SIDE EFFECTS OF SOME RECOMMENDED INSCTICIDES FOR CONTROLLING BOLLWORMS ON FOUR TRICHOGRAMMATIDS SURVIVORSHIP

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Abstract

Laboratory study was conducted to estimate the differences in sensitivity of the various immature stages of four trichogrammatids to insecticides for designing a program including the best time to release the parasitoids and that to spray the insecticides to reduce bollworms infestation in cotton fields. The insecticides tested are recommended for controlling cotton bollworms in Egypt i.e., Karate (Lambda-cyhalothrin), Kendo, Danitol (Fenpropathrin), Sumi-gold (Esfenvalerate), Larvin (Thiodicarb) and Curacron (Profenofose). The treated trichogrammatids were *Trichogrammatoidea bactrae, Trichogramma evanescens, Trichogramma embryophagum* and *Trichogramma brassicae,* and the concerned immature stages at the time of treatment were eggs, larvae, prepupae, freshly formed pupa and mature pupa (3 hours & 1, 3, 5 and 7-days from stinging). Susceptibility of the parasitoids to the insecticidal effect varied, significantly, according to the wasp species, wasp stage and the tested compound. Regardless of parasitoid stage or the tested compound, the 4 parasitoid species could be divided into two groups based on the percentage of adult emergence after treatment. The first group included *T. embryophagum* and *T. bactrae*, which were more tolerant to the insecticidal effect and had the same overall mean of adult emergence (55.9%). The second group included *T. evanescens* and *T. brassicae* which were less tolerant to the insecticidal effect and varied insignificantly in the overall mean percentage of emergence due to treatments (51.12 and 53.05%, respectively). Generally, the effect of the aforementioned insecticides appeared to be positively related to progressing of development at the time of treatment.

INTRODUCTION

For integrated control of pests, LiLi-Ying (1982) mentioned that, it is very important to know the toxicity of the pesticides to each developmental stage of *Trichogramma*. Many investigators such as (Brar *et al.* 1991 and Consoli *et al.* 1998), indicated that the majority of insecticides that adversely affected development of immature stages for different species of *Trichogramma* in different hosts are organophosphates. The efficacy of this parasitoid is very much influenced by the insecticide spray schedule imposed prior to and after the release (Naryana and Babu, 1992). The less harmful insecticides to the eggs, larvae, pupae and adult of *T.*

japonicum were spanon, rogor and, metaphose + BHC-, respectively. For *T. dedrolimi*, rogor was less toxic to adults and eggs, metaphos + BHC was less toxic to larvae and pupae. Spraying and dusting are more dangerous to *Trichogramma* than other measures of insecticide treatments. However, the major obstacle for successful establishment of *Trichogramma* in cotton is the heavy annual use of organophosphate and pyrethroid insecticides applied to cotton primarily for control of pink bollworm (Beasley& Henneberry, 1984). Thus for the integration of biological control with chemical control, it is important to know the effect of various insecticides on the beneficial insects (Varma & Singh, 1987 and Stevenson & Walter 1983). Moreover, for successful establishment of *Trichogramma*, insecticide applications for pink bollworm and other cotton pests have to be minimized (Hutchison *et al.* 1990). From these points of view, came the idea of the presented study on *Trichogramma evanescens*, *Trichogrammatoidea bactrae*, *T. embryophagum* and *T. brassicae* to investigate the differences in sensitivity of the various immature stages of the four trichogrammatids to insecticides for designing a program including the best time to release the parasitoids and that to spray the recommended insecticides.

MATERIALS AND METHODS

The tested insecticides:

The insecticides tested are recommended for controlling cotton bollworms in Egypt by the Ministry of Agriculture and Land Reclamation, i.e. Karate (Lambda-cyhalothrin 5% E.C., the recommended concentration was 750 cm^3 /400 L water, kendo (Lambda-cyhalothrin), 5% E. C. , the recommended concentration was 375 cm^3 /400 L water, Danitol (Fenpropathrin 30% E. C.), the recommended concentration was 500 cm^3 /400 L water), sumi-gold (Esfenvalerate 20% E. C.,) the recommended concentration was 150 cm^3 /400 L water), larvin (Thiodicarb 80% DF), the recommended concentration was 500g/400 L water) and Curacron (Profenofos 72% E. C.), the recommended concentration was 750 cm^3 /400 L water. The recommended volume in the field/ feddan).

