.39	6.94	2.78	8.33
F test	NS	NS	NS	**	NS	**
LSD 0.05				6.89		7.42
0.01				9.04		9.74

NS = Non significant ** = P< 0.01

Table 3: Continued

	Larval mortality (%) at different days of third instar								
	3			4			5		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	1.39	1.39	8.33	4.17	1.39	6.94	4.17	5.55	5.55
S_2	8.33	5.55	11.11	5.55	2.78	11.11	1.39	2.78	11.11
S_3	8.78	2.78	12.50	5.55	2.78	11.11	9.72	1.39	6.94
S_4	6.94	1.39	11.11	5.55	0.00	8.33	12.50	0.00	16.66
S_5	9.72	0.00	6.94	12.50	1.39	1.39	5.55	4.17	8.33
S_6	8.33	2.78	12.50	9.72	2.78	11.11	5.55	2.78	11.11
S_7	8.33	4.17	9.72	4.17	1.39	9.72	12.50	1.39	11.11
S_8	8.33	1.49	13.88	8.33	1.39	9.72	9.72	2.78	13.89
Tr_9	9.72	0.00	5.55	2.78	0.00	11.11	4.17	4.17	11.11
Tr_{10}	6.94	5.55	6.94	6.94	1.39	9.72	9.72*	5.55	4.17
Tr_{11}	5.55	4.17	11.11	2.78	2.78	9.72	9.72	0.00	6.94
Tr_{12}	5.55	5.55	6.94	6.94	1.39	1.38	4.17	1.39	5.55
Tr_{13}	12.50	0.00	9.72	6.94	0.00	11.11	8.33	2.78	12.50
Tr_{14}	11.10	2.78	8.33	8.33	1.39	11.11	9.72	0.00	5.55
Tr_{15}	8.33	1.39	9.72	5.55	1.39	16.16	12.50	1.39	11.11
Tr_{16}	12.49	6.94	2.78	5.55	0.00	8.33	8.33	0.00	6.94
Tr_{17}	6.94	5.55	4.17	4.17	0.00	8.33	8.33	2.78	8.33
Tr_{18}	5.55	4.17	9.72	4.17	0.00	2.78	2.78	2.78	8.33
Tr_{19}	8.33	1.39	9.72	8.33	2.78	12.50	8.33	1.39	6.94
Tr_{20}	9.72	1.39	4.17	4.17	1.39	9.72	6.94	0.00	1.39
Tr_{21}	15.28	6.94	8.33	13.89	1.39	6.94	16.66	1.39	6.94
Tr_{22}	8.33	2.78	6.94	13.89	4.17	9.72	16.66	0.00	8.33
Tr_{23}	8.33	2.78	15.27	12.50	2.78	5.55	8.33	0.00	11.11
Tr_{24}	5.55	4.17	8.33	6.94	1.39	9.72	8.33	0.00	5.55
Tr_{25}	9.72	4.17	11.10	6.94	2.78	1.39	12.50	1.39	12.50
Tr_{26}	12.50	1.39	11.11	8.33	0.00	6.94	15.27	2.78	6.94
Tr_{27}	11.11	2.78	9.72	9.72	1.39	11.11	8.33	1.39	4.17
Tr_{28}	9.72	2.78	11.11	5.55	1.39	11.11	8.33	4.17	12.50
Tr_{29}	11.11	2.78	5.55	2.78	1.39	12.50	13.88	1.39	12.50
Tr_{30}	8.33	2.78	5.55	8.33	4.17	6.94	12.50	1.39	11.11
Tr_{31}	12.50	1.39	8.33	11.11	2.78	11.11	16.66	1.39	5.55
Tr_{32}	9.72	5.55	8.33	8.33	2.78	12.50	9.72	0.00	4.17
Tr_{33}	12.50	2.78	9.72	8.33	1.39	9.72	15.27	1.39	9.72
Tr_{34}	8.33	1.39	9.72	6.94	2.78	1.39	8.33	2.78	8.33
Tr_{35}	13.88	2.78	6.94	6.94	1.39	8.33	9.72	1.39	8.33
Tr_{36}	6.94	1.39	8.33	4.11	4.17	8.33	6.94	2.78	5.55
F test	*	*	NS	*	NS	*	**	NS	NS
LSD 0.05	6.27	4.20		6.47		7.39	6.09		
0.01	8.22	5.51		8.48		9.69	7.98		

NS = Non significant *, ** = P< 0.05, P< 0.01, respectively

Table 3: Continued

	Larval mortality (%) at different days of fourth instar								
	6			7			8		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	12.49	5.55	1.39	11.10	4.16	4.17	8.33	8.33	4.16
S_2	11.10	9.71	4.17	12.49	9.71	8.33	6.94	8.33	1.38
S_3	6.10	9.71	2.78	12.49	8.33	5.55	8.33	6.94	4.16
S_4	9.71	9.71	6.94	5.55	8.33	5.56	5.55	9.71	1.38
S_5	2.77	12.49	4.17	2.77	6.94	4.17	0.00	2.77	1.38
S_6	6.94	8.33	6.94	6.94	6.94	2.78	4.16	6.94	1.38
S_7	8.33	13.88	4.17	5.55	13.88	0.00	0.00	1.38	2.77
S_8	16.66	13.88	4.17	6.94	12.49	1.39	0.00	12.49	4.16
Tr_9	8.33	9.71	1.39	2.77	4.16	6.94	8.33	8.33	1.38
Tr_{10}	4.16	8.33	1.39	11.10	8.33	5.55	2.77	9.71	6.94
Tr_{11}	6.94	11.10	1.39	5.55	11.10	4.17	4.16	5.55	2.77
Tr_{12}	8.33	8.33	5.55	8.33	15.27	9.72	6.94	2.77	1.38
Tr_{13}	9.71	13.88	5.55	6.93	12.49	1.39	2.77	2.77	1.38
Tr_{14}	6.94	12.49	5.55	5.55	11.10	8.32	2.77	2.77	0.00
Tr_{15}	5.55	12.49	2.78	8.33	9.71	4.17	9.72	5.55	0.00
Tr_{16}	11.10	12.49	6.94	8.33	8.33	4.17	4.16	4.16	2.77
Tr_{17}	5.55	13.38	4.17	5.55	5.55	6.94	8.38	0.00	1.38
Tr_{18}	8.33	11.10	4.17	4.16	11.10	9.72	6.94	5.55	2.77
Tr_{19}	8.33	12.49	2.78	8.33	11.10	4.17	6.94	4.16	5.55
Tr_{20}	8.33	13.88	6.94	6.94	11.10	8.33	5.55	11.10	4.16
Tr_{21}	11.10	11.10	6.94	5.55	9.71	9.77	0.00	15.27	5.55
Tr_{22}	11.10	6.94	6.94	5.55	8.33	2.78	0.00	11.10	8.33
Tr_{23}	8.33	9.71	4.17	6.94	13.88	4.17	4.16	13.88	4.16
Tr_{24}	8.33	11.10	6.94	5.55	11.10	4.17	5.55	4.16	0.00
Tr_{25}	8.33	12.49	5.55	8.33	15.27	8.33	1.38	5.55	6.94
Tr_{26}	13.88	9.71	9.72	2.77	12.49	8.33	0.00	5.55	4.16
Tr_{27}	6.94	12.49	5.55	5.55	15.27	5.55	0.00	4.16	1.38
Tr_{28}	8.33	13.88	2.78	8.33	9.71	6.94	0.00	9.71	1.38
Tr_{29}	11.10	12.49	6.94	4.16	12.49	2.78	2.77	6.94	1.38
Tr_{30}	9.72	12.49	4.17	2.77	11.10	6.94	0.00	5.55	6.94
Tr_{31}	1.38	13.88	5.55	0.00	11.10	4.17	0.00	8.33	4.16
Tr_{32}	4.16	13.88	0.00	4.16	12.49	4.17	1.38	8.33	4.16
Tr_{33}	11.10	12.49	1.39	1.38	12.49	8.33	1.38	5.55	1.38
Tr_{34}	8.33	13.88	8.33	2.77	11.10	1.39	2.77	2.77	2.77
Tr_{35}	6.94	12.49	5.55	1.38	15.27	2.78	1.38	2.77	2.77
Tr_{36}	5.55	11.10	4.17	4.16	11.10	4.17	4.16	2.77	5.55
F test	NS	**	NS	*	**	NS	**	**	NS
LSD 0.05		4.34		6.80	5.97		5.70	6.01	
0.01		5.69		8.92	7.83		7.48	7.88	

NS = Non significant *, ** = P< 0.05, P< 0.01, respectively

Table 3: Continued

	Larval mortality (%) at different days of fifth instar					
	9			10		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	2.77	0.00	1.38	0.00	0.00	2.77
S_2	4.16	2.77	0.00	1.38	0.00	0.00
S_3	2.77	2.77	2.77	4.16	2.77	1.38
S_4	2.77	4.16	1.38	0.00	2.77	0.00
S_5	0.00	1.38	4.16	0.00	0.00	0.00
S_6	4.16	6.93	0.00	5.55	2.77	0.00
S_7	1.38	0.00	2.77	0.00	0.00	2.77
S_8	0.00	2.77	0.00	0.00	4.16	0.00
Tr_9	2.77	0.00	5.55	4.16	0.00	0.00
Tr_{10}	5.55	1.38	1.38	4.16	0.00	0.00
Tr_{11}	4.16	0.00	1.38	4.16	0.00	0.00
Tr_{12}	5.55	1.38	0.00	0.00	0.00	2.77
Tr_{13}	2.77	1.38	1.38	0.00	0.00	0.00
Tr_{14}	2.77	4.16	1.38	1.38	0.00	0.00
Tr_{15}	1.38	2.77	1.38	1.38	4.16	0.00
Tr_{16}	1.38	4.16	4.16	0.00	0.00	1.38
Tr_{17}	2.77	0.00	2.77	0.00	0.00	0.00
Tr_{18}	1.38	2.77	0.00	1.38	0.00	1.38
Tr_{19}	2.77	5.55	0.00	0.00	2.77	0.00
Tr_{20}	1.38	0.00	2.77	0.00	0.00	0.00
Tr_{21}	0.00	6.94	5.55	0.00	1.38	0.00
Tr_{22}	0.00	5.55	2.77	0.00	1.38	0.00
Tr_{23}	1.38	1.38	4.16	0.00	0.00	0.00
Tr_{24}	1.38	0.00	4.16	1.38	0.00	0.00
Tr_{25}	1.38	1.38	4.16	0.00	0.00	0.00
Tr_{26}	0.00	1.38	2.77	0.00	0.00	1.38
Tr_{27}	0.00	0.00	2.77	0.00	0.00	0.00
Tr_{28}	1.38	2.77	2.77	0.00	1.38	0.00
Tr_{29}	1.38	4.16	1.38	0.00	4.16	0.00
Tr_{30}	1.38	4.16	2.77	1.38	2.77	0.00
Tr_{31}	0.00	1.38	4.22	0.00	1.38	1.38
Tr_{32}	1.38	2.77	1.38	0.00	0.00	1.38
Tr_{33}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{34}	1.38	0.00	2.77	1.38	0.00	2.77
Tr_{35}	1.38	1.38	1.38	0.00	0.00	1.38
Tr_{36}	2.77	2.77	0.00	1.38	1.38	0.00
F test	NS	**	NS	**	**	NS
LSD 0.05	--	4.19	--	3.18	2.75	--
0.01	--	5.49	--	4.17	3.61	

NS = Non significant ** = P< 0.01

Table 3: Continued

	Larval mortality (%) at different days of sixth instar					
	11			12		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	0.00	0.00	0.00	0.00	0.00	0.00
S_2	1.38	0.00	0.00	1.38	0.00	0.00
S_3	0.00	1.38	1.38	0.00	0.00	1.38
S_4	0.00	1.38	0.00	0.00	0.00	0.00
S_5	0.00	0.00	0.00	0.00	0.00	0.00
S_6	1.38	1.38	0.00	1.38	0.00	0.00
S_7	0.00	0.00	0.00	0.00	0.00	0.00
S_8	0.00	1.38	0.00	0.00	0.00	0.00
Tr_9	1.38	0.00	0.00	0.00	0.00	0.00
Tr_{10}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{11}	1.38	0.00	0.00	0.00	0.00	0.00
Tr_{12}	0.00	0.00	2.77	0.00	0.00	1.38
Tr_{13}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{14}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{15}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{16}	0.00	0.00	4.16	0.00	0.00	2.77
Tr_{17}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{18}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{19}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{20}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{21}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{22}	0.00	1.38	0.00	0.00	0.00	0.00
Tr_{23}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{24}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{25}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{26}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{27}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{28}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{29}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{30}	0.00	0.00	1.38	0.00	0.00	0.00
Tr_{31}	0.00	0.00	0.00	0.00	0.00	1.38
Tr_{32}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{33}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{34}	0.00	0.00	0.00	0.00	0.00	0.00
Tr_{35}	0.00	0.00	0.00	0.00	0.00	1.38
Tr_{36}	0.00	0.00	0.00	0.00	0.00	0.00
F test	NS	NS	NS	NS	NS	NS

NS = Non significant

Table 4: Mortalities of lepidopterous larvae fed on leaves sprayed with different bacterial preparations derived from *Bt* strains and their transconjugants in F_2 generation

	Larval mortality (%) at different days of second instar					
	1			2		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	2.77	1.38	2.77	6.94	4.16	5.55
S_2	4.16	6.94	6.94	6.94	1.38	4.16
S_3	1.38	4.16	4.16	8.33	2.77	2.77
S_4	5.55	2.77	6.94	8.33	2.77	4.16
S_5	5.55	4.16	8.33	4.16	1.38	1.38
S_6	4.16	5.55	5.55	8.33	1.38	5.55
S_7	4.16	4.16	6.94	5.55	4.16	0.00
S_8	8.33	4.16	4.16	4.16	4.16	5.55
Tr_9	8.33	1.38	5.55	4.16	5.55	0.00
Tr_{10}	5.55	2.77	5.55	4.16	2.77	5.55
Tr_{11}	5.55	4.16	4.16	2.77	1.38	4.16
Tr_{12}	8.33	2.77	5.55	5.55	4.16	4.16
Tr_{13}	8.33	4.16	6.94	8.33	8.33	0.00
Tr_{14}	6.94	2.77	6.94	4.16	1.38	4.16
Tr_{15}	4.16	4.16	8.33	6.94	1.38	4.16
Tr_{16}	5.55	1.38	4.16	8.33	6.94	4.16
Tr_{17}	4.16	4.16	6.94	6.94	4.16	2.77
Tr_{18}	6.94	1.38	1.38	5.55	4.16	4.16
Tr_{19}	4.16	2.77	5.55	6.94	0.00	4.16
Tr_{20}	5.55	2.77	6.94	6.94	1.38	5.55
Tr_{21}	5.55	5.55	8.33	11.10	4.16	4.16
Tr_{22}	6.94	5.55	5.55	9.71	2.77	5.55
Tr_{23}	2.77	5.55	4.16	11.10	1.38	2.77
Tr_{24}	4.16	8.33	4.16	9.71	2.77	1.38
Tr_{25}	6.94	6.94	5.55	8.33	2.77	6.94
Tr_{26}	6.94	4.16	6.94	8.33	1.38	4.16
Tr_{27}	2.77	6.94	5.55	6.94	0.00	2.77
Tr_{28}	2.77	4.16	8.33	6.94	2.77	1.38
Tr_{29}	5.55	4.16	8.33	5.55	5.55	2.77
Tr_{30}	4.16	4.16	4.16	9.71	2.77	6.94
Tr_{31}	6.94	1.38	4.16	5.55	8.33	6.94
Tr_{32}	8.33	2.77	2.77	2.77	6.94	2.77
Tr_{33}	5.55	4.16	6.94	8.33	2.77	1.38
Tr_{34}	4.16	5.55	6.94	8.33	2.77	4.16
Tr_{35}	4.16	5.55	6.94	8.33	2.77	1.38
Tr_{36}	5.55	5.55	8.33	4.16	2.77	1.38
F test	NS	NS	NS	NS	NS	NS