The treated trichogrammatids:

The treated trichogrammatids were *T. bactrae, T. evanescens, T. embryophagum* and *T. brassicae,* and the concerned immature stages at the time of treatment were eggs, larvae, prepupae, freshly formed pupa and mature pupa (3 hours & 1, 3, 5 and 7-days from stinging). These stages were selected according to the previous studies, which mentioned that, the total developmental period of *Trichogramma* (from egg to adult) required about 8 days at 27±1°C. Eggs hatch in about 22 hours while the

periods of 2, 1.5 and 3.5 days were estimated for the larvae, prepupa and pupa, respectively (Flanders 1937, Hutchison *et al.*, 1990 and Abd El-Hafez 1995).

Rearing technique:

1. Host rearing:

Pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) was reared in Bollworms Department, Plant Protection Research Institute for several generations on modified artificial diet as described by Abd El-Hafez *et al.* (1982).

2. Parasitoid rearing:

In the present work, four trichogrammatids belonged to *Trichogramma* and *Trichogrammatoidea* genera were reared on pink bollworm and Angoumois grain moth eggs. These parasitoids are namely *Trichogramma evanescens* Westwood (native strain), *Trichogrammatoidea bactrae* Nagaraja (imported from USA in 1992) and *T. embryophagum* Hartig and *T. brassicae* Bezdenko imported from Iran in 1998. Host egg sheets (2000-2500eggs) were exposed to *Trichogramma* adults (100-150 adults) into glass jars (0.4 - liter) provided with filter paper witted by 10% sucrose solution for nutrition and covered with cloth-wrapped cotton kept in position by rubber band. Egg sheets were renewed daily to avoid super-parasitism. The four trichogrammatid species were maintained in *P. gossypiella* eggs under laboratory conditions at 27±1°C and 80±5% R.H.

Effects on parasitoids emergence:

For each *Trichogramma* spp., cards of pink bollworm parasitized eggs at different periods after parasitization i.e., 3hr., 1, 3, 5 and 7 days were dipped for five seconds in each of the tested insecticides at the recommended concentration. The egg cards for check were dipped in tap water. Each card contained 150-200 parasitized eggs, ten cards were used for each treatment. After allowing the treated fluid to dry at room temperature, each card was placed in a glass vial, incubated at the same rearing conditions until adults' emergence. Accordingly, the percentages of parasitoids emergence were calculated.

RSULTS AND DISCUSSION

Data in Tables (1- 5) show the emergence percentages of the parasitoids that have been developed and emerged after treatment as different immature stages with six insecticides recommended to be used against cotton bollworms.

T. evanescens.- Data in Table (1) show that adult *T. evanescens* emergence from *P. gossypiella* eggs was significantly affected by insecticidal treatment (F value = 1300.011) and the parasitoid age at the time of treatment (F value = 129.203). In check, the percentages of adult emergence averaged 94.50% and ranged between

93.07–96.82% at treatments of the different stages. Comparing the tested compounds, the carbamate compound (Larvin) resulted the highest percentages of adults' emergence from host eggs when applied to all immature stages (59.88-89.54%with a mean of 75.72%). On the contrary, the organophosphorus compound (Curacron) was extremely toxic followed by the two pyrethroids´ Danitol and Karat as the percentages of emergence averaged 14.6, 25.16 & 29.45% and ranged between 1.83-36.75, 14.50-37.22 and 8.28-58.00% when applied to all immature stages, respectively. The other two-pyrethroide compounds (Kendo and Sumi-gold) caused moderate toxicities as the percentages of adults' emergence averaged 65.84 and 52.85% when applied to all stages, respectively.

Statistically there were significant differences between the different stages when treated with the same compound. Moreover, the susceptibility of the same stage to the adverse effect differed significantly according to the tested compounds. For example, 8.28% of adults emerged when pupae were treated with the pyrethroid compound Karat at the day before emergence (7-days old) while 58.00% of parasitoids succeeded to emerge when treatment took place early during the egg stage (3 hours from stinging). On the other hand, almost equal percentages of adults emerged when the parasitoids were treated by the same compound as first instar larvae, prepupae and freshly formed pupae (26.72, 27.01 and 27.22%, respectively).

Also, the adverse effect of the pyrethroid compound (Kendo) differed according to the treated stage of *T. evanescens.* So, treatment of freshly formed pupae yielded the lowest percentage of adult emergence (31.56%) followed by mature pupae (55.68%) and first instar larvae (67.35%), while the highest percentages of adult emergence were recorded at the parasitoid egg stage (87.95%) followed by prepupae stage (86.66%).

On the other hand, the first instar larvae were the most susceptible to Danitol treatment as, 14.50% of the parasitoids only emerged as adults, while this percent increased to 19.98, 20.75, 33.36 and 37.22% when treatment took place on prepupae, mature pupae, freshly formed pupae and egg stage, respectively. Furthermore, prepupae and freshly formed pupae were more susceptible to the adverse effect of Sumi-gold than the other stages, while first instar larvae were the most tolerant stage.

Table 1. Emergence of *Trichogramma evanescens* treated as developmental immature stages in *pectinphora gossypiella* eggs with some insecticides recommended for controlling bollworms.

Treatments	Immature stages at the time of treatment					(Mean % ± S.D.)	L.S.D(5%)
	Egg stage	1st larvae	prepupae	Freshly formed pupa	Mature pupa		
Check	93.07^{aB} ± 1.57 (90-95.7)	94.24^{aB} ± 1.42 (91.4-95.8)	96.82^{aA} ± 1. 9 (92.7-98.9)	93.87^{aB} ± 2.59 (89.3-96.8)	94.52^{aB} ± 2.999 (87.7-98.2)	94.50^{a} ± 2.37 (87.7-98.9)	1.977
Karate	58.00^{cA} ± 9.8 (39.6-76.6)	26.72^{dB} ± 2.76 (20.9-31)	27.01^{dB} ± 2.19 (21.8-29.4)	27.22^{eB} ± 2.1.9 (21.8-29.4)	8.28^{eC} ± 1.44 (6.1-10.4)	29.45^{e} ± 16. 94 (6.1-76. 6)	4. 310
Kendo	87.95^{aA} ± 4.18 (84.4-95.1)	67.35^{cB} ± 13.57 (51.4-87.6)	86.66^{bA} ± 2.98 (81.1- 90)	31.56^{dD} ± 1.36 (29.1-34)	55.68^{cC} ± 5.98 (44.3-66.7)	65.84^{c} ± 22.25 (29.1-95.1)	4.260
Danitol	37.22^{dA} ± 6.22 (29.2-45.9)	14.50^{eC} ± 5.08 (9.1-24.3)	19.98^{eB} ± 3.76 (13.5-25.4)	33.36^{dA} ± 3.53 (25-39.3)	20.75^{dB} ± 4.39 (15.5-28.9)	25.16^{f} ± 9.8 (9.1-45.9)	3.866
Sumi-gold	54.08^{cB} ± 10.86 (35.9-88.9)	73.75^{bA} ± 6.61 (62.86-84)	39.73^{cC} ± 3.28 (34.9-45.7)	38.84^{cC} ± 5.87 (27.3-45)	57.87^{bcB} ± 6.57 (50-71)	52.85^{d} ± 13.34 (27.3-84.0)	6.895
Larvin	78.69^{bB} ± 4.56 (70.2-85.2)	89.54^{aA} ± 1.78 (86.1-92.1)	81.69^{bB} ± 1.67 (78.4-83.2)	68.78^{bC} ± 5.36 (60-78.2)	59.88^{bD} ± 4.76 (52.8-68.5)	75.72^{b} ± 11.11 (52.8-92.1)	3.256
Curacron	10.38^{dBC} ± 5.30 (3.2-18.3)	16.37^{eB} ± 7.64 (4.8-26.25)	36.75^{cA} ± 13.79 (8.7-53.6)	7.70^{fCD} ± 6.03 (0-18.8)	1.83^{fD} ± 1.99 (0-4.5)	14.60^{g} ± 14.34 (0-53.60)	6.528
Mean	59.91^{A} ± 28.32 (3.2-95.7)	54.64^{B} ± 32.88 (4.8-95.8)	55.52^{B} ± 30.09 (8.7-98.9)	43.05^{C} ± 27.24 (0-96.8)	42.69^{C} ± 31.48 (0-98.2)	51.16 ± 30.71 (0-98.9)	1.910
L.S.D(5%)	7.100	4.907	5.180	4.165	3.944	2.268	

ANOVA yielded significant difference between treated stages (F value = 129.203 and LSD = 1.910) and between the tested insecticides (F value = 1300.011 and LSD = 2.268). Means in the column followed by different small litters, or in a row by different capital letters are significantly different.