NS = Non significant

Table 4: Continued

	Larval mortality (%) at different days of third instar								
	3			4			5		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	1.38	5.55	0.00	0.00	1.38	0.00	0.00	1.38	1.38
S_2	1.38	4.16	4.16	1.38	1.38	2.77	2.77	0.00	2.77
S_3	2.77	2.77	1.38	0.00	2.77	2.77	0.00	0.00	4.16
S_4	2.77	2.77	1.38	1.38	1.38	0.00	0.00	1.38	1.38
S_5	0.00	5.55	0.00	0.00	1.38	0.00	2.77	1.38	2.77
S_6	1.38	5.55	0.00	1.38	1.38	0.00	1.38	0.00	1.38
S_7	1.38	0.00	1.38	2.77	5.55	1.38	0.00	2.77	1.38
S_8	1.38	4.16	1.38	0.00	4.16	1.38	0.00	1.38	2.77
Tr_9	0.00	1.38	0.00	1.38	2.77	1.38	1.38	4.16	1.38
Tr_{10}	1.38	4.16	1.38	1.38	1.38	0.00	0.00	2.77	1.38
Tr_{11}	1.38	2.77	0.00	1.38	2.77	1.38	1.38	0.00	0.00
Tr_{12}	0.00	2.77	0.00	0.00	0.00	0.00	1.38	1.38	2.77
Tr_{13}	0.00	2.77	0.00	1.38	2.77	2.77	1.38	1.38	1.38
Tr_{14}	0.00	5.55	1.38	1.38	0.00	0.00	1.38	2.77	1.38
Tr_{15}	1.38	2.77	0.00	0.00	2.77	0.00	2.77	2.77	2.77
Tr_{16}	1.38	1.38	0.00	0.00	2.77	1.38	2.77	6.94	0.00
Tr_{17}	0.00	2.77	0.00	1.38	4.16	1.38	0.00	2.77	1.38
Tr_{18}	1.38	2.77	0.00	0.00	2.77	0.00	0.00	1.38	1.38
Tr_{19}	0.00	2.77	1.38	0.00	1.38	2.77	0.00	2.77	2.77
Tr_{20}	0.00	2.77	0.00	0.00	1.38	0.00	2.77	1.38	0.00
Tr_{21}	0.00	5.55	0.00	0.00	1.38	0.00	1.38	1.38	2.77
Tr_{22}	2.77	4.16	1.38	1.38	4.16	1.38	0.00	4.16	0.00
Tr_{23}	0.00	4.16	0.00	0.00	4.16	0.00	1.38	0.00	2.77
Tr_{24}	0.00	1.38	0.00	0.00	0.00	4.16	1.38	2.77	2.77
Tr_{25}	0.00	1.38	1.38	0.00	1.38	1.38	1.38	1.38	1.38
Tr_{26}	0.00	2.77	0.00	1.38	2.77	0.00	4.16	2.77	0.00
Tr_{27}	1.38	2.77	1.38	0.00	1.38	1.38	0.00	4.16	0.00
Tr_{28}	1.38	1.38	0.00	0.00	4.16	4.16	1.38	1.38	1.38
Tr_{29}	0.00	1.38	0.00	1.38	2.77	0.00	0.00	4.16	1.38
Tr_{30}	1.38	0.00	1.38	0.00	0.00	2.77	1.38	2.77	1.38
Tr_{31}	0.00	1.38	0.00	1.38	0.00	1.38	1.38	0.00	1.38
Tr_{32}	0.00	0.00	1.38	1.38	0.00	1.38	5.55	1.38	1.38
Tr_{33}	0.00	0.00	1.38	0.00	1.38	1.38	2.77	2.77	1.38
Tr_{34}	1.38	2.77	0.00	0.00	1.38	1.38	0.00	0.00	1.38
Tr_{35}	1.38	0.00	0.00	1.38	0.00	0.00	2.77	0.00	2.77
Tr_{36}	1.38	0.00	0.00	1.38	1.38	1.38	0.00	1.38	0.00
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant

Table 4: Continued

	Larval mortality (%) at different days of fourth instar								
	6			7			8		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	1.38	1.38	2.77	4.16	0.00	4.16	2.77	0.00	2.77
S_2	2.77	0.00	0.00	2.77	0.00	0.00	2.77	0.00	5.55
S_3	8.33	2.77	1.38	0.00	0.00	0.00	1.38	0.00	4.16
S_4	4.16	0.00	0.00	1.38	1.38	2.77	0.00	1.38	1.38
S_5	2.77	2.77	0.00	1.38	1.38	1.38	2.77	0.00	2.77
S_6	2.77	2.77	1.38	0.00	0.00	0.00	1.38	1.38	1.38
S_7	0.00	0.00	1.38	4.16	1.38	1.38	1.38	0.00	1.38
S_8	6.94	1.38	1.38	1.38	1.38	2.77	0.00	1.38	0.00
Tr_9	1.38	0.00	1.38	1.38	2.77	4.16	2.77	0.00	0.00
Tr_{10}	1.38	1.38	0.00	1.38	1.38	1.38	1.38	2.77	0.00
Tr_{11}	4.16	1.38	1.38	4.16	1.38	1.38	1.38	0.00	1.38
Tr_{12}	0.00	2.77	0.00	2.77	0.00	0.00	1.38	0.00	2.77
Tr_{13}	1.38	1.38	0.00	2.77	1.38	0.00	1.38	4.16	2.77
Tr_{14}	2.77	2.77	0.00	1.38	0.00	2.77	2.77	1.38	1.38
Tr_{15}	2.77	2.77	0.00	4.16	1.38	0.00	1.38	1.38	1.38
Tr_{16}	2.77	1.38	1.38	4.16	0.00	1.38	0.00	1.38	1.38
Tr_{17}	0.00	0.00	1.38	1.38	0.00	0.00	2.77	2.77	0.00
Tr_{18}	0.00	0.00	1.38	2.77	0.00	1.38	0.00	1.38	0.00
Tr_{19}	0.00	1.38	2.77	2.77	2.77	6.94	1.38	0.00	2.77
Tr_{20}	0.00	2.77	2.77	1.38	1.38	0.00	5.55	4.16	0.00
Tr_{21}	1.38	0.00	2.77	1.38	2.77	0.00	2.77	5.55	2.77
Tr_{22}	0.00	4.16	5.55	1.38	0.00	2.77	0.00	2.77	1.38
Tr_{23}	2.77	0.00	2.77	1.38	2.77	4.16	1.38	0.00	1.38
Tr_{24}	2.77	1.38	0.00	1.38	1.38	2.77	1.38	0.00	2.77
Tr_{25}	0.00	4.16	1.38	2.77	1.38	0.00	1.38	1.38	1.38
Tr_{26}	2.77	0.00	2.77	1.38	1.38	1.38	2.77	1.38	1.38
Tr_{27}	0.00	0.00	1.38	2.77	0.00	1.38	1.38	2.77	1.38
Tr_{28}	2.77	2.77	2.77	0.00	1.38	0.00	1.38	1.38	2.77
Tr_{29}	0.00	0.00	0.00	4.16	1.38	1.38	2.77	1.38	0.00
Tr_{30}	1.38	0.00	1.38	0.00	1.38	2.77	0.00	0.00	1.38
Tr_{31}	1.38	4.16	0.00	1.38	0.00	2.77	4.16	0.00	1.38
Tr_{32}	0.00	2.77	0.00	2.77	1.38	2.77	0.00	1.38	0.00
Tr_{33}	1.38	2.77	1.38	2.77	0.00	1.38	1.38	1.38	2.77
Tr_{34}	1.38	2.77	0.00	1.38	1.38	1.38	4.16	0.00	0.00
Tr_{35}	0.00	4.16	0.00	0.00	0.00	1.38	1.38	2.77	1.38
Tr_{36}	2.77	2.77	2.77	0.00	1.38	1.38	2.77	1.38	1.38
F test	*	NS	NS	NS	NS	NS	NS	NS	NS
LSD 0.05	4.29								
0.01	5.62								

NS =Non significant * = P< 0.05

Table 4. Continued

	Larval mortality (%) at different days of fifth instar					
	9			10		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	4.16	0.00	0.00	1.38	0.00	1.38
S_2	1.38	0.00	2.77	1.38	0.00	5.55
S_3	2.77	0.00	4.16	1.38	0.00	1.38
S_4	0.00	1.38	1.38	1.38	1.38	0.00
S_5	1.38	0.00	0.00	1.38	0.00	2.77
S_6	1.38	1.38	1.38	1.38	1.38	1.38
S_7	0.00	2.77	1.38	1.38	1.38	0.00
S_8	2.77	1.38	2.77	2.77	2.77	0.00
Tr_9	1.38	2.77	0.00	1.38	0.00	0.00
Tr_{10}	0.00	0.00	1.38	1.38	0.00	1.38
Tr_{11}	1.38	1.38	1.38	0.00	2.77	2.77
Tr_{12}	1.38	1.38	1.38	2.77	2.77	2.77
Tr_{13}	1.38	0.00	0.00	1.38	1.38	1.38
Tr_{14}	0.00	1.38	2.77	1.38	1.38	2.77
Tr_{15}	0.00	0.00	0.00	0.00	1.38	1.38
Tr_{16}	0.00	1.38	2.77	2.77	1.38	2.77
Tr_{17}	0.00	1.38	0.00	1.38	1.38	1.38
Tr_{18}	0.00	2.77	1.38	1.38	1.38	0.00
Tr_{19}	1.38	0.00	2.77	1.38	0.00	0.00
Tr_{20}	0.00	1.38	1.38	1.38	1.38	2.77
Tr_{21}	0.00	2.77	0.00	2.77	1.38	1.38
Tr_{22}	1.38	1.38	1.38	1.38	1.38	4.16
Tr_{23}	0.00	0.00	1.38	0.00	1.38	1.38
Tr_{24}	0.00	2.77	2.77	1.38	1.38	1.38
Tr_{25}	1.38	0.00	1.38	1.38	0.00	1.38
Tr_{26}	0.00	4.16	1.38	2.77	0.00	1.38
Tr_{27}	1.38	1.38	2.77	2.77	0.00	1.38
Tr_{28}	1.38	0.00	2.77	1.38	9.71	1.38
Tr_{29}	0.00	0.00	0.00	2.77	1.38	4.16
Tr_{30}	1.38	2.77	1.38	2.77	1.38	1.38
Tr_{31}	0.00	2.77	1.38	2.77	2.77	0.00
Tr_{32}	0.00	2.77	0.00	2.77	2.77	0.00
Tr_{33}	0.00	2.77	1.38	0.00	1.38	1.38
Tr_{34}	0.00	2.77	1.38	0.00	0.00	1.38
Tr_{35}	2.77	0.00	0.00	2.77	1.38	2.77
Tr_{36}	1.38	1.38	0.00	2.77	2.77	2.77
F test	NS	NS	NS	NS	*	NS
LSD 0.05					3.58	
0.01					4.70	

NS =Non significant * = P< 0.05

Table 4: Continued

	Larval mortality (%) at different days of sixth instar					
	11			12		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
S_1	1.38	0.00	2.77	1.38	0.00	0.00
S_2	1.38	0.00	2.77	1.38	0.00	0.00
S_3	1.38	0.00	0.00	0.00	0.00	2.77
S_4	1.38	0.00	2.77	1.38	0.00	4.16
S_5	4.16	0.00	1.38	2.77	0.00	1.38
S_6	2.77	0.00	2.77	2.77	0.00	4.16
S_7	4.16	0.00	2.77	2.77	0.00	2.77
S_8	1.38	0.00	5.55	5.55	0.00	4.16
Tr_9	4.16	0.00	5.55	2.77	0.00	4.16
Tr_{10}	2.77	0.00	1.38	4.16	0.00	1.38
Tr_{11}	4.16	2.77	1.38	2.77	0.00	2.77
Tr_{12}	2.77	4.16	1.38	2.77	0.00	2.77
Tr_{13}	2.77	0.00	2.77	2.77	0.00	0.00
Tr_{14}	2.77	0.00	1.38	2.77	0.00	4.16
Tr_{15}	4.16	0.00	2.77	1.38	0.00	2.77
Tr_{16}	2.77	0.00	2.77	4.16	0.00	2.77
Tr_{17}	1.38	0.00	1.38	4.16	0.00	1.38
Tr_{18}	2.77	0.00	2.77	1.38	0.00	2.77
Tr_{19}	2.77	1.38	2.77	2.77	0.00	0.00
Tr_{20}	2.77	0.00	1.38	4.16	0.00	2.77
Tr_{21}	4.16	1.38	4.16	4.16	0.00	1.38
Tr_{22}	2.77	1.38	0.00	4.16	0.00	2.77
Tr_{23}	2.77	0.00	2.77	2.77	0.00	2.77
Tr_{24}	2.77	2.77	2.77	4.16	0.00	1.38
Tr_{25}	4.16	0.00	2.77	4.16	0.00	2.77
Tr_{26}	2.77	0.00	2.77	1.38	0.00	4.16
Tr_{27}	2.77	5.55	1.38	4.16	0.00	4.16
Tr_{28}	2.77	0.00	1.38	4.16	0.00	4.16
Tr_{29}	2.77	1.38	2.77	2.77	0.00	2.77
Tr_{30}	2.77	1.38	1.38	5.55	1.38	1.38
Tr_{31}	6.94	2.77	4.16	4.16	2.77	2.77
Tr_{32}	1.38	0.00	4.16	2.77	4.16	4.16
Tr_{33}	5.55	1.38	1.38	2.77	1.38	2.77
Tr_{34}	4.16	4.16	2.77	4.16	1.38	2.77
Tr_{35}	1.38	2.77	1.38	2.77	2.77	2.77
Tr_{36}	2.77	1.38	1.38	2.77	2.77	1.38
F test	NS	**	NS	NS	**	NS
LSD 0.05		2.93			1.98	
0.01		3.84			2.60	

NS =Non significant ** = P< 0.01

Table 5: Weight of surviving larvae (mg) fed on leaves sprayed with different bacterial preparations derived from *Bt* strains and their transconjugants in F_1 generation

	Weight of surviving larvae								
	First instar			Second instar					
	1			2			3		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	0.71	0.84	0.66	4.27	4.77	4.35	5.64	6.29	5.67
S_1	0.60	0.56	0.59	3.76	4.69	3.65	4.91	6.62	5.84
S_2	0.53	0.60	0.59	3.68	4.77	3.80	5.14	6.58	5.55
S_3	0.56	0.51	0.55	3.86	4.86	3.93	5.17	6.58	6.06
S_4	0.56	0.56	0.54	4.03	4.69	3.84	5.24	6.55	5.84
S_5	0.54	0.57	0.57	3.78	4.77	3.93	5.24	6.64	5.70
S_6	0.57	0.54	0.56	3.74	4.77	3.96	5.17	6.79	5.60
S_7	0.59	0.60	0.60	3.62	4.85	4.20	5.09	6.74	5.87
S_8	0.51	0.57	0.52	3.79	4.77	3.47	5.26	6.76	5.91
Tr_9	0.46	0.57	0.53	3.79	4.63	3.69	5.26	6.50	5.46
Tr_{10}	0.53	0.57	0.58	3.73	4.69	3.93	5.24	6.51	5.78
Tr_{11}	0.58	0.61	0.58	3.57	4.69	3.95	5.23	6.59	5.89
Tr_{12}	0.58	0.64	0.53	3.68	4.54	3.82	5.24	6.73	5.68
Tr_{13}	0.56	0.61	0.59	3.60	4.85	3.99	5.73	6.54	5.83
Tr_{14}	0.53	0.67	0.54	3.63	4.69	4.01	5.15	6.62	5.60
Tr_{15}	0.55	0.61	0.64	3.74	4.76	3.79	5.24	6.97	5.64
Tr_{16}	0.54	0.58	0.62	3.64	4.69	3.85	5.17	6.66	5.78
Tr_{17}	0.42	0.53	0.59	3.53	4.69	3.77	4.50	6.84	6.19
Tr_{18}	0.52	0.55	0.62	3.42	4.69	3.89	5.23	6.97	5.52
Tr_{19}	0.35	0.53	0.62	3.64	4.77	3.88	5.17	6.70	5.93
Tr_{20}	0.40	0.61	0.64	3.69	4.85	3.86	5.15	7.02	5.78
Tr_{21}	0.56	0.68	0.57	3.59	4.85	3.90	5.00	6.13	5.91
Tr_{22}	0.48	0.47	0.51	3.82	4.85	3.87	5.28	6.52	5.88
Tr_{23}	0.48	0.59	0.61	3.54	4.77	3.58	5.24	6.70	5.77
Tr_{24}	0.53	0.58	0.57	3.61	4.85	3.70	5.32	6.97	5.63
Tr_{25}	0.62	0.55	0.55	3.48	4.77	3.69	5.26	6.77	5.72
Tr_{26}	0.59	0.54	0.59	3.48	4.69	3.64	4.95	6.92	5.84
Tr_{27}	0.52	0.63	0.65	3.75	4.77	3.67	5.26	6.85	5.92
Tr_{28}	0.48	0.62	0.58	3.54	4.69	3.71	5.18	6.46	5.85
Tr_{29}	0.56	0.58	0.59	3.75	4.54	3.75	5.26	6.83	5.55
Tr_{30}	0.60	0.55	0.55	3.75	4.69	3.79	5.24	6.96	5.89
Tr_{31}	0.55	0.53	0.63	3.64	4.69	3.79	5.00	6.87	5.61
Tr_{32}	0.54	0.53	0.58	3.75	4.77	3.93	5.09	6.56	6.41
Tr_{33}	0.45	0.54	0.59	3.65	4.69	3.76	5.09	6.71	5.74
Tr_{34}	0.53	0.46	0.60	3.97	4.54	4.01	5.17	6.91	5.66
Tr_{35}	0.41	0.60	0.57	3.75	4.54	3.81	5.26	6.79	5.74
Tr_{36}	0.55	0.52	0.57	3.69	4.69	3.69	5.26	6.80	5.39
F test	**	**	**	*	NS	NS	NS	NS	**
LSD 0.05	0.10	0.09	0.07	0.41					0.33
0.01	0.13	0.11	0.09	0.54					0.44

NS =Non significant *, ** = P< 0.05, P< 0.01, respectively

Table 5: Continued

	Weight of surviving larvae Third instar								
	4			5			6		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	17.41	18.02	18.94	34.88	33.26	36.61	55.56	55.71	57.36
S_1	9.85	12.03	9.99	14.43	17.81	16.43	20.98	28.51	24.64
S_2	10.00	11.48	9.83	12.77	18.08	16.15	21.56	26.79	24.51
S_3	10.00	11.23	10.04	14.65	19.17	16.32	21.00	27.67	24.11
S_4	10.17	11.94	9.96	15.04	18.10	20.91	22.48	25.44	25.87
S_5	10.00	11.82	10.01	15.00	19.02	15.32	21.02	26.17	24.41
S_6	10.00	11.50	10.14	14.71	19.84	15.43	21.94	26.36	25.16
S_7	10.00	11.73	10.01	14.81	20.34	16.74	20.37	27.18	24.39
S_8	10.28	11.45	10.39	14.57	19.81	16.77	22.04	25.35	25.77
Tr_9	10.00	11.38	10.67	14.67	19.89	16.87	21.67	26.28	25.67
Tr_{10}	10.00	11.57	10.65	14.71	20.94	17.00	21.21	26.70	25.67
Tr_{11}	10.00	11.84	10.05	14.74	19.94	16.32	21.20	27.03	24.82
Tr_{12}	9.83	12.07	11.20	14.50	21.44	17.32	21.39	26.88	25.70
Tr_{13}	10.00	11.52	10.35	15.00	19.92	16.52	21.60	24.79	25.80
Tr_{14}	10.00	11.35	10.53	14.64	19.91	16.18	22.34	26.66	24.89
Tr_{15}	10.00	11.20	10.26	14.91	18.27	16.02	21.54	26.41	25.29
Tr_{16}	10.00	12.20	10.48	14.62	19.98	16.47	21.56	25.61	25.41
Tr_{17}	9.74	11.87	10.32	14.76	19.56	16.75	21.34	27.67	23.79
Tr_{18}	10.00	11.13	10.58	14.06	20.47	16.89	22.01	27.69	23.16
Tr_{19}	10.00	11.85	10.30	14.79	20.60	16.06	21.57	25.37	23.49
Tr_{20}	10.28	11.31	10.74	15.02	20.42	16.73	20.18	26.06	21.49
Tr_{21}	10.00	11.52	10.07	13.94	20.53	16.46	21.94	25.62	24.90
Tr_{22}	10.00	10.65	10.00	14.32	18.74	16.13	21.08	24.36	24.29
Tr_{23}	10.00	11.81	9.72	15.18	20.08	16.31	23.52	25.22	24.63
Tr_{24}	10.00	11.31	10.51	15.29	20.08	16.54	22.54	26.00	24.79
Tr_{25}	10.00	11.33	9.91	15.76	20.48	16.43	21.33	26.05	23.54
Tr_{26}	9.79	11.38	9.99	13.88	18.91	16.42	20.33	27.37	24.57
Tr_{27}	10.00	11.52	10.06	14.62	19.93	16.12	21.58	21.08	25.02
Tr_{28}	10.57	11.33	10.51	14.79	20.42	16.74	21.66	26.31	24.72
Tr_{29}	10.00	11.76	10.05	14.69	19.86	16.47	22.19	27.03	27.63
Tr_{30}	10.00	11.59	10.34	14.36	18.96	16.65	20.90	26.47	28.63
Tr_{31}	10.00	11.67	10.47	14.67	17.74	16.25	21.55	26.84	24.76
Tr_{32}	10.00	11.52	10.32	14.41	19.80	16.74	21.79	27.51	25.64
Tr_{33}	10.00	11.58	10.45	14.39	20.17	15.94	21.16	27.38	23.25
Tr_{34}	10.00	12.16	10.34	14.74	20.08	16.85	23.86	26.53	25.38
Tr_{35}	10.00	12.08	10.31	14.33	20.10	16.24	21.23	26.07	24.46
Tr_{36}	10.21	11.74	10.37	14.78	20.03	16.64	22.13	25.70	24.94
F test	**	**	**	**	**	**	**	**	**
LSD 0.05	0.49	1.63	1.67	1.11	3.27	4.28	2.75	4.32	5.99
0.01	0.64	2.15	2.19	1.46	4.28	5.81	3.61	5.67	7.85

** = P< 0.01

Table 5: Continued

	Weight of surviving larvae Fourth instar								
	7			8			9		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	115.72	114.59	117.31	179.50	185.18	187.35	259.18	266.17	267.23
S_1	39.15	50.17	44.70	55.76	68.53	70.25	79.17	103.37	91.21
S_2	35.63	49.45	43.76	58.08	71.66	66.75	89.22	108.09	86.25
S_3	36.22	51.19	41.06	55.67	81.59	68.22	80.94	108.94	89.25
S_4	36.67	51.49	45.58	54.62	70.31	75.19	85.94	101.00	95.01
S_5	36.01	47.12	45.15	58.11	73.30	70.29	82.05	101.01	91.92
S_6	35.68	49.67	45.50	54.39	96.70	69.80	80.55	89.44	97.50
S_7	35.95	50.86	44.26	53.83	72.88	72.18	81.03	118.50	95.00
S_8	34.86	50.34	44.58	42.78	74.80	71.36	67.08	106.69	94.16
Tr_9	36.01	50.14	44.97	55.72	73.18	71.25	81.08	100.70	93.75
Tr_{10}	38.18	49.49	45.53	55.40	72.41	71.66	76.67	99.02	97.44
Tr_{11}	36.39	51.12	44.97	65.22	80.15	70.66	79.60	107.63	93.00
Tr_{12}	35.98	50.11	42.26	56.83	69.12	74.85	81.02	107.06	90.27
Tr_{13}	35.86	48.89	44.71	56.07	71.66	69.19	79.44	98.72	89.50
Tr_{14}	35.98	49.44	43.95	55.22	69.19	71.24	80.47	96.58	86.58
Tr_{15}	39.63	49.87	49.38	62.12	67.05	69.02	84.58	95.55	87.77
Tr_{16}	35.16	52.56	44.78	55.44	68.35	71.45	84.44	107.40	90.00
Tr_{17}	33.91	51.04	45.03	55.26	75.68	72.42	80.39	102.92	95.35
Tr_{18}	42.84	50.34	47.80	47.76	73.27	74.93	80.05	96.88	91.60
Tr_{19}	37.44	50.35	45.06	58.56	97.97	72.80	86.72	101.40	96.83
Tr_{20}	36.99	54.36	41.76	62.83	76.22	74.37	81.03	96.66	103.92
Tr_{21}	27.78	51.49	45.55	36.78	82.70	75.13	51.67	128.03	72.00
Tr_{22}	31.39	49.58	43.66	50.56	72.33	69.02	66.67	90.97	96.44
Tr_{23}	35.91	48.03	43.49	62.00	69.69	69.02	81.03	94.30	92.50
Tr_{24}	35.77	49.54	40.66	56.29	71.51	72.34	84.64	101.21	98.89
Tr_{25}	35.89	49.76	49.83	54.17	76.36	80.72	80.42	94.44	116.55
Tr_{26}	29.72	52.52	43.16	47.89	83.99	77.58	67.50	105.27	90.00
Tr_{27}	36.05	48.79	44.67	58.28	78.47	72.47	91.39	101.80	92.00
Tr_{28}	33.90	47.48	44.41	69.91	83.99	84.30	81.94	93.19	102.50
Tr_{29}	35.84	52.50	54.97	61.16	74.24	90.94	76.97	108.72	120.00
Tr_{30}	35.48	49.20	50.06	58.67	71.91	78.05	81.17	100.83	103.16
Tr_{31}	37.22	52.07	46.00	58.14	70.66	82.08	80.83	107.91	98.20
Tr_{32}	35.95	50.89	45.36	57.72	69.63	79.82	78.89	103.05	108.37
Tr_{33}	30.55	51.73	44.23	47.61	66.98	70.77	80.00	102.53	91.80
Tr_{34}	35.88	49.69	45.10	63.82	73.39	71.63	64.78	99.44	106.71
Tr_{35}	35.93	47.53	42.63	57.51	72.11	72.34	80.32	100.55	93.00
Tr_{36}	35.56	49.45	46.50	68.99	74.73	70.38	82.12	98.17	96.25
F test	**	**	**	**	**	**	**	**	**
LSD 0.05	6.74	7.86	12.43	16.16	21.28	24.38	16.59	26.73	36.40
0.01	8.84	10.30	16.30	21.19	27.91	31.97	21.76	35.05	47.73

** = P< 0.01

Table 5: Continued

	Weight of surviving larvae Fifth instar					
	10			11		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	352.18	365.36	367.79	430.48	431.17	370.04
S_1	115.56	153.66	128.55	164.33	222.92	204.00
S_2	100.42	156.01	134.58	179.25	227.67	192.41
S_3	106.50	176.40	134.16	166.97	249.91	196.30
S_4	127.91	149.52	161.38	179.92	244.96	230.97
S_5	109.11	152.72	138.17	171.78	222.19	197.32
S_6	106.63	150.41	155.55	171.08	210.99	222.77
S_7	110.00	158.09	157.11	160.03	240.48	234.85
S_8	90.83	167.50	120.55	142.08	237.38	175.41
Tr_9	120.61	147.64	139.22	171.58	215.81	200.08
Tr_{10}	119.17	161.25	156.33	171.25	221.55	224.22
Tr_{11}	102.59	152.00	144.66	172.20	220.97	207.00
Tr_{12}	133.06	165.17	146.64	185.67	222.81	207.83
Tr_{13}	113.67	148.58	139.61	180.06	218.66	204.44
Tr_{14}	143.61	150.17	140.00	190.03	221.42	201.94
Tr_{15}	125.28	155.16	136.10	180.33	246.88	294.99
Tr_{16}	116.11	161.11	127.50	180.00	236.29	289.12
Tr_{17}	123.44	157.02	144.66	173.00	232.81	206.99
Tr_{18}	107.02	149.16	148.74	167.84	220.00	209.61
Tr_{19}	122.28	159.16	151.05	183.17	229.50	207.79
Tr_{20}	114.58	152.08	143.66	165.58	223.05	207.01
Tr_{21}	73.33	220.83	110.83	113.33	307.66	158.33
Tr_{22}	91.67	142.01	150.55	141.67	192.77	215.00
Tr_{23}	110.00	138.75	144.44	171.36	203.47	206.10
Tr_{24}	111.89	152.67	147.18	177.83	223.45	208.84
Tr_{25}	117.50	150.00	180.05	185.83	238.61	272.22
Tr_{26}	91.67	161.74	152.49	141.67	240.13	220.55
Tr_{27}	108.47	153.33	139.58	171.25	226.00	203.19
Tr_{28}	110.00	150.00	173.05	166.39	214.02	238.88
Tr_{29}	109.86	172.91	186.66	168.61	258.32	259.16
Tr_{30}	113.67	149.25	148.44	171.08	225.36	222.77
Tr_{31}	114.44	152.02	148.23	170.83	227.63	221.82
Tr_{32}	109.17	167.08	148.11	171.17	245.27	204.68
Tr_{33}	91.67	147.91	142.77	141.67	226.11	205.55
Tr_{34}	109.17	154.16	151.83	170.11	226.11	239.41
Tr_{35}	109.31	150.00	144.66	165.97	220.27	207.70
Tr_{36}	111.15	156.42	144.55	167.33	240.42	209.24
F test	**	**	**	**	**	**
LSD 0.05	29.20	45.20	56.02	41.91	69.22	
LSD 0.01	38.29	59.27	73.46	54.95	90.77	

NS =Non significant ** = P< 0.01

Table 5: Continued

	Weight of surviving larvae Sixth instar					
	12			13		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	491.75	515.83	517.84	564.30	571.50	573.17
S_1	223.53	258.63	231.91	276.25	306.75	304.04
S_2	229.17	259.01	220.41	301.17	314.12	287.50
S_3	227.64	248.66	221.38	287.50	310.43	306.94
S_4	229.11	252.35	274.72	271.11	305.65	345.83
S_5	229.92	266.80	226.65	261.00	305.34	298.11
S_6	221.33	294.77	254.44	279.17	306.11	299.99
S_7	211.83	269.91	268.33	262.50	324.52	350.00
S_8	176.67	283.33	198.05	221.67	340.00	275.00
Tr_9	245.75	252.27	228.72	286.81	300.11	303.05
Tr_{10}	209.58	252.36	256.27	201.25	305.58	339.16
Tr_{11}	207.22	254.51	237.66	264.02	305.41	314.16
Tr_{12}	231.44	250.49	233.15	277.11	306.94	284.64
Tr_{13}	221.94	250.00	235.44	271.94	300.00	320.55
Tr_{14}	248.61	250.99	208.91	298.33	302.65	304.16
Tr_{15}	207.89	281.61	285.55	276.00	366.66	289.22
Tr_{16}	253.05	268.51	203.57	305.55	326.66	297.50
Tr_{17}	233.67	261.19	237.66	280.28	290.23	297.50
Tr_{18}	201.67	248.61	245.13	253.52	294.27	320.83
Tr_{19}	232.11	262.50	248.16	288.06	350.13	311.19
Tr_{20}	216.67	257.36	234.74	260.28	304.16	306.19
Tr_{21}	140.00	352.77	193.58	193.89	420.13	252.50
Tr_{22}	181.67	211.80	255.55	226.94	250.00	325.00
Tr_{23}	221.11	226.52	213.38	260.14	279.05	327.22
Tr_{24}	226.94	254.46	262.56	272.50	303.69	328.88
Tr_{25}	237.92	270.83	295.80	278.33	283.33	355.83
Tr_{26}	178.89	271.11	255.41	229.17	263.74	343.05
Tr_{27}	217.78	255.55	234.02	255.83	302.91	304.16
Tr_{28}	210.14	250.00	290.97	252.78	290.97	354.16
Tr_{29}	216.11	299.99	306.66	254.72	350.00	395.83
Tr_{30}	225.50	246.25	266.11	273.33	301.52	330.00
Tr_{31}	191.33	270.83	257.82	275.69	312.91	335.71
Tr_{32}	207.50	295.05	235.11	260.83	334.16	315.00
Tr_{33}	177.50	258.25	237.22	230.56	308.33	306.94
Tr_{34}	210.50	256.94	283.70	266.67	291.66	338.21
Tr_{35}	216.81	249.99	239.46	288.61	300.00	298.88
Tr_{36}	214.53	262.79	236.38	250.00	315.35	311.11
F test	**	**	**	**	**	NS
LSD 0.05	54.23	77.36	102.83	65.08	93.70	
0.01	71.10	101.43	134.84	85.34	122.86	