The percentages of adult emergence averaged 54.08, 73.75, 39.73, 38.84 and 57.87% when *P. gossypiella* eggs parasitized by *T. evanescens* in the egg stage, first instar larvae, prepupae, freshly formed pupae, and mature pupae were treated, respectively. Generally, the susceptibility to the adverse effect of the tested compounds was increased by increasing the age of immature stages when treated, so the pupal stage (freshly formed and mature) was the most susceptible to the adverse effect of the insecticides compared with the other stages (Table, 1).

T. bactrae.- Data presented in Table (2) reveal that, all insecticidal treatments of *P. gossypiella* eggs parasitized by immature stages of *T.bactrae* led to a significantly lower percentages of adults' emergence. In control, water treatment reduced significantly adult emergence from *P. gossypiella* eggs when *T .bactrae* was treated as first instar larva or mature pupa (7-days old), while treatment of the other stages did not cause any significant effect. The percentage of adult emergence in control averaged 95.32% and ranged between 93.65-97.3% at all immature treatments. As occurred in case of *T. evanescens*, emergence of *T. bactrae* adults from *P. gossypiella* eggs was significantly affected by insecticidal treatment (F value = 484.149 & LSD = 2.942) and the parasitoid stage at the time of treatment (F value = 88.795 and LSD = 2.486). The carbamate compound (Larvin) still the safest compound resulted the maximum % of adult emergence (77.68, 53.61-95.28%) when applied to all freshly formed stages. On the contrary, the pyrethroid compound (Karat) was the most toxic one (17.7- 40.3 % emergence), followed by the organophosphorous compound Curacron (41.65%) and the pyrethroid Danitol (46.57%). The other two-pyrethroid compounds (Kendo and Sumi-gold) did not vary significantly in their effect as they caused moderate toxicity levels so the percentages of adult emergence averaged 50.03 and 52.48%, respectively. There were significant differences between means of emergence percentage by treatment in different stages when treated with the same compound or between the tested compounds when applied to the same stage. Egg stage (3hrs old) and freshly formed pupae (5-days old) were more tolerant to the adverse effect of the toxic compound Karat, while 1^{st} instar larvae, prepupae and mature pupae were more susceptible, percentages of adult's emergence averaged 40.31, 37.24, 21.35, 18.46 and 17.7%, respectively. Also, the egg stage was the most tolerant to the adverse effect of Kendo (80.10% emergence), while the pupal stage (freshly formed and mature) was the most susceptible (28.62 and 30.36% emergence, respectively).

Table 2. Emergence of *Trichogrammaatoidea bactrae* treated as developmental immature stages in *pectinphora gossypiella* eggs with some insecticides recommended for controlling bollworms.