NS =Non significant ** = P< 0.01

Table 6: Weight of surviving larvae (mg) fed on leaves sprayed with different bacterial preparations derived from *Bt* strains and their transconjugants in F_2 generation

	Weight of surviving larvae								
	First instar			Second instar					
	1			2			3		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	0.74	0.72	0.72	4.83	4.77	4.78	6.56	6.14	6.47
S_1	0.52	0.64	0.58	4.75	4.69	5.00	7.18	7.01	6.80
S_2	0.66	0.67	0.56	4.66	4.84	4.40	7.13	6.82	6.50
S_3	0.67	0.71	0.58	4.83	4.52	4.69	6.81	6.83	7.21
S_4	0.62	0.61	0.61	4.75	4.54	4.61	7.37	6.70	6.70
S_5	0.61	0.60	0.67	4.75	4.84	4.94	7.13	7.00	6.57
S_6	0.54	0.61	0.59	4.75	4.61	4.78	6.87	6.70	6.86
S_7	0.55	0.61	0.67	4.66	4.77	4.49	7.18	6.83	6.66
S_8	0.54	0.58	0.66	4.66	4.77	4.79	6.71	6.82	6.51
Tr_9	0.64	0.62	0.68	4.66	4.77	4.35	7.03	7.04	7.21
Tr_{10}	0.57	0.53	0.71	4.66	4.54	4.61	7.13	6.61	6.31
Tr_{11}	0.69	0.59	0.69	4.75	4.69	4.85	6.92	6.56	7.77
Tr_{12}	0.56	0.64	0.71	4.91	4.84	4.71	7.30	6.92	6.75
Tr_{13}	0.56	0.63	0.60	4.58	4.84	4.28	6.90	7.21	6.89
Tr_{14}	0.53	0.67	0.57	4.75	4.77	4.63	7.13	6.66	6.22
Tr_{15}	0.51	0.65	0.69	4.75	4.41	4.47	7.07	6.51	6.05
Tr_{16}	0.65	0.56	0.74	4.75	4.77	4.33	7.03	7.13	6.74
Tr_{17}	0.57	0.60	0.72	4.75	4.84	4.42	7.07	6.92	6.46
Tr_{18}	0.55	0.66	0.71	5.05	4.77	4.94	7.03	7.02	7.86
Tr_{19}	0.59	0.65	0.68	4.66	4.84	4.42	7.13	7.76	6.14
Tr_{20}	0.53	0.64	0.63	4.66	4.77	4.49	7.02	6.77	5.84
Tr_{21}	0.51	0.64	0.56	4.75	4.77	4.49	6.93	6.99	6.36
Tr_{22}	0.58	0.60	0.54	4.75	4.69	4.69	6.85	6.72	6.48
Tr_{23}	0.57	0.70	0.61	4.75	4.77	4.79	7.20	6.77	6.37
Tr_{24}	0.59	0.66	0.61	4.66	4.77	5.24	6.93	6.29	6.64
Tr_{25}	0.62	0.68	0.68	4.66	4.69	4.69	6.97	6.80	6.65
Tr_{26}	0.54	0.61	0.67	4.75	4.77	4.64	7.02	6.92	6.53
Tr_{27}	0.59	0.62	0.71	4.75	4.69	5.01	7.09	6.57	6.57
Tr_{28}	0.62	0.63	0.62	4.91	4.54	4.54	7.03	6.65	6.59
Tr_{29}	0.56	0.71	0.61	4.83	4.77	4.49	7.07	6.89	6.62
Tr_{30}	0.53	0.71	0.54	4.66	4.77	4.80	7.03	6.77	6.31
Tr_{31}	0.68	0.57	0.60	4.83	4.77	4.78	7.07	7.27	6.62
Tr_{32}	0.58	0.62	0.59	4.75	4.77	4.78	6.98	7.15	6.57
Tr_{33}	0.68	0.59	0.61	4.75	4.69	4.69	7.03	6.93	6.74
Tr_{34}	0.55	0.62	0.67	4.83	4.77	4.84	9.07	6.83	6.84
Tr_{35}	0.60	0.64	0.72	4.66	4.77	4.78	6.99	6.85	6.70
Tr_{36}	0.56	0.59	0.75	4.75	4.69	4.61	7.18	6.70	6.55
F test	**	**	**	NS	NS	NS	NS	NS	NS
LSD 0.05	0.07	0.07	0.08						
0.01	0.09	0.09	0.10						

** = P< 0.01 NS =Non significant

Table 6: Continued

	Weight of surviving larvae Third instar								
	4			5			6		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	23.16	19.41	20.08	35.06	36.61	37.83	57.32	53.55	57.00
S_1	14.77	17.94	17.10	24.27	26.33	28.53	32.86	37.18	38.66
S_2	14.84	18.76	16.60	24.06	28.77	28.88	31.73	36.44	38.23
S_3	14.67	17.79	17.07	24.15	27.53	28.44	32.91	36.70	36.29
S_4	14.73	17.22	16.13	22.80	26.64	27.39	33.48	35.97	36.06
S_5	14.69	17.70	16.54	25.08	26.95	27.29	33.39	36.20	36.88
S_6	15.00	17.71	16.53	24.77	26.82	27.87	32.49	36.07	36.87
S_7	14.54	16.66	15.57	24.04	28.02	26.69	32.41	35.38	31.44
S_8	14.99	17.65	16.24	24.75	29.22	29.97	33.21	36.17	39.24
Tr_9	14.75	16.68	16.23	24.55	27.71	27.67	33.97	36.06	37.33
Tr_{10}	14.75	17.28	14.97	23.57	26.89	23.78*	32.77	36.25	32.94
Tr_{11}	14.84	16.89	16.14	24.10	28.26	26.79	33.08	36.42	35.25
Tr_{12}	14.58	16.40	15.56	23.84	26.63	25.84	34.69	35.96	34.39
Tr_{13}	15.12	16.84	15.89	22.15*	27.22	26.33	33.25	36.12	37.51
Tr_{14}	14.58	18.11	16.06	23.95	26.16	26.00	33.86	36.18	35.94
Tr_{15}	14.92	15.83	15.05	24.06	27.81	25.02	33.23	36.15	37.67
Tr_{16}	14.83	17.49	15.79	23.97	27.97	25.90	33.13	38.00	36.88
Tr_{17}	14.52	16.60	15.82	24.06	27.33	26.05	33.56	35.52	37.07
Tr_{18}	14.90	17.13	16.75	23.66	26.59	27.93	32.32	35.70	37.45
Tr_{19}	14.63	17.35	14.29	24.27	26.14	22.31	31.48	36.97	33.12
Tr_{20}	14.49	15.85	15.05	22.30	27.22	24.86	33.76	36.07	35.83
Tr_{21}	14.73	17.84	15.85	23.77	26.65	25.47	33.16	36.31	35.99
Tr_{22}	14.84	16.24	15.33	23.46	28.29	25.27	33.17	36.11	37.96
Tr_{23}	14.95	16.13	15.84	24.51	28.69	27.13	33.71	35.14	35.51
Tr_{24}	14.75	15.42	16.30	24.06	26.45	25.54	32.66	35.77	36.14
Tr_{25}	14.66	16.92	15.52	23.95	26.67	24.25	33.07	35.57	35.62
Tr_{26}	14.66	16.59	15.66	24.02	26.89	25.58	30.64	36.09	36.57
Tr_{27}	14.75	15.60	16.17	23.95	26.75	26.88	33.66	36.03	38.46
Tr_{28}	14.69	16.72	15.81	24.11	27.94	25.27	33.16	36.58	35.81
Tr_{29}	14.52	16.57	15.49	24.04	26.34	26.10	32.97	36.40	38.67
Tr_{30}	14.83	16.46	14.33	23.82	26.60	21.74	33.23	35.57	31.71
Tr_{31}	14.67	16.93	16.31	24.95	26.36	26.10	33.53	36.06	35.77
Tr_{32}	14.61	16.68	15.50	24.18	26.33	25.07	32.27	36.28	34.87
Tr_{33}	14.75	16.68	15.66	23.61	26.58	25.31	33.06	36.15	34.78
Tr_{34}	14.92	16.99	15.70	24.00	26.64	33.90	32.50	36.21	36.33
Tr_{35}	14.75	16.51	15.98	23.97	26.93	26.41	33.11	35.91	35.03
Tr_{36}	14.93	16.51	15.96	24.18	27.22	26.49	32.57	36.07	35.62
F test	**	**	**	**	**	**	**	**	**
LSD 0.05	0.55		1.93	1.62	2.69	4.37	1.95	1.76	5.31
0.01	0.72		2.54	2.13	3.53	5.73	2.56	2.30	6.97

NS =Non significant ** = P< 0.01

Table 6: Continued

		Weight of surviving larvae Fourth instar								
		7			8			9		
Microbial strains		Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.		122.47	116.97	116.09	193.91	184.06	192.32	273.93	265.21	257.49
S_1		59.80	60.82	71.29	87.32	86.74	102.16	114.83	114.58	125.41
S_2		60.31	63.17	70.00	88.89	95.50	103.33	116.46	115.84	123.78
S_3		61.76	61.40	68.00	91.45	88.30	103.91	116.95	114.34	127.79
S_4		63.21	62.84	66.60	87.75	91.53	95.28	115.88	149.20	122.86
S_5		61.77	62.39	71.29	88.96	93.88	105.14	118.92	119.23	129.43
S_6		61.70	63.59	67.66	90.00	90.99	98.54	116.58	119.04	122.96
S_7		59.61	61.62	67.66	87.32	94.25	101.83	114.88	118.18	127.94
S_8		60.33	63.17	69.12	89.81	90.18	101.49	119.38	117.12	137.01
Tr_9		60.48	64.29	68.35	86.94	94.58	98.12	117.01	119.69	125.75
Tr_{10}		59.65	63.49	61.78	87.29	95.16	92.09	114.85	118.18	123.08
Tr_{11}		60.63	66.92	66.36	89.31	98.84	95.17	114.99	122.30	122.05
Tr_{12}		58.92	62.88	65.59	88.05	95.07	94.51	117.90	119.88	118.09
Tr_{13}		60.31	63.24	65.23	88.45	94.52	96.88	115.75	120.39	125.08
Tr_{14}		60.48	58.64	67.34	89.10	94.33	91.46	115.16	123.56	127.31
Tr_{15}		60.31	63.45	65.88	88.83	96.36	95.68	116.51	116.98	122.31
Tr_{16}		60.66	66.43	68.99	89.01	99.00	98.86	116.42	125.16	126.77
Tr_{17}		60.65	62.10	65.99	88.48	91.99	100.10	116.42	117.40	124.30
Tr_{18}		60.48	63.08	67.12	88.44	93.14	96.50	117.47	117.86	126.24
Tr_{19}		60.78	64.25	63.80	89.57	93.00	96.29	117.29	113.63	119.63
Tr_{20}		60.43	63.71	61.04	92.24	95.03	92.83	114.58	119.35	126.22
Tr_{21}		59.22	63.19	61.79	86.98	94.89	94.09	114.03	125.96	125.92
Tr_{22}		63.04	63.33	65.27	89.41	92.52	95.95	114.23	123.75	128.40
Tr_{23}		61.75	63.58	67.37	90.63	90.97	100.49	118.56	116.39	127.91
Tr_{24}		60.55	59.16	64.63	88.78	97.33	94.61	116.08	120.35	120.23
Tr_{25}		60.18	62.73	62.66	88.76	94.40	92.10	116.58	118.79	121.31
Tr_{26}		59.70	63.94	63.29	85.84	95.42	91.54	111.91	119.14	115.80
Tr_{27}		60.68	63.12	66.96	88.95	91.27	100.69	116.77	122.47	131.91
Tr_{28}		61.47	65.31	65.04	88.80	96.93	95.36	116.32	139.11	119.12
Tr_{29}		59.90	63.70	67.79	88.78	91.80	96.68	116.69	124.43	128.06
Tr_{30}		60.89	62.30	55.52	89.08	93.46	81.91	116.69	113.32	103.81*
Tr_{31}		60.16	63.83	67.81	89.18	95.13	95.03	120.95	121.77	117.33
Tr_{32}		59.53	63.47	62.54	87.98	95.16	93.31	114.55	119.14	122.10
Tr_{33}		60.18	61.25	62.54	88.87	90.13	93.31	116.58	117.69	116.62
Tr_{34}		60.18	65.07	64.20	89.27	95.03	93.74	118.57	120.46	118.49
Tr_{35}		60.74	64.02	64.75	88.06	91.81	95.98	116.14	117.80	123.67
Tr_{36}		58.50	66.34	64.60	89.14	93.03	94.05	116.81	120.66	120.91
F test		**	**	**	**	**	**	**	**	**
LSD	0.05	4.67	5.26	9.98	5.92	6.22	15.14	6.74	27.56	18.35
	0.01	6.12	6.89	13.08	7.76	8.16	19.85	8.83	36.15	24.06

** = P< 0.01

Table 6: Continued

	Weight of surviving larvae Fifth instar					
	10			11		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	379.05	363.98	359.48	451.73	435.45	468.81
S_1	186.20	193.33	200.74	262.33	273.75	290.76
S_2	191.49	186.07	208.24	273.29	273.05	298.53
S_3	187.96	190.64	202.42	276.81	273.05	287.49
S_4	187.61	196.66	209.61	266.27	290.18	251.35
S_5	188.48	198.87	216.54	272.79	284.55	296.44
S_6	190.70	200.72	203.94	272.23	279.46	298.89
S_7	184.59	203.01	200.41	264.09	279.16	308.40
S_8	188.98	204.14	213.96	281.98	284.77	323.03
Tr_9	185.52	204.74	211.48	270.41	284.62	307.49
Tr_{10}	183.10	212.26	193.61	265.11	284.34	275.88
Tr_{11}	188.22	206.86	198.84	282.57	295.97	290.30
Tr_{12}	180.40	194.07	195.33	276.94	285.62	279.79
Tr_{13}	188.64	203.24	202.93	273.64	284.93	295.41
Tr_{14}	187.70	201.04	210.87	277.21	284.72	295.37
Tr_{15}	183.43	198.10	203.52	276.61	279.62	346.72
Tr_{16}	196.89	211.15	220.24	267.45	297.93	297.89
Tr_{17}	186.66	197.15	211.55	270.33	278.79	292.18
Tr_{18}	186.87	201.32	209.05	261.74	285.07	302.41
Tr_{19}	189.51	201.50	202.83	272.72	280.30	283.92
Tr_{20}	186.52	201.43	209.33	265.37	284.98	297.83
Tr_{21}	183.12	198.30	213.46	265.47	281.94	303.95
Tr_{22}	191.82	197.37	209.46	269.94	269.28	292.65
Tr_{23}	189.97	194.63	204.48	278.17	276.48	295.34
Tr_{24}	186.62	209.80	200.22	270.79	290.32	282.82
Tr_{25}	186.44	201.78	204.83	270.54	285.97	287.41
Tr_{26}	181.30	201.57	200.29	266.18	285.97	284.71
Tr_{27}	186.71	194.09	218.44	274.07	291.80	298.37
Tr_{28}	187.14	210.07	289.15	266.99	292.61	294.28
Tr_{29}	186.90	193.80	216.56	271.42	284.93	301.29
Tr_{30}	189.25	196.71	279.20	277.46	280.55	256.63
Tr_{31}	189.28	201.75	203.35	276.52	285.25	302.91
Tr_{32}	167.72	199.25	206.54	265.29	288.95	302.03
Tr_{33}	193.83	194.03	191.50	270.02	269.44	281.29
Tr_{34}	191.86	197.08	192.92	259.50	275.05	292.37
Tr_{35}	188.85	200.95	204.39	273.33	285.23	320.70
Tr_{36}	167.48	205.65	205.90	271.45	285.80	293.63
F test	**	**	**	**	**	**
LSD 0.05	21.03	17.23	32.07	29.90	18.04	60.77
0.01	27.58	22.60	42.04	39.21	23.66	79.68