Treatments	Immature stages at the time of treatment					(Mean % · S.D.)	L.S.D
	Egg stage	1st larva	prepupa	Freshly formed pupa	Mature pupa		
Check	97.30^{aA} ± 1.55 (94.7-99.2)	94.69^{aB} ± 2.65 (91.2-98.6)	96.67^{aA} ± 1.34 (93.8-98.9)	97.3^{aA} ± 0.68 (95.9-98.2)	93.65^{aB} ± 1.89 (91.9-97.1)	95.32^{a} ± 2. 07 (91.2-99.2)	1.661
Karate	40.31^{dA}±11.66 (23.3-58.1)	21.35^{eB}± 3.34 (13.4-26)	18.46^{eB}± 3.63 (10-23.1)	37.24^{eA}± 7.88 (21.8-48.9)	17.7^{eB}± 2.18 (15.3-21.4)	27.01^{e}± 11.76 (10 -58.1)	5. 522
Kendo	80.10^{bA}± 3.87 (72.9-86.9)	55.4^{dB}± 2.91 (49.6-58.1)	55.65^{cB}± 6.81 (45-66.7)	28.62^{fC}± 3.80 (23.4-37.1)	30.36^{dC}± 11.23 (15.2-48.1)	50.03^{c}± 20.2 (15.2-86.96)	5. 314
Dantol	61.79^{cA}± 10.96 (42.1-80.5)	62.84^{cA}± 9.79 (49.6-74.4)	24.16^{eC}± 3.32 (19.2-31.1)	39.95^{deB}± 8.35 (27.1-58)	44.11^{cB}± 5.28 (37.1-54.2)	46.57^{d}± 16.5 (19.2-80.5)	6.598
Sumi-gold	59.88^{cB}± 15.90 (35.3-81.5)	82.73^{bA}± 7.2 (64.7-89.9)	39.52^{dC}± 5.43 (31.5-48.6)	43.79^{dC}± 5.04 (35.4-50.4)	36.47^{dC}± 10.65 (11.1-49.2)	52.48^{c}± 19.67 (11.11- 89.98)	7. 963
Larvin	73.55^{bB}± 7.52 (58.3-83.9)	95.28^{aA}± 2.58 (90.2-99.1)	93.42^{aA}± 1.58 (91.1-95.8)	72.51^{bB}± 4.71 (64.7-79.8)	53.61^{bC} ± 3.46 (48.7-58.3)	77.68^{b}± 16.1 (48.7-99.1)	3. 667
Curacron	34.00^{eC}± 5.20 (26.5-45.5)	16.14^{fD}± 6.30 (3.5-26.7)	82.40^{bA}± 21.08 (41.4-100)	53.74^{cB}± 7.55 (41- 65. 9)	21.96^{eD}± 6.17 (11.5-34.3)	41.65^{d}± 26.5 (3. 5-100)	9.017
Mean	63.85^{A}± 22.5 (32.30-99.2)	61.21^{B}± 30.93 (3.50-94.2)	58.61^{C}± 31.61 (10.0-100)	53.31^{D}± 23.05 (21.8-98.2)	42.55^{E}± 24.84 (11.11-97.10)	55.82± 30.71 (3.5-100)	2.486
L.S.D.	8.3397	5.027	7.915	5.355	6.216	2.942	

ANOVA yielded significant difference between treated stages (F value = 88.795 and LSD = 2.486) and between the tested insecticides (F value = 484.149 and LSD = 2.942). Means in the column followed by different small litters, or in a row by different capital letters are significantly different

Treatment at the 1st instar larvae or prepupae by Kendo resulted, approximately, the same % of adults' emergence (55.4& 55.65%). As for the pyrethroid Danitol, treatment of prepupae yielded the lowest percentage of adults' emergence (24.16%) while treatment of egg stage and first instar larvae yielded, significantly, the highest percentages (61.79 and 62.84%, respectively). Exposure of the same parasitoid as freshly formed or mature pupae to the same compound resulted in moderate percentages of adults' emergence (39.95 and 44.11%, respectively). High percentage of adults' emergence (82.73%) occurred after treatment the first instar larval with the insecticide Sumi-gold while this percentage was reduced significantly to 43.79, 39.52 and 36.47% when the parasitoids were treated with the same compound as freshly formed pupae, prepupae and mature pupae in *P. gossypiella* eggs, respectively.

T. embryophagum.- The present results (Table3) show that all the tested insecticides affected, significantly, the emergence of *T. embryophagum* adults from *P. gossypiella* eggs (F value = 1493.809 & LSD = 2.039). The percentage of adult's emergence was significantly related to the age of immature stages at the time of treatment (F value = 129.180 and LSD = 1.724). In control, treatment of all immature stages with water did not affect the emergence of adults except in case of first instar larval treatment. The percentage of adult emergence in control averaged 95.31% and ranged between 93.89–96.42% at the different treatments of the different stages.

The carbamate compound (Larvin) resulted the highest mean percentage of adults' emergence (86.2, 59.3-99.2%) compared to the other insecticides (Table 3). It could be noted that, when the parasitoid was in its 1st larval instar or freshly formed pupae the treatment did not affect significantly adults' emergence, as the percentages of emergence were similar to that of control (93.97 and 94.98%).