** = P< 0.01

Table 6: Continued

	Weight of surviving larvae Sixth instar					
	12			13		
Microbial strains	Cry + endo	endo		Cry	Cry + endo	e n d o
Cry						
Cont.	528.56	517.75	508.67	585.77	522.71	576.33
S_1	292.85	302.41	292.50	330.46	333.50	326.00
S_2	305.61	312.26	292.50	344.75	344.83	331.00
S_3	304.98	299.95	292.50	345.33	337.53	324.67
S_4	285.00	306.90	297.67	338.49	338.83	330.00
S_5	303.01	312.49	292.50	343.77	345.16	332.50
S_6	303.05	307.05	292.50	341.59	353.00	325.17
S_7	295.78	306.58	292.50	330.46	338.83	330.50
S_8	304.50	312.76	318.67	345.29	350.50	330.00
Tr_9	302.13	317.98	297.50	334.68	346.20	313.33
Tr_{10}	297.25	312.96	298.83	328.51	351.99	329.50
Tr_{11}	296.67	325.90	309.33	335.00	354.27	318.83
Tr_{12}	298.74	314.70	315.00	335.00	353.05	319.33
Tr_{13}	304.49	313.03	314.17	344.25	340.16	332.33
Tr_{14}	301.74	313.30	288.83	289.48	340.37	321.33
Tr_{15}	308.64	307.57	288.00	340.00	338.70	325.50
Tr_{16}	285.94	328.23	293.33	328.46	346.83	325.67
Tr_{17}	299.18	307.28	299.00	335.28	333.50	326.83
Tr_{18}	304.82	307.67	293.33	326.42	345.04	319.33
Tr_{19}	303.32	312.78	276.33	337.43	341.04	324.67
Tr_{20}	289.24	312.94	287.33	333.92	354.75	331.50
Tr_{21}	303.86	315.27	330.33	343.41	346.95	349.00
Tr_{22}	288.46	315.25	308.50	329.99	346.38	349.00
Tr_{23}	310.16	307.79	292.50	358.83	344.25	331.00
Tr_{24}	302.53	819.65	304.17	332.08	352.83	325.67
Tr_{25}	300.02	312.22	292.50	340.00	350.50	337.83
Tr_{26}	284.44	312.43	286.67	327.00	350.50	331.00
Tr_{27}	310.41	294.95	320.17	339.97	343.87	337.33
Tr_{28}	301.20	320.20	302.67	340.00	355.33	329.00
Tr_{29}	301.02	301.48	304.33	338.75	332.16	330.5
Tr_{30}	309.96	306.90	281.50	351.36	334.83	325.33
Tr_{31}	308.07	313.07	292.50	357.14	350.33	335.33
Tr_{32}	295.79	312.47	288.50	333.03	350.33	324.67
Tr_{33}	301.33	300.74	311.50	342.89	334.33	325.83
Tr_{34}	309.37	306.55	297.64	351.18	345.08	324.67
Tr_{35}	302.69	311.47	297.50	344.22	350.83	318.33
Tr_{36}	307.83	325.56	308.50	340.70	358.86	324.67
F test	**	**	**	**	**	**
LSD 0.05	29.91	19.44	32.20	41.90	30.79	26.02
0.01	39.22	25.49	42.22	54.94	40.36	34.12

** = P< 0.01

Table 7: Embryo mortality percent among F_1 generation due to lepidopterous eggs treated with different bacterial preparations derived from *Bt* strains and their transconjugants

	Bacterial preparations First instar		
Microbial strains	Cry + endo	Endo	Cry
Cont.	0.00	0.00	0.00
S_1	18.75	22.29	25.00
S_2	25.20	25.83	24.79
S_3	21.87	16.25	19.79
S_4	28.75	15.21	19.38
S_5	31.25	12.29	15.83
S_6	26.87	12.29	21.46
S_7	70.50	19.58	26.25
S_8	36.45	22.50	30.21
Tr_9	32.29	21.50	17.50
Tr_{10}	18.75	13.33	21.67
Tr_{11}	17.08	25.42	13.96
Tr_{12}	20.83	30.21	19.58
Tr_{13}	14.79	33.54	28.13
Tr_{14}	14.16	33.00	35.42
Tr_{15}	25.00	29.38	28.96
Tr_{16}	26.88	23.75	27.79
Tr_{17}	37.50	18.54	24.79
Tr_{18}	25.00	23.96	28.13
Tr_{19}	45.00	15.00	27.50
Tr_{20}	42.29	23.33	29.38
Tr_{21}	17.71	31.04	30.42
Tr_{22}	32.33	40.83	41.46
Tr_{23}	25.00	25.83	39.38
Tr_{24}	14.79	25.21	26.04
Tr_{25}	11.25	13.33	20.42
Tr_{26}	8.33	12.71	14.58
Tr_{27}	21.66	32.50	17.29
Tr_{28}	25.83	27.71	13.75
Tr_{29}	19.58	18.13	15.29
Tr_{30}	8.75	17.71	20.00
Tr_{31}	28.13	17.91	27.92
Tr_{32}	28.13	15.00	23.96
Tr_{33}	35.42	12.50	24.17
Tr_{34}	27.08	36.46	23.75
Tr_{35}	40.42	26.25	33.33
Tr_{36}	13.13	17.29	28.75
F test	**	**	**
LSD 0.05	6.62	6.28	6.63
0.01	8.41	8.24	8.69

** = P< 0.01

Table 8: Embryo mortality percent among F_2 generation lepidopterous eggs treated with different bacterial preparations derived from *Bt* strains and their transconjugants

	Bacterial preparations First instar		
Microbial strains	Cry + endo	Endo	Cry
Cont.	0.00	0.00	0.00
S_1	15.41	11.87	17.70
S_2	5.83	10.62	22.08
S_3	9.58	4.37	23.95
S_4	8.33	15.62	19.58
S_5	9.58	17.29	8.75
S_6	18.12	14.29	26.04
S_7	13.75	14.37	9.37
S_8	19.58	21.25	10.41
Tr_9	6.25	27.70	7.50
Tr_{10}	14.16	19.37	2.08
Tr_{11}	6.87	22.70	10.20
Tr_{12}	10.41	9.79	8.12
Tr_{13}	24.58	10.41	26.45
Tr_{14}	16.87	6.66	23.75
Tr_{15}	30.62	7.91	7.70
Tr_{16}	29.16	16.45	7.70
Tr_{17}	23.12	13.54	2.91
Tr_{18}	30.83	11.66	5.41
Tr_{19}	23.95	9.16	16.45
Tr_{20}	16.66	24.16	13.75
Tr_{21}	13.75	15.20	21.25
Tr_{22}	9.79	23.33	16.87
Tr_{23}	11.25	9.79	12.08
Tr_{24}	10.51	8.33	11.87
Tr_{25}	10.62	10.20	10.83
Tr_{26}	17.70	21.87	8.95
Tr_{27}	17.50	28.75	4.58
Tr_{28}	10.00	12.50	16.25
Tr_{29}	13.54	4.16	15.62
Tr_{30}	18.37	13.12	19.79
Tr_{31}	1.67	23.33	29.58
Tr_{32}	12.50	28.75	29.79
Tr_{33}	5.20	22.08	15.20
Tr_{34}	11.04	28.75	6.25
Tr_{35}	10.83	23.08	3.12
Tr_{36}	18.33	13.79	6.04
F test	**	**	**
LSD 0.05	6.31	6.08	6.08
0.01	8.28	7.98	7.97

** = P< 0.01

Table 9: Embryo mortality percent among F_3 generation due to lepidopterous eggs treated with different bacterial preparations derived from *Bt* strains and their transconjugants

	Bacterial preparations First instar		
Microbial strains	Cry + endo	Endo	Cry
Cont.	0.00	0.00	0.00
S_1	9.16	11.66	9.58
S_2	15.58	13.66	17.08
S_3	15.83	11.45	15.83
S_4	14.37	12.08	16.45
S_5	15.83	8.95	15.20
S_6	10.00	11.45	10.62
S_7	12.91	11.87	7.50
S_8	16.87	15.41	21.25
Tr_9	9.16	11.25	9.16
Tr_{10}	12.70	11.45	14.79
Tr_{11}	16.45	13.95	13.33
Tr_{12}	19.37*	11.87	8.12
Tr_{13}	8.75	7.70	11.25
Tr_{14}	11.25	6.87	11.66
Tr_{15}	13.12	13.75	15.83
Tr_{16}	12.29	8.33	16.04
Tr_{17}	7.08	11.87	6.66
Tr_{18}	12.91	10.62	12.91
Tr_{19}	12.29	12.29	15.83
Tr_{20}	15.41	16.04	13.83
Tr_{21}	15.83	20.20	16.25
Tr_{22}	15.20	23.75	15.20
Tr_{23}	12.66	15.83	16.25
Tr_{24}	12.91	20.62	14.58
Tr_{25}	10.16	12.91	13.12
Tr_{26}	11.25	13.54	15.41
Tr_{27}	11.87	14.58	16.04
Tr_{28}	12.50	12.70	15.62
Tr_{29}	14.37	7.91	11.87
Tr_{30}	12.29	12.29	12.08
Tr_{31}	14.37	20.83	18.33
Tr_{32}	7.91	7.29	7.91
Tr_{33}	10.62	10.00	9.58
Tr_{34}	8.54	9.37	11.66
Tr_{35}	14.37	10.20	15.62
Tr_{36}	4.37	7.50	9.58
F test	**	**	**
LSD 0.05	6.62	5.88	6.76
0.01	8.68	7.72	8.86

** = P< 0.01

toumanoffi (3S14, HD201) were toxic for larvae of *L. cuprina*, but none of three serovar *Kurstaki* strains tested were toxic. In addition, Levinson *et al.* (1990) attributed the toxicity for fly larvae to the production of β-endotoxin types 1 and 2 and found no evidence for β-endotoxin in the non-toxic strains. With the exception of non significant mortalities in some of transconjugants, the toxicity of these strains and their transconjugants is probably due to the production of β-exotoxin.

The same trend of mortalities was found in F_2 generation (Table 4). In the tests against lepidopterous larvae in F_2, a wide spectrum of mortalities was achieved by all three bacterial preparations. In the 5th instar endospores from Tr_{28} revealed a higher mortalities against lepidopterous larvae over their mid-parents. Endospores in fifth and sixth instars appeared a significant effect in mortalities than other bacterial preparations. The data raise the intriguing possibility that physical or physiological changes occur in lepidopterous larvae over 9 days old feeding on leaves sprayed with bacterial preparations resulting a significant effect of endospores in mortalities, then it is possible that, when host larvae are over 9 days old, the *B. thuringiensis* endospores becomes relatively more important, the crystal and (or) crystals + endospores becomes relatively less important compared with the toxic action of *Bt* endospores. In any case, the data do suggest the possibility the mode of action of different bacterial preparations is different among the old of larvae. Endospores from Tr_{28} caused a higher percent mortality in 5 th instar larvae of *S. littoralis* than did cry or cry + end (Table 4). Possibly, the increased toxicity of transconjugant (Tr_{28}) whole cultures could be related either with a higher production of endospores than other strains or with a higher whole growth. It can be concluded that mating between different *Bt* serovars can not only produce asporogenous strains of *B. thuringiensis* but can also improve the toxicity of the crystal. These transconjugants clones could eventually prove useful in complementing the effectiveness of the parent strains as biological control agents. The results also point up the need for better standardization of *Bacillus* preparations. At present of necessity, commercial materials are formulated on the basis of spore count. The mortality, developmental stages, reproductive potential and longevity of *S. littoralis* were significantly affected by bioinsecticide. The efficient strains of *Bt* are very important to overcome the losses in plant due to storage pests include the large quantity consumed by the insects, loss in seed viability, contamination of seeds and loss in quality due to biochemical changes induced by their activities. The present results are in agreement with Faruki and Khan

Table 10: Relative reduction rate in the weight of surviving larvae affected by bacterial preparations derived from *Bt* strains and their transconjugants in F_1 generation

		Reduction ratio in the weight of surviving larvae								
		First instar			Second instar					
		1			2			3		
Microbial strains		Cry + endo	Endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1		0.84	0.67	0.91	0.88	0.97	0.89	0.87	0.88	0.99
S_2		0.78	0.69	0.90	0.86	0.98	0.85	0.92	0.94	0.96
S_3		0.79	0.62	0.83	0.90	0.98	0.90	0.90	0.91	1.00
S_4		0.77	0.68	0.83	0.93	0.97	0.88	0.92	0.89	0.99
S_5		0.73	0.68	0.84	0.88	0.98	0.91	0.92	0.86	0.99
S_6		0.80	0.65	0.85	0.87	0.98	0.92	0.91	0.95	0.98
S_7		0.83	0.72	0.90	0.85	0.98	0.85	0.91	0.91	0.99
S_8		0.71	0.68	0.79	0.89	0.98	0.80	0.92	0.92	0.99
Tr_9		0.65	0.69	0.81	0.89	0.95	0.70	0.95	0.93	0.96
Tr_{10}		0.74	0.67	0.89	0.87	0.97	0.90	0.92	0.93	0.98
Tr_{11}		0.81	0.73	0.89	0.85	0.96	0.91	0.90	0.94	1.00
Tr_{12}		0.83	0.77	0.83	0.86	0.95	0.87	0.95	0.95	0.98
Tr_{13}		0.78	0.73	0.89	0.80	0.98	0.92	0.93	0.93	0.99
Tr_{14}		0.74	0.77	0.82	0.84	0.97	0.93	0.93	0.94	0.98
Tr_{15}		0.77	0.74	0.96	0.87	0.96	0.92	0.91	0.93	0.98
Tr_{16}		0.73	0.69	0.95	0.85	0.97	0.88	0.89	0.91	0.98
Tr_{17}		0.67	0.64	0.91	0.83	0.97	0.86	0.95	0.91	1.00
Tr_{18}		0.73	0.66	0.95	0.81	0.97	0.90	0.86	0.98	0.97
Tr_{19}		0.49	0.64	0.94	0.85	0.98	0.90	0.89	0.91	0.99
Tr_{20}		0.62	0.73	0.97	0.86	0.98	0.89	0.92	0.98	0.98
Tr_{21}		0.79	0.80	0.88	0.84	0.98	0.90	0.90	0.86	0.99
Tr_{22}		0.67	0.57	0.78	0.89	0.98	0.89	0.93	0.89	0.99
Tr_{23}		0.67	0.71	0.89	0.83	0.97	0.82	0.90	0.96	0.99
Tr_{24}		0.75	0.68	0.87	0.85	0.98	0.85	0.95	0.98	0.98
Tr_{25}		0.79	0.66	0.84	0.83	0.98	0.85	0.93	0.95	0.98
Tr_{26}		0.84	0.65	0.88	0.81	0.97	0.84	0.88	0.93	0.99
Tr_{27}		0.73	0.75	0.96	0.88	0.98	0.84	0.93	0.94	0.99
Tr_{28}		0.69	0.74	0.91	0.83	0.97	0.85	0.92	0.92	0.99
Tr_{29}		0.79	0.70	0.90	0.88	0.95	0.86	0.93	0.94	0.98
Tr_{30}		0.84	0.67	0.84	0.88	0.97	0.90	0.93	0.98	0.99
Tr_{31}		0.77	0.63	0.93	0.85	0.97	0.87	0.89	0.92	0.97
Tr_{32}		0.76	0.65	0.85	0.88	0.98	0.90	0.90	0.90	1.00
Tr_{33}		0.58	0.65	0.89	0.85	0.97	0.87	0.92	0.91	0.99
Tr_{34}		0.75	0.71	0.92	0.91	0.96	0.92	0.92	0.97	0.98
Tr_{35}		0.56	0.72	0.87	0.88	0.95	0.86	0.92	0.97	0.98
Tr_{36}		0.77	0.63	0.87	0.86	0.97	0.85	0.93	0.95	0.98
F test		**	**	**	**	NS	**	NS	NS	**
LSD	0.05	0.11	0.09	0.10	0.07		0.04			0.01
	0.01	0.15	0.11	0.13	0.09		0.05			0.02