On the contrary, the organophosphorus compound Curacron inhibited completely the emergence of the parasitoids when treatment took place on eggs or the pupal stage, while 13.45 and 45.65% of adults emerged after treatment at the first instar larvae and prepupa, respectively. The order of toxicity of the tested compounds could be arranged descendingly as follows: Curacron> Kendo> Karat> Sumi-gold> Danitol> Larvin. When the pyrethroid compound Karate was tested, higher percentage of adults (77.20%) emerged when treatment was done immediately after stinging (egg stage), while the lower percentage (16.96%) was emerged when done at the day before emergence (mature pupae). The percentage of emergence averaged 53.02, 36.26 and 51.74% when treatment was done during first instar larvae, prepupae and freshly formed pupae, respectively. In case of treatment with Kendo, parasitoids seemed to be more tolerant to the adverse effect of this pyrethroid when treated as prepupae (87.2% emergence). On the other hand, lower percentages of adults emerged when treatments were done on egg stage (22.53%), freshly formed pupae (21.16%) and mature pupae (24.11%).

Table 3. Emergence (Mean % ± SD) of *Trichogramma embryophagum* treated as developmental immature stages in *pectinphora gossypiella* eggs with some insecticides recommended for controlling bollworms.

Treatments	Immature stages at the time of treatment					(Mean ± S.D.)	L.S.D5%
	Egg stage	1st larvae	prepupae	Freshly formed pupa	Mature pupa		
Check	96.42^{aA}± 2.08 (93.6-98.5)	93.89^{aB}± 1.98 (91.2-96.6)	95.57^{aA}± 4.44 (91.6-99.3)	95.36^{aAB}± 1.36 (92.5-97.6)	95.34^{aA}± 4.22 (92.3-98.2)	95.31^{a}± 3.07 (91.2-99.3)	1.838
Karate	77.20^{cA}± 6.00 (70.80-86.10)	53.02^{cB}± 6.13 (46.5-61.4)	36.26^{eC}± 2.64 (34.8-41.6)	51.74^{cB}± 5.18 (40.0-59.01)	16.96^{fD}± 2.14 (13. 3-20.0)	47.04^{e}± 20.65 (13.3-86.1)	4.276
Kendo	22.53^{eC}± 8.9 (9.8-40.0)	35.54^{dB}± 7.57 (18.8-48.6)	87.20^{bA} ± 7.20 (75.2-95.7)	21.16^{eC}± 4.07 (13.8-27.7)	24.11^{eC}± 3.85 (17.7-31.0)	38.11^{f}± 26.11 (9.8-95.7)	5.722
Danitol	76.15^{cB}± 3.73 (71.1-81.5)	81.57^{bA}± 3.66 (74.1-89.1)	30.18^{fE}± 2.46 (25.2-33.1)	35.33^{dD}± 4.39 (26.1-41.11)	64.57^{cC}± 8.06 (48.5-77.7)	57.56^{c}± 21.76 (25.2-89.1)	4.362
Sumi-gold	41.09^{dC}± 6.20 (30.77-51.11)	62.45^{eA}± 2.05 (58.7-65.7)	56.52^{cA}± 5.13 (45.8-61.6)	60.15^{bA}± 9.15 (43.2-74.5)	50.45^{dB}± 7.74 (40.4-61.2)	54.13^{d}± 9.96 (30.77-74.5)	5.636
Larvin	89.66^{bA}± 2.53 (86.3-93.3)	93.97^{aA}± 5.10 (84.3-98.0)	82.57^{bB}± 9.30 (65.13-92.3)	94.98^{aA}± 3. 86 (88.3-99.2)	69.88^{bC}± 6.60 (59.3-80.0.)	86.21^{b}± 10.96 (59.3-99.2)	5.202
Curacron	0^{fC}	13.45^{eB}± 3.83 (5.4-17.9)	45.65^{dA}± 6.20 (31.7-53.5)	0^{fC}	0.07^{gC}± 0.21 (0-0.67)	11.83^{g}± 18.14 (0-53.5)	3.225
Mean	57.58^{B}± 34.6 (0-98.5)	61.98^{A}± 28.74 (5.4-98.0)	61.99^{A}± 25.17 (25.2-99.3)	51.25^{C}± 33.77 (0-99.2)	45.91^{D}± 31.82 (0-98.2)	55.74± 31.47 (0-99.3)	1.724
L.S.D.	4.510	4.372	5.027	4.350	4.666	2.039	

ANOVA yielded significant difference between treated stages (F value = 129.180 and LSD = 1.724) and between the tested insecticides (F value = 1493.809 and LSD = 2.039). Means in the column followed by different small litters, or in a row by different capital letters are significantly different