NS = Non significant ** = P< 0.01

Table 10: Continued

	Reduction ratio in weight of surviving larvae Third instar								
	4			5			6		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.56	0.67	0.53	0.41	0.54	0.44	0.38	0.49	0.43
S_2	0.57	0.64	0.53	0.37	0.54	0.44	0.39	0.48	0.43
S_3	0.57	0.65	0.54	0.42	0.55	0.45	0.38	0.47	0.42
S_4	0.57	0.67	0.53	0.43	0.52	0.44	0.41	0.46	0.45
S_5	0.57	0.66	0.53	0.43	0.57	0.42	0.38	0.47	0.43
S_6	0.57	0.64	0.54	0.42	0.60	0.42	0.40	0.47	0.47
S_7	0.57	0.65	0.53	0.42	0.61	0.46	0.37	0.48	0.43
S_8	0.59	0.64	0.55	0.42	0.59	0.46	0.40	0.46	0.45
Tr_9	0.57	0.69	0.57	0.42	0.60	0.45	0.39	0.47	0.45
Tr_{10}	0.57	0.65	0.56	0.43	0.63	0.47	0.38	0.48	0.45
Tr_{11}	0.57	0.66	0.53	0.42	0.60	0.45	0.38	0.49	0.43
Tr_{12}	0.56	0.67	0.59	0.41	0.65	0.47	0.39	0.48	0.45
Tr_{13}	0.57	0.64	0.55	0.43	0.60	0.45	0.39	0.46	0.45
Tr_{14}	0.57	0.63	0.56	0.41	0.60	0.44	0.40	0.48	0.44
Tr_{15}	0.57	0.62	0.54	0.43	0.55	0.44	0.39	0.48	0.44
Tr_{16}	0.57	0.68	0.56	0.42	0.60	0.45	0.39	0.46	0.45
Tr_{17}	0.57	0.67	0.55	0.43	0.59	0.46	0.39	0.50	0.41
Tr_{18}	0.59	0.62	0.55	0.41	0.62	0.46	0.40	0.50	0.41
Tr_{19}	0.57	0.66	0.55	0.41	0.62	0.44	0.39	0.46	0.41
Tr_{20}	0.59	0.63	0.57	0.43	0.61	0.42	0.36	0.47	0.38
Tr_{21}	0.57	0.64	0.53	0.41	0.62	0.44	0.40	0.46	0.44
Tr_{22}	0.57	0.69	0.53	0.41	0.57	0.44	0.38	0.44	0.43
Tr_{23}	0.57	0.66	0.51	0.47	0.60	0.44	0.42	0.46	0.43
Tr_{24}	0.57	0.63	0.56	0.44	0.60	0.45	0.41	0.47	0.43
Tr_{25}	0.57	0.63	0.52	0.45	0.61	0.45	0.38	0.47	0.41
Tr_{26}	0.55	0.63	0.53	0.40	0.57	0.45	0.37	0.51	0.43
Tr_{27}	0.57	0.64	0.53	0.42	0.60	0.44	0.39	0.45	0.44
Tr_{28}	0.61	0.63	0.56	0.42	0.61	0.54	0.39	0.47	0.43
Tr_{29}	0.57	0.66	0.53	0.42	0.60	0.45	0.41	0.49	0.48
Tr_{30}	0.57	0.65	0.55	0.41	0.57	0.45	0.38	0.48	0.50
Tr_{31}	0.57	0.65	0.55	0.42	0.53	0.45	0.39	0.48	0.43
Tr_{32}	0.57	0.64	0.55	0.41	0.59	0.46	0.39	0.50	0.45
Tr_{33}	0.57	0.65	0.55	0.41	0.61	0.44	0.44	0.49	0.41
Tr_{34}	0.57	0.68	0.55	0.42	0.60	0.46	0.42	0.48	0.44
Tr_{35}	0.57	0.67	0.55	0.41	0.58	0.45	0.38	0.47	0.43
Tr_{36}	0.58	0.66	0.66	0.42	0.60	0.45	0.40	0.46	0.44
F test	**	**	**	**	**	**	**	**	**
LSD 0.05	0.04	0.09	0.09	0.04	0.09	0.09	0.04	0.07	0.10
0.01	0.05	0.11	0.11	0.05	0.12	0.12	0.05	0.09	0.13

** = $P < 0.01$

Table 10: Continued

		Reduction ratio in weight of surviving larvae Fourth instar								
		7			8			9		
Microbial strains		Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1		0.34	0.44	0.38	0.31	0.37	0.38	0.31	0.39	0.32
S_2		0.31	0.44	0.37	0.33	0.39	0.36	0.35	0.41	0.32
S_3		0.31	0.45	0.35	0.31	0.41	0.36	0.32	0.41	0.33
S_4		0.32	0.45	0.39	0.31	0.38	0.40	0.33	0.38	0.36
S_5		0.31	0.41	0.38	0.33	0.40	0.37	0.32	0.38	0.35
S_6		0.31	0.44	0.39	0.30	0.37	0.37	0.31	0.34	0.36
S_7		0.31	0.44	0.38	0.30	0.39	0.38	0.32	0.45	0.36
S_8		0.30	0.44	0.38	0.24	0.41	0.38	0.26	0.40	0.35
Tr_9		0.31	0.44	0.38	0.31	0.39	0.38	0.32	0.38	0.35
Tr_{10}		0.33	0.44	0.39	0.31	0.39	0.38	0.30	0.37	0.37
Tr_{11}		0.32	0.45	0.39	0.81	0.41	0.38	0.31	0.41	0.35
Tr_{12}		0.31	0.44	0.36	0.32	0.37	0.40	0.31	0.41	0.33
Tr_{13}		0.31	0.44	0.38	0.31	0.39	0.37	0.31	0.37	0.34
Tr_{14}		0.31	0.44	0.38	0.35	0.37	0.38	0.33	0.36	0.33
Tr_{15}		0.34	0.44	0.42	0.31	0.36	0.37	0.31	0.36	0.33
Tr_{16}		0.31	0.46	0.38	0.31	0.37	0.38	0.34	0.41	0.34
Tr_{17}		0.30	0.45	0.39	0.32	0.41	0.39	0.31	0.39	0.36
Tr_{18}		0.36	0.44	0.41	0.36	0.39	0.40	0.31	0.37	0.34
Tr_{19}		0.32	0.44	0.39	0.32	0.43	0.39	0.34	0.38	0.36
Tr_{20}		0.32	0.48	0.36	0.27	0.41	0.40	0.32	0.36	0.39
Tr_{21}		0.29	0.45	0.39	0.19	0.45	0.40	0.20	0.48	0.27
Tr_{22}		0.27	0.43	0.38	0.34	0.39	0.37	0.26	0.34	0.37
Tr_{23}		0.31	0.42	0.37	0.31	0.38	0.37	0.32	0.36	0.35
Tr_{24}		0.31	0.44	0.35	0.31	0.39	0.42	0.33	0.38	0.37
Tr_{25}		0.31	0.44	0.42	0.31	0.41	0.43	0.31	0.36	0.44
Tr_{26}		0.24	0.46	0.37	0.26	0.45	0.42	0.26	0.37	0.34
Tr_{27}		0.31	0.43	0.38	0.31	0.43	0.39	0.35	0.38	0.35
Tr_{28}		0.30	0.42	0.38	0.37	0.41	0.45	0.32	0.35	0.38
Tr_{29}		0.31	0.46	0.43	0.32	0.40	0.49	0.30	0.41	0.45
Tr_{30}		0.31	0.43	0.43	0.31	0.39	0.42	0.32	0.38	0.39
Tr_{31}		0.32	0.45	0.40	0.31	0.38	0.44	0.31	0.41	0.37
Tr_{32}		0.31	0.45	0.39	0.26	0.38	0.43	0.31	0.39	0.41
Tr_{33}		0.27	0.45	0.38	0.32	0.36	0.38	0.31	0.39	0.35
Tr_{34}		0.31	0.44	0.39	0.32	0.40	0.38	0.25	0.38	0.38
Tr_{35}		0.31	0.43	0.36	0.32	0.39	0.39	0.31	0.38	0.35
Tr_{36}		0.31	0.42	0.40	0.38	0.40	0.38	0.32	0.37	0.36
F test		**	**	**	**	**	**	**	**	**
LSD	0.05	0.05	0.06	0.10	0.23	0.12	0.13	0.06	0.10	0.14
	0.01	0.07	0.08	0.13	0.30	0.16	0.17	0.08	0.13	0.18

** = P< 0.01

Table 10: Continued

	Reduction ratio in the weight of surviving larvae Fifth instar					
	10			11		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.33	0.42	0.35	0.40	0.52	0.55
S_2	0.31	0.43	0.37	0.43	0.53	0.52
S_3	0.29	0.48	0.37	0.41	0.61	0.53
S_4	0.37	0.41	0.44	0.42	0.57	0.62
S_5	0.31	0.44	0.38	0.40	0.52	0.53
S_6	0.30	0.41	0.42	0.40	0.49	0.58
S_7	0.31	0.43	0.43	0.37	0.56	0.64
S_8	0.36	0.46	0.43	0.33	0.55	0.48
Tr_9	0.34	0.40	0.38	0.40	0.50	0.54
Tr_{10}	0.34	0.44	0.43	0.40	0.51	0.61
Tr_{11}	0.29	0.42	0.39	0.40	0.51	0.56
Tr_{12}	0.38	0.45	0.40	0.43	0.52	0.58
Tr_{13}	0.38	0.41	0.38	0.42	0.51	0.55
Tr_{14}	0.41	0.41	0.38	0.44	0.51	0.55
Tr_{15}	0.36	0.43	0.37	0.42	0.58	0.53
Tr_{16}	0.33	0.44	0.35	0.42	0.57	0.51
Tr_{17}	0.35	0.43	0.39	0.41	0.54	0.56
Tr_{18}	0.31	0.41	0.41	0.39	0.51	0.57
Tr_{19}	0.35	0.44	0.41	0.42	0.53	0.56
Tr_{20}	0.32	0.42	0.39	0.38	0.52	0.56
Tr_{21}	0.21	0.60	0.30	0.26	0.71	0.43
Tr_{22}	0.26	0.39	0.41	0.33	0.45	0.58
Tr_{23}	0.31	0.38	0.39	0.40	0.47	0.56
Tr_{24}	0.32	0.42	0.40	0.41	0.50	0.51
Tr_{25}	0.33	0.41	0.57	0.43	0.55	0.66
Tr_{26}	0.26	0.43	0.42	0.33	0.56	0.60
Tr_{27}	0.31	0.42	0.38	0.40	0.53	0.55
Tr_{28}	0.31	0.41	0.47	0.38	0.50	0.63
Tr_{29}	0.31	0.47	0.51	0.39	0.59	0.68
Tr_{30}	0.32	0.41	0.41	0.40	0.52	0.60
Tr_{31}	0.30	0.42	0.40	0.39	0.53	0.60
Tr_{32}	0.31	0.46	0.40	0.40	0.54	0.65
Tr_{33}	0.26	0.40	0.39	0.33	0.53	0.56
Tr_{34}	0.31	0.42	0.41	0.39	0.53	0.63
Tr_{35}	0.31	0.41	0.39	0.39	0.51	0.56
Tr_{36}	0.31	0.43	0.39	0.39	0.56	0.56
F test	**	**	**	**	**	NS
LSD 0.05	0.08	0.11	0.15	0.10	0.15	
0.01	0.10	0.15	0.19	0.12	0.20	

** = P< 0.01

Table 10: Continued

	Reduction ratio in the weight of surviving larvae Sixth instar					
	12			13		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.48	0.50	0.45	0.49	0.54	0.53
S_2	0.47	0.50	0.42	0.53	0.55	0.50
S_3	0.46	0.57	0.43	0.51	0.46	0.54
S_4	0.45	0.49	0.53	0.48	0.53	0.60
S_5	0.44	0.49	0.44	0.46	0.53	0.52
S_6	0.46	0.57	0.49	0.49	0.53	0.52
S_7	0.43	0.52	0.52	0.47	0.57	0.61
S_8	0.36	0.55	0.38	0.39	0.58	0.48
Tr_9	0.46	0.49	0.44	0.51	0.52	0.53
Tr_{10}	0.43	0.49	0.50	0.45	0.51	0.60
Tr_{11}	0.42	0.49	0.46	0.47	0.53	0.55
Tr_{12}	0.47	0.49	0.45	0.49	0.54	0.50
Tr_{13}	0.45	0.48	0.46	0.48	0.52	0.56
Tr_{14}	0.49	0.49	0.46	0.53	0.53	0.53
Tr_{15}	0.44	0.55	0.55	0.46	0.64	0.51
Tr_{16}	0.50	0.52	0.59	0.51	0.56	0.59
Tr_{17}	0.47	0.51	0.46	0.49	0.51	0.52
Tr_{18}	0.43	0.48	0.47	0.45	0.52	0.56
Tr_{19}	0.45	0.51	0.48	0.51	0.56	0.54
Tr_{20}	0.46	0.50	0.45	0.46	0.53	0.54
Tr_{21}	0.36	0.68	0.37	0.34	0.72	0.44
Tr_{22}	0.30	0.41	0.49	0.40	0.44	0.56
Tr_{23}	0.46	0.44	0.46	0.46	0.49	0.57
Tr_{24}	0.46	0.49	0.51	0.48	0.53	0.57
Tr_{25}	0.49	0.52	0.57	0.55	0.63	0.62
Tr_{26}	0.37	0.53	0.49	0.41	0.46	0.60
Tr_{27}	0.44	0.50	0.45	0.45	0.53	0.53
Tr_{28}	0.43	0.48	0.57	0.45	0.51	0.61
Tr_{29}	0.44	0.57	0.59	0.45	0.60	0.68
Tr_{30}	0.46	0.48	0.52	0.48	0.53	0.58
Tr_{31}	0.46	0.53	0.50	0.49	0.55	0.58
Tr_{32}	0.43	0.54	0.45	0.46	0.58	0.55
Tr_{33}	0.36	0.50	0.46	0.41	0.54	0.53
Tr_{34}	0.43	0.50	0.54	0.47	0.51	0.55
Tr_{35}	0.44	0.48	0.46	0.50	0.52	0.55
Tr_{36}	0.44	0.51	0.42	0.44	0.55	0.54
F test	**	**	**	**	**	NS
LSD 0.05	0.09	0.15	0.19	0.12	0.16	
0.01	0.12	0.20	0.25	0.15	0.21	

** = P< 0.01

Table 11: Relative reduction rate in the weight of surviving larvae affected by bacterial preparations derived from *Bt* strains and their transconjugants in F_2 generation

	Reduction ratio in the weight of surviving larvae								
	First instar			Second instar					
	1			2			3		
Microbial strains	Cry + endo	Endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.71	0.90	0.80	0.95	0.94	0.94	1.00	1.00	0.95
S_2	0.89	0.94	0.78	0.93	0.97	0.91	1.00	1.00	0.93
S_3	0.89	0.97	0.78	0.97	0.91	0.93	1.00	1.00	0.98
S_4	0.81	0.83	0.83	0.95	0.91	0.90	0.99	1.00	0.93
S_5	0.82	0.83	0.92	0.95	0.97	0.91	1.00	1.00	0.93
S_6	0.73	0.85	0.83	0.95	0.93	0.92	1.00	1.00	0.93
S_7	0.75	0.85	0.93	0.95	0.96	0.89	0.98	1.00	0.94
S_8	0.74	0.81	0.90	0.93	0.96	0.89	1.00	1.00	0.92
Tr_9	0.87	0.85	0.93	0.95	0.96	0.86	0.95	1.00	0.97
Tr_{10}	0.77	0.75	0.99	0.93	0.93	0.90	0.99	1.00	0.90
Tr_{11}	0.94	0.83	0.94	0.98	0.94	0.96	1.00	1.00	0.95
Tr_{12}	0.77	0.90	0.97	0.98	0.97	0.90	0.96	1.00	0.94
Tr_{13}	0.77	0.87	0.84	0.93	0.97	0.87	0.95	1.00	0.95
Tr_{14}	0.72	0.93	0.77	0.97	0.96	0.92	0.97	1.00	0.88
Tr_{15}	0.70	0.91	0.95	0.97	0.93	0.89	0.98	1.00	0.86
Tr_{16}	0.88	0.79	0.96	0.97	0.96	0.87	0.99	1.00	0.93
Tr_{17}	0.78	0.84	1.00	0.97	0.97	0.91	0.99	1.00	0.91
Tr_{18}	0.80	0.90	0.94	0.98	0.96	0.94	0.99	1.00	0.93
Tr_{19}	0.81	0.90	0.91	0.93	0.97	0.87	0.99	1.00	0.87
Tr_{20}	0.72	0.90	0.87	0.93	0.96	0.89	1.00	1.00	0.83
Tr_{21}	0.70	0.88	0.77	0.95	0.96	0.89	0.98	1.00	0.90
Tr_{22}	0.79	0.84	0.75	0.95	0.94	0.92	0.98	1.00	0.92
Tr_{23}	0.77	0.95	0.86	0.95	0.96	0.94	0.97	1.00	0.91
Tr_{24}	0.81	0.91	0.85	0.95	0.96	0.97	0.99	1.00	0.93
Tr_{25}	0.83	0.91	0.92	0.97	0.94	0.92	0.99	1.00	0.93
Tr_{26}	0.73	0.85	0.91	0.95	0.96	0.96	0.98	1.00	0.91
Tr_{27}	0.81	0.87	0.96	0.95	0.94	0.93	1.00	1.00	0.93
Tr_{28}	0.84	0.89	0.85	0.98	0.91	0.90	0.99	1.00	0.92
Tr_{29}	0.76	0.93	0.83	0.97	0.96	0.91	0.99	1.00	0.94
Tr_{30}	0.72	0.86	0.76	0.93	0.96	0.91	0.99	1.00	0.90
Tr_{31}	0.92	0.79	0.82	0.97	0.96	0.94	0.99	1.00	0.94
Tr_{32}	0.77	0.87	0.80	0.95	0.96	0.92	0.99	1.00	0.93
Tr_{33}	0.92	0.82	0.84	0.95	0.94	0.90	0.99	1.00	0.93
Tr_{34}	0.76	0.87	0.84	0.97	0.96	0.97	1.00	1.00	0.95
Tr_{35}	0.82	0.89	0.99	0.93	0.96	0.90	0.95	1.00	0.93
Tr_{36}	0.76	0.82	1.00	0.95	0.94	0.90	1.00	1.00	0.90
F test	**	**	**	NS	NS	**	NS	NS	**
LSD 0.05	0.10	0.09	0.09			0.08			0.07
0.01	0.13	0.12	0.12			0.10			0.09

** = P<0.01 NS = Non significant *, ** = P< 0.05, P< 0.01, respectively

Table 11: Continued

		Reduction ratio in weight of surviving larvae Third instar								
		4			5			6		
Microbial strains		Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1		0.64	0.93	0.85	0.70	0.72	0.75	0.58	0.70	0.68
S_2		0.64	0.96	0.84	0.69	0.79	0.76	0.56	0.68	0.67
S_3		0.64	0.92	0.86	0.69	0.75	0.75	0.58	0.69	0.63
S_4		0.64	0.89	0.77	0.65	0.72	0.72	0.59	0.67	0.63
S_5		0.64	0.91	0.82	0.72	0.74	0.72	0.58	0.67	0.64
S_6		0.65	0.90	0.80	0.71	0.73	0.73	0.57	0.67	0.64
S_7		0.63	0.86	0.78	0.69	0.77	0.70	0.57	0.66	0.66
S_8		0.65	0.90	0.81	0.71	0.79	0.79	0.58	0.67	0.69
Tr_9		0.64	0.86	0.79	0.70	0.76	0.70	0.60	0.67	0.65
Tr_{10}		0.64	0.90	0.71	0.68	0.74	0.63	0.57	0.68	0.57
Tr_{11}		0.84	0.87	0.81	0.69	0.77	0.76	0.58	0.68	0.62
Tr_{12}		0.63	0.85	0.77	0.68	0.73	0.68	0.61	0.67	0.61
Tr_{13}		0.66	0.87	0.78	0.68	0.74	0.69	0.58	0.67	0.65
Tr_{14}		0.63	0.93	0.78	0.69	0.71	0.68	0.58	0.66	0.64
Tr_{15}		0.65	0.82	0.76	0.69	0.76	0.68	0.58	0.67	0.65
Tr_{16}		0.64	0.90	0.79	0.69	0.75	0.70	0.58	0.71	0.69
Tr_{17}		0.63	0.86	0.78	0.69	0.74	0.75	0.59	0.67	0.65
Tr_{18}		0.65	0.88	0.82	0.68	0.72	0.74	0.57	0.67	0.61
Tr_{19}		0.63	0.89	0.74	0.70	0.71	0.59	0.50	0.69	0.61
Tr_{20}		0.62	0.90	0.71	0.69	0.74	0.66	0.59	0.67	0.63
Tr_{21}		0.64	0.92	0.78	0.68	0.73	0.67	0.58	0.68	0.64
Tr_{22}		0.64	0.92	0.75	0.67	0.77	0.67	0.58	0.67	0.65
Tr_{23}		0.65	0.91	0.78	0.70	0.78	0.71	0.59	0.65	0.66
Tr_{24}		0.64	0.88	0.81	0.69	0.72	0.67	0.57	0.67	0.62
Tr_{25}		0.63	0.87	0.77	0.69	0.73	0.66	0.58	0.66	0.64
Tr_{26}		0.63	0.86	0.77	0.73	0.73	0.72	0.53	0.67	0.70
Tr_{27}		0.64	0.89	0.80	0.69	0.73	0.71	0.59	0.67	0.65
Tr_{28}		0.64	0.85	0.77	0.69	0.75	0.72	0.58	0.68	0.56
Tr_{29}		0.63	0.85	0.77	0.69	0.72	0.70	0.58	0.68	0.62
Tr_{30}		0.64	0.85	0.71	0.69	0.72	0.57	0.58	0.66	0.58
Tr_{31}		0.64	0.87	0.81	0.72	0.72	0.69	0.59	0.67	0.64
Tr_{32}		0.63	0.86	0.77	0.69	0.72	0.70	0.56	0.68	0.62
Tr_{33}		0.64	0.86	0.78	0.68	0.73	0.68	0.58	0.67	0.58
Tr_{34}		0.65	0.88	0.78	0.69	0.73	0.70	0.57	0.68	0.63
Tr_{35}		0.64	0.85	0.77	0.69	0.73	0.69	0.58	0.67	0.66
Tr_{36}		0.65	0.85	0.79	0.69	0.74	0.70	0.57	0.67	0.62
F test		**	**	*	**	**	**	**	**	**
LSD	0.05	0.04	0.06	0.09	0.03	0.07	0.10	0.04	0.03	0.08
	0.01	0.05	0.07	0.12	0.04	0.09	0.13	0.05	0.04	0.10

*, ** = P< 0.05, P< 0.01, respectively

Table 11: Continued

	Reduction ratio in weight of surviving larvae Fourth instar								
	7			8			9		
Microbial strains	Cry + endo	endo	Cry	Cry + endo	endo	Cry	Cry + endo	endo	Cry
Cont.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.49	0.52	0.61	0.45	0.47	0.53	0.42	0.43	0.49
S_2	0.49	0.54	0.60	0.46	0.51	0.54	0.43	0.44	0.48
S_3	0.51	0.52	0.60	0.49	0.48	0.54	0.43	0.43	0.50
S_4	0.52	0.54	0.57	0.49	0.50	0.50	0.42	0.45	0.48
S_5	0.51	0.53	0.61	0.51	0.51	0.55	0.44	0.45	0.50
S_6	0.50	0.54	0.58	0.46	0.50	0.51	0.43	0.45	0.48
S_7	0.49	0.53	0.58	0.45	0.50	0.53	0.42	0.45	0.50
S_8	0.49	0.54	0.58	0.46	0.49	0.53	0.44	0.44	0.54
Tr_9	0.50	0.55	0.59	0.45	0.51	0.51	0.43	0.45	0.49
Tr_{10}	0.49	0.54	0.55	0.45	0.52	0.48	0.42	0.44	0.48
Tr_{11}	0.50	0.57	0.56	0.48	0.54	0.50	0.42	0.46	0.47
Tr_{12}	0.48	0.54	0.56	0.46	0.52	0.49	0.43	0.45	0.46
Tr_{13}	0.50	0.54	0.56	0.46	0.51	0.50	0.42	0.46	0.49
Tr_{14}	0.50	0.50	0.57	0.46	0.51	0.48	0.42	0.47	0.49
Tr_{15}	0.50	0.54	0.57	0.46	0.52	0.52	0.43	0.44	0.47
Tr_{16}	0.50	0.57	0.59	0.46	0.54	0.50	0.43	0.47	0.49
Tr_{17}	0.50	0.53	0.54	0.46	0.50	0.50	0.43	0.44	0.48
Tr_{18}	0.50	0.54	0.56	0.45	0.51	0.52	0.43	0.44	0.49
Tr_{19}	0.50	0.55	0.52	0.44	0.51	0.49	0.43	0.43	0.49
Tr_{20}	0.50	0.55	0.53	0.48	0.52	0.48	0.42	0.45	0.49
Tr_{21}	0.49	0.54	0.53	0.45	0.52	0.51	0.44	0.47	0.49
Tr_{22}	0.49	0.54	0.56	0.46	0.50	0.48	0.42	0.47	0.50
Tr_{23}	0.51	0.54	0.58	0.47	0.49	0.52	0.42	0.44	0.50
Tr_{24}	0.50	0.51	0.56	0.46	0.53	0.49	0.43	0.46	0.47
Tr_{25}	0.49	0.54	0.54	0.46	0.51	0.47	0.43	0.45	0.47
Tr_{26}	0.54	0.55	0.54	0.45	0.52	0.51	0.41	0.45	0.45
Tr_{27}	0.50	0.54	0.58	0.46	0.50	0.56	0.43	0.46	0.51
Tr_{28}	0.51	0.56	0.55	0.46	0.53	0.50	0.43	0.52	0.46
Tr_{29}	0.49	0.56	0.58	0.46	0.50	0.48	0.43	0.47	0.50
Tr_{30}	0.50	0.53	0.47	0.46	0.51	0.43	0.43	0.43	0.40
Tr_{31}	0.49	0.55	0.63	0.46	0.51	0.50	0.45	0.46	0.46
Tr_{32}	0.49	0.54	0.54	0.45	0.52	0.47	0.44	0.45	0.48
Tr_{33}	0.49	0.53	0.53	0.46	0.49	0.49	0.44	0.44	0.47
Tr_{34}	0.49	0.56	0.55	0.46	0.52	0.50	0.44	0.45	0.48
Tr_{35}	0.50	0.55	0.54	0.46	0.50	0.50	0.43	0.42	0.50
Tr_{36}	0.48	0.57	0.54	0.45	0.51	0.49	0.43	0.46	0.47
F test	**	**	**	**	**	**	**	**	**
LSD 0.05	0.05	0.05	0.08	0.03	0.03	0.08	0.02	0.09	0.07
0.01	0.06	0.06	0.10	0.04	0.04	0.10	0.03	0.11	0.09

** = P< 0.01

Table 11: Continued

	Reduction ratio in the weight of surviving larvae Fifth instar					
	10			11		
Microbial strains Cry	Cry + endo		endo	Cry	Cry + endo	e n d o
Cont.	1.00	1.00	1.00	1.00	1.00	1.00
S_1	0.49	0.53	0.56	0.58	0.63	0.62
S_2	0.50	0.51	0.58	0.61	0.64	0.61
S_3	0.50	0.53	0.56	0.61	0.63	0.61
S_4	0.49	0.56	0.59	0.59	0.66	0.64
S_5	0.50	0.55	0.60	0.60	0.65	0.64
S_6	0.55	0.55	0.57	0.60	0.64	0.64
S_7	0.49	0.56	0.56	0.59	0.64	0.66
S_8	0.50	0.56	0.60	0.63	0.65	0.69
Tr_9	0.49	0.56	0.59	0.65	0.65	0.66
Tr_{10}	0.48	0.58	0.54	0.59	0.65	0.59
Tr_{11}	0.50	0.56	0.56	0.63	0.64	0.66
Tr_{12}	0.48	0.53	0.55	0.66	0.65	0.60
Tr_{13}	0.50	0.56	0.57	0.61	0.65	0.63
Tr_{14}	0.50	0.55	0.59	0.61	0.65	0.63
Tr_{15}	0.48	0.55	0.57	0.61	0.64	0.63
Tr_{16}	0.52	0.58	0.62	0.59	0.68	0.60
Tr_{17}	0.49	0.54	0.59	0.60	0.64	0.63
Tr_{18}	0.46	0.56	0.58	0.58	0.64	0.65
Tr_{19}	0.50	0.56	0.57	0.61	0.63	0.61
Tr_{20}	0.49	0.56	0.58	0.59	0.64	0.62
Tr_{21}	0.48	0.55	0.59	0.58	0.65	0.65
Tr_{22}	0.51	0.54	0.59	0.60	0.62	0.63
Tr_{23}	0.49	0.54	0.57	0.62	0.64	0.64
Tr_{24}	0.49	0.58	0.56	0.60	0.66	0.60
Tr_{25}	0.49	0.56	0.57	0.60	0.66	0.61
Tr_{26}	0.48	0.56	0.56	0.59	0.66	0.61
Tr_{27}	0.49	0.53	0.61	0.61	0.67	0.64
Tr_{28}	0.49	0.58	0.51	0.59	0.67	0.63
Tr_{29}	0.49	0.53	0.60	0.60	0.65	0.69
Tr_{30}	0.50	0.54	0.61	0.58	0.64	0.55
Tr_{31}	0.50	0.56	0.57	0.61	0.65	0.65
Tr_{32}	0.47	0.55	0.57	0.58	0.65	0.65
Tr_{33}	0.51	0.53	0.53	0.59	0.62	0.60
Tr_{34}	0.49	0.54	0.54	0.58	0.63	0.63
Tr_{35}	0.50	0.55	0.57	0.62	0.65	0.61
Tr_{36}	0.49	0.57	0.58	0.61	0.65	0.63
F test	**	**	**	**	**	**
LSD 0.05	0.06	0.05	0.09	0.07	0.04	0.10
0.01	0.07	0.06	0.11	0.10	0.05	0.13