The other pyrithroid Danitol gave different results than Kendo. The lower percentage (30.18%) of adults emerged when treatment took place on the prepupal stage and the higher percentages of adults were emerged when treatment was done at first instar larvae (81.57%) or egg stage (76.15%). However, 35.33 and 64.57% of parasitoids completed their development and emerged after treatment of freshly formed and mature pupae, respectively. As for Sumi-gold, treatment of parasitoid at the egg stage resulted in the lower percentage of emerged adults (41.09%) followed by treatment as mature pupae (50.45%), while 62.45, 56.52 and 60.15% of adults emerged after treatment during the first instar larvae, prepupae, and freshly formed pupae, respectively. Overall, It could be deduced that *T. embryophagum* was more susceptible to the adverse effect of the tested insecticides when treated as pupae while, it was more tolerant when treatment was done at first instar larvae or prepupae.

T. brassicae.- Results in Table (4) revealed that emergence rate of *.T. brassicae* adults from parasitized pink bollworm eggs varied significantly, according to the applied insecticides (F value = 1245.632 & LSD = 1.96) and the stage of the treated parasitoid, (F value = 757.407 and LSD = 1.660). In control treatment, water adversely affected the parasitoid emergence and this influence increased significantly with increasing age of immature stages at the time of treatment. The percentage of adult emergence averaged 95.12% (91.62-97.15%). Sumi-gold treatments resulted in higher percentage of emergence (67.7%, 56.57-80.34%) when applied to different immature stages. It could be noted that freshly formed pupae were the highest susceptible to the toxic effect of this compound (56.57%emergence). On the other hand, the organophosphoric compound (Curacron) was statistically the most toxic compound followed by the pyrethroide compound Karate as the percentages of emergence averaged 23.53 (0.96-86.04) and 27.16% (13.11-37.17)%, respectively.

Regarding the parasitoid stage at the time of treatment, it could be noted that pupal stage (mature or immature) is the most susceptible stage to the insecticidal effect of Curacron compared to the other stages as 6.5 and 0.96% only of *T. brassicae* adults emerged from pink bollworm eggs. On the contrary, slight effect was achieved when treatment was done when the parasitoid was still in the egg stage (86.04% emergence). Also, exposure of the pupal stage to Kendo led to emergence of lower percentage of adults averaged 23.36 and 37.49% when freshly formed and mature pupae were treated. But, when treatment was done on egg or prepupal stage, 88.56 and 87.92% of these immature stages succeeded to emerge from parasitized *P. gossypiella* eggs. On the other hand, treatment of first instar larvae by Kendo resulted in emergence of a moderate percent of adults (59.58%). As for Danitol treatments, the lower percent (13.16%) of adults emerged after treatment of fresh pupae followed by 20.88 and 24.31% when mature pupae and prepupae were treated, respectively. Treatment of first instar larvae produced the higher percentage of adult emergence (88.78%), while treatment of the egg stage produced a moderate percentage (59.15%).

Table 4. Emergence Mean % ± SD of *Trichogramma brassicae* treated as developmental immature stages in *pectinphora gossypiella* eggs with some insecticides recommended for controlling bollworms.