** = $P < 0.01$

Table 11: Continued

Microbial strains		Reduction ratio in the weight of surviving larvae Sixth instar 12 Cry + endo	endo	Cry	13 Cry + endo	endo	Cry
Cont.		1.00	1.00	1.00	1.00	1.00	1.00
S_1		0.55	0.58	0.58	0.56	0.64	0.57
S_2		0.58	0.60	0.58	0.60	0.66	0.58
S_3		0.56	0.58	0.58	0.59	0.65	0.58
S_4		0.56	0.60	0.59	0.58	0.65	0.57
S_5		0.57	0.61	0.58	0.57	0.66	0.56
S_6		0.57	0.59	0.58	0.58	0.68	0.57
S_7		0.56	0.59	0.59	0.56	0.65	0.58
S_8		0.58	0.61	0.62	0.59	0.72	0.57
Tr_9		0.57	0.62	0.56	0.57	0.66	0.55
Tr_{10}		0.56	0.61	0.54	0.56	0.67	0.54
Tr_{11}		0.56	0.63	0.59	0.57	0.68	0.55
Tr_{12}		0.57	0.61	0.58	0.58	0.68	0.56
Tr_{13}		0.57	0.61	0.59	0.57	0.65	0.58
Tr_{14}		0.57	0.61	0.57	0.58	0.65	0.56
Tr_{15}		0.58	0.60	0.55	0.58	0.65	0.57
Tr_{16}		0.54	0.65	0.58	0.56	0.66	0.57
Tr_{17}		0.57	0.60	0.59	0.57	0.64	0.57
Tr_{18}		0.58	0.59	0.57	0.56	0.66	0.56
Tr_{19}		0.60	0.60	0.56	0.58	0.66	0.57
Tr_{20}		0.55	0.61	0.58	0.57	0.66	0.58
Tr_{21}		0.57	0.61	0.65	0.59	0.68	0.61
Tr_{22}		0.55	0.61	0.64	0.56	0.66	0.60
Tr_{23}		0.59	0.60	0.58	0.60	0.66	0.58
Tr_{24}		0.57	0.62	0.60	0.57	0.68	0.56
Tr_{25}		0.57	0.61	0.59	0.58	0.67	0.59
Tr_{26}		0.54	0.61	0.58	0.56	0.67	0.58
Tr_{27}		0.59	0.57	0.62	0.58	0.66	0.59
Tr_{28}		0.57	0.63	0.60	0.58	0.68	0.57
Tr_{29}		0.57	0.58	0.60	0.58	0.64	0.58
Tr_{30}		0.59	0.59	0.55	0.60	0.66	0.57
Tr_{31}		0.59	0.61	0.61	0.61	0.67	0.58
Tr_{32}		0.55	0.60	0.64	0.57	0.67	0.57
Tr_{33}		0.57	0.58	0.56	0.59	0.63	0.57
Tr_{34}		0.59	0.59	0.55	0.60	0.66	0.56
Tr_{35}		0.60	0.60	0.59	0.59	0.67	0.55
Tr_{36}		0.57	0.63	0.61	0.58	0.69	0.58
F test		**	**	**	**	**	**
LSD	0.05	0.06	0.04	0.06	0.06	0.05	0.05
	0.01	0.07	0.05	0.08	0.07	0.06	0.07

** = P< 0.01

(1996), who found that *Bt* var. *kurstaki* had significant effects on the mortality of *Bt k*-treated *C. cautella* larvae and also *Btk* treatments significantly reduced pupation and adult emergence. It is known that susceptibility to insecticides is affected by the kind and quantity of food eaten by insects or stored in their body tissues (Gaines and Mistric, 1960). A resistant crop variety reduces the rate of pest population increase by causing higher mortality by extending the developmental periods and by reducing the reproductive potential.

Effect of bioinsecticide on the weight of surviving larvae: All bacterial preparations from *Bt* strains and their transconjugants significantly affect to decrease the weight of surviving larvae compared to control experiment in F_1 generation (Table 5). In addition, many of transconjugants affect to greatly reduce the weight of surviving larvae than affected by the mid-parents. It is suggested that the δ-endotoxin activity was responsible for the reduction in the weight of surviving larvae and partly responsible for the inactivation on leaves feeding sprayed by the bioinsecticide. Although, the surviving larvae grew well in control experiment. The insecticidal activity of parasporal inclusions makes lepidopterous larvae not feeding well on leaves, this makes the bacterium a promising agent for the biological control of pests of economic importance. The feeding effects on the leaves sprayed by different *Bt* preparations on the weight of surviving larvae appeared to be confined to the midgut epithelial cells. The disruption of the midgut epithelial cell microvilli by *Bt* has been observed in other insect hosts by Mathavan *et al.* (1989). This result suggests that *Bt* toxins initially modify the microvillar membranes, leading to suggest that the louse toxin may target certain cell receptors that are present only on selected midgut cells. These results are consistent with the findings of Kinsinger and McGaughey (1979) in lepidopterous larvae. The presence of isolated, damaged cells of insects suggested that direct contact with a toxin is required and that the cytopathological effects do not diffuse laterally. Vacuolation of the *Bt*-affected midgut epithelial cells was also observed by Mathavan *et al.* (1989) in lepidopterous hosts.

In the first instar, cry + endo from transconjugants 19, 20 and also endospores from Tr_{22} was more effective to reducing significantly the weight of surviving larvae. Endospores from Tr_{27} was also more reducing effective the weight of surviving larvae in the third instar, the same effect also shown by cry + endo from Tr_{21} in 4th and 6th instars and also endospores from Tr_{22} in 6th instar. This suggests that osmotic regulation of the lepidopteran insects midgut cells was disrupted by their feeding on the fed containing this bacterial preparations leading to disstimulate larval feeding on this fed. It is well documented that there is a dramatic variation in toxicity of different bacterial preparations among different instars. The difference in toxicity between three proteins must be due to differences either in the structure of proteins themselves (e.g. differences in the primary sequence of the proteins) or in the preparation methods used (e.g. minor differences in the residues eliminated in the trypsin-activation process or small conformational changes induced during the solubilization process). The low toxicity effect against this insect are due to the low specific-binding suggests that this protein binds to the larval midgut with very low affinity (Iracheta *et al.*, 2000).

Bacterial proteins from *Bacillus thuringiensis* (*Bt*) strains and their transconjugants display toxicity towards lepidopterous larvae in F_2 generation, an economically important insect (Table 6). High reduction levels in the weight of surviving larvae revealed by most *Bt* strains in the 1st, 3rd, 4th, 5th and 6th instars. Cry + endo from Tr_{15}, Tr_{21} appeared to significantly reduce the weight of surviving larvae and also endospores from Tr_{10} affect the first instar. Cry + endo from Tr_{13} and Tr_{26} and also crystals from Tr_{30}, Tr_{19}, Tr_{30} and Tr_{10} affect to significantly reduce the weight of surviving larvae in the 3rd instar, as well as, crystals from Tr_{30} revealed the same trend in 4th instar larvae. However, there were clear differences in degree of sensitivity to different bacterial preparations from different strains among different instars. *B. thuringiensis* strains, formulations, or transconjugants combining different crystal proteins, will have less chances of selecting for resistance in insects, most likely, this would require the simultaneous occurrence of more than one resistance gene. Results indicated that transconjugants of *Bt* strains are more effective than their parents could be selected successfully to be utilized in the field as part of an integrated biological control programme for insects. Results reported here about the toxicity effect of endospores are in agreement with Moar *et al.* (1995), who reported that the spores from *B. thuringiensis* are known to increase the toxicity of *Bt* proteins to some insects. Miyasono *et al.* (1994) found that toxin-free spores did not kill larvae, but spores increased the toxicity of *Bt kurstaki* crystals to larvae from a susceptible strain of diamondback moth. The interaction observed between these spores and toxins exemplifies synergism, in which the toxicity of a mixture is greater than expected on the basis of the independent toxicity of its components (Tabashnik, 1992). The results suggest that in some, but not all cases, spores increased mortality and reducing the weight of surviving larvae by interacting with individual *Bt* toxins, naturally occurring mixtures of *Bt* toxins in crystals and *Bt* formulations.

The results reported here suggested that the weight of surviving larvae was affected by all *Bt* preparations and was significantly lower than that of the control larvae and also significantly lower by bioinsecticide of most transconjugants over that reduced by their mid-parents. The excretion of the larvae was reduced markedly, suggesting that feeding was inhibited by *Bt* product. This suggests that crop loss could be prevented even without achieving high larval mortality and the inhibition of feeding. The results also indicated that the bioinsecticide material caused a severe weight loss in the surviving larvae by some transconjugants over their mid-parents.

***Bt* bioinsecticide affect on mortality of lepidopterous embryo:** The results indicated the embryo mortality due to affected by *Bt* products was over the control experiment (Table 7, 8, 9). This revealed that different *Bt* preparations were significantly more toxic in F_1 and F_2 generations than F_3. Many of transconjugants were more toxic than their mid-parents. In addition, embryo mortality percent reached to 45.0, 30.83 and 19.37 in F_1, F_2 and F_3 generations, respectively, due to the effect of cry + end.

The results provide additional examples of synergism between spores and toxins of *B. thuringiensis*, but they also confirm that such synergism is far from universal (Liu *et al*., 1998). Along with the results of previous work (Tang *et al*., 1996), the present results suggest for lepidopterous larvae that the extent of synergism between spores and toxins at *Bt* depends on the strain of insect, the type of spore, the set of toxins, the presence of other materials, such as formulation ingredients and the concentrations of spores and toxins. On the other hand, embryo mortality due to endospores was reached to 40.83, 32.08 and 23.75 in F_1, F_2 and F_3 generations, respectively.

The observed toxicity of spore preparations to embryo apparently was caused by synergism between spores and the small amount of toxin (< 0.5%) in the spore preparations (Liu *et al*., 1998). It can be concluded that in some, but not all cases, spores increased embryo mortality by interacting with individual *Bt* toxins, naturally occurring mixtures of *Bt* toxins in crystals and *Bt* formulations. It is tempting to assume that the absence of spores in *Bt* toxin expressing transgenic plants and transgenic bacteria will accelerate evolution of pest resistance. Direct experimental evaluations will be needed to test this hypothesis.

Embryo mortality due to crystals reached to 39.38, 29.79 and 18.33 in F_1, F_2 and F_3 generations, respectively. The observed toxicity of *Bt* preparations on embryo, apparently was caused in F_1 generation. Previous results showed that toxin-free spores are not toxic (Li *et al*., 1987; Miyasono *et al*., 1994), however, Liu *et al*. (1998) found that streptomycin eliminated toxicity of the spore preparation, but did not reduce the toxicity of Cry 1Ab to susceptible larvae. Results of this initial series of tests indicates that *Bt* formulations can be used to significantly increase embryo mortality of lepidopterous. For this, investigations will be continued to induce new *Bt* recombinants against lepidopterous pests of cotton, soybeans and vegetables. These bacteria have high degrees of insect specificity and environmental safety, which makes them particularly suitable for use against lepidopterous populations resistant to synthetic chemical insecticides.

Effect of *B. thuringiensis* products on the weight of surviving larvae: When larvae are exposed continuously to low levels of *Bt* products (Tables 10 and 11), the follow up of the symptoms caused in the insect by the microbe (*Bt*) preparation is extended to three insect generation. One of these symptoms due to *Bt* products is the reduction in the weight of survivors, (Table 10 and 11). Dulmage and Martinez (1973) demonstrated that sub-lethal doses of the microbe had marked effects on insect development. In future studies in this respect, it is recommended in bioassays for recording these effects through recording the following parameters: larval period, percentage pupation, pupal weight, percentage adult emergence and adult fecundity and fertility. In the results reported herein, most of bacterial strains significantly reduced the weight of survivors among F_1 and F_2 generations than untreated larvae in control experiment. Many of *Bt* transconjugants reduced significantly the weight of surviving larvae among F_1 and F_2 generations over their mid-parents. This may be due to the activity of *Bt* products in resulting feeding inhibition. The effect of *Bt* products on F_2 generation may be due to the residual effect of *Bt* products. It is recommended as a criterion in comparing activities of *Bt* preparations, since for instance, weight reduction in young larvae caused by crystal proteins is a more sensitive parameter than LC_{50} (mortality) in insect species susceptible to *Bt* subsp. *Kurstaki* (MacIntosh *et al*., 1990). The control larvae are fed on untreated diets from the start of the bioassay. The microbe preparation, the length of exposure and combinations of toxins are determine the rate of reduction in the weight of surviving larvae (Salama *et al*., 1981).

This assay considering a short-term exposure, in which the larvae feeding on dietary *Bt* products in F_1 generation only and then transferred the eggs of F_1 giving F_2 larvae which diets without *Bt* products. This bioassay reflect pest management situations in the field when: (I) the larvae feed for a short time on the microbe and then escape feeding by penetrating into inner tissues of the plant, (ii) the microbial product covers the plant canopy only partially, so that defoliators feed on plant parts devoid of *Bt* and (iii) the products activity at lethal concentrations is lost rapidly under direct sunlight and phylloplane effects. The results show that second instar in F_2 generation revealed a lower residual effect than other instars.

Crystal + endospores are more reducing effective the weight of survivors than other *Bt* products as shown in F_1 and F_2 generations. Most commercial products are based on the spore-crystal complex. This mixture is the natural product obtained from the fermentation process. In products used in Japan, spores are inactivated to avoid detrimental effects to the silkworm, which is used commercially for the production of silk. The crystal of *Bt* is responsible for the insecticidal effect in the majority of agricultural pests, but spore effects have been determined against several insects. Burges *et al.* (1976) found from the pathogenicity classification of insect type III made by Heimpel and Angus (1959) for *Bt*, that both spores and crystals were necessary to kill *Epbestia kuebniella*. Therefore, bioassays of purified spores are useful to evaluate their role in developing moth control strategies with *B. thuringiensis*. It can be concluded that larvae exposed to higher doses of *Bt* products lose weight before they die.

It was concluded that some of recombinant bacterial strains that combine toxins from *B. thuringiensis* showed enhanced toxicity against *S. littoralis*, while others did not. Although the increased toxicity observed with some of these recombinants was attributed to synergistic interactions. Regardless to these recombinant toxins, it may be extremely useful in expanding the host range and in overcoming resistance to *Bt* products. In some, but not all cases, spores increased mortality by interacting with individual *Bt* toxins, naturally occurring mixtures of *B. thuringiensis* toxins in crystals and *Bt* formulations. It is attempting to assume that the absence of spores in *Bt* toxin-expressing transgenic plants and transgenic bacteria will accelerate evolution of pest resistance. Synergistic interactions may also proceed from cooperative receptor binding and formation of hybrid pores, allowing a most efficient membrane permeability breakdown. The data suggest that frequent applications (24 h intervals) at smaller old may provide more effective seasonal control of lepidopterous than emergency application at higher old-larvae.

This study also suggest that use of single toxins in sprays or in transgenic plants may be less durable than spore-crystal formulations of *B. thuringiensis*. This could provide a model for developing new strategies for managing resistance to Cry proteins in bacterial insecticides and transgenic plants. Because of *S. littoralis* is generally a migratory insect, development of resistance in the field may appear limited in most regions. *S. littoralis* is an important pest in many crops, the possibility of resistance should not be overlooked, particularly where transgenic plants that utilize one toxin *Bt* gene are used. In the foreseeable future, it is expected that the need for new recombinant *Bt* strains is useful tools for developing rational control strategies with *Bt* will continue.

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