Treatments	Immature stages at the time of treatment					Mean % ± SD	L.S.D 5%
	Egg stage	1st larvae	prepupae	Freshly formed pupa	Mature pupa		
Check	97.15^{aA}± 1.16 (94.6-99.2)	96.76^{aA}± 2.004 (91.5-98.65)	95.67^{aAB}± 1.08 (93.6-97.2)	94.40^{aB}± 2.13 (90. 73-98.4)	91.62^{aC}± 1.08 (90.0- 93.36)	95.12^{a}± 2.51 (90-99.2)	1.585
Karate	32.48^{fB}± 1.96 (30.1-35.7)	34.84^{eAB}± 4.6 (24.7-41.1)	37.17^{dA}± 9.20 (24.3-53.7)	13.11^{dD}± 4.37 (7.5-19.8)	18.21^{eC}± 3.88 (11.1-22.7)	27.16^{e}± 11.01 (7.5-53.7)	4. 329
Kendo	$88.56^{bc\ A}$ ±3.07 (88.1-91.8)	59.58^{dB} ± 4.98 (52.99-70.0)	87.92^{bA}± 4.00 (82.0-92. 3)	23.36^{cD}± 8.73 (10-38.4)	37.49^{cC}± 10.60 (23.6-53.0)	59.19^{c}± 27.41 (10-92.9)	5.659
Danitol	59.15^{eB}± 6.84 (49.15-74.07)	88.78^{bA}± 4.81 (84.0-96.67)	24.31^{eC}± 6.29 (16.1-33.0)	13.16^{dD}± 2.02 (9.4-17.3)	20.88^{eC}± 2.69 (15.8-25.2)	41.26^{d}± 29.2 (9.4-96.67)	4.021
Sumi-gold	80.34^{dA}± 3.62 (73.8-85.9)	61.36^{dD}± 1.57 (59.8-64.7)	72.73^{cB}± 7.2 (60.8-83.6)	56.57^{bE}± 8.88 (40.7-70.4)	67.49^{bC}± 1.92 (64.3-71.6)	67.70± 9.93^{b} (40.71-85.92)	4.471
Larvin	90.12^{bA}± 1.03 (83.8-92.9)	76.80^{cB}± 3.65 (70-90.9)	37.40^{dD}± 7.36 (24.3-75.3)	57.18^{bC}± 6.19 (50-69.2)	27.16^{dE}± 7.62 (16.7-39.7)	57.73^{c}± 24.37 (16.7-91.8)	4.698
Curacron	86.04^{cA}± 4.39 (77.7-93.7)	11.59^{fB}± 3.39 (5.1-15.9)	12.56^{fB}± 1.39 (10.9-14.7)	6. 50^{eC}± 2.89 (3.1-12.8)	0. 96^{fD}± 1.28 (0-3.2)	23.53^{f}± 31.97 (0-93.7)	2. 391
Mean	76.26^{A}± 21.49 (30.1-99.2)	61.38^{B}± 32.66 (5.1-98.65)	52 $.40^{C}$± 28.28 (10.9-97.2)	37.75^{D}± 30.79 (3.1-98.41)	37.69^{D}± 29.73 (0-93.36)	53.10± 31.87 (0-99.2)	1.660
L.S.D.	3.299	3.305	5.324	5.136	4.976	1.960	

ANOVA yielded significant difference between treated stages (F value = 757.407 and LSD = 1.660) and between the tested insecticides (F value = 1254.632 and LSD = 1.960).

Means in the column followed by different small litters, or in a row by different capital letters are significantly different

Table 5. Overall mean percentages of emergence of four trichogrammatids treated as developmental immature stages in *pectinphora* gossypiella eggs with some recommended insecticides for controlling bollworms (mean of five treated ages ± SE)

treatments	Parasitoid spp.				Mean± SE	LSD 5%
	T. evanescens	*T. bactrae*	*T. embryophagum*	*T. brassicae*		
Check	94.5^{aB} ± 1.23 (87.7 – 98.9)	95.92^{aA} - 1.18 (91.2 – 99.2)	95.31^{aAB} ± 1.18 (91.2 99.3)	95.11^{aAB} ± 1.26 (90.99.2)	95.21^{a} ± 0.58 (84.3 - 99.3)	ns
Karate	29.45^{eB} ± 8.45 (6.1 – 76.6)	27.0^{fC} - 5.8 (10.0 58.1)	47.04^{eA} ± 10.33 (13.3 – 86.1)	27.16^{eC} ± 5.51 (7.5 – 53.7)	32.66^{f} ± 3.94 (6.1 – 86.1)	2.198
Kendo	65.84^{cA} ± 11.13 (29.1 – 95.1)	50.03^{cC} - 10.15 (15.2 – 86.96)	38.11^{fD} ± 13.06 (9.8 – 95.7)	59.23^{cB} ± 13.71 (10.0 – 92.9)	53.30^{d} ± 5.86 (9.8 – 95.7)	2.673
Danitol	25.16^{fD} ± 4.9 (9.1 – 45.9)	46.57^{dB} - 8.25 (19.2 – 80.5)	57.56^{cA} ± 10.88 (25.2 - 89.1)	41.26^{dC} ± 14.6 (9.4 – 96.7)	42.64^{e} ± 23.55 (9.1– 96.67)	2.29
Sumi-gold	52.85^{dB} + 7.35 (27.3 – 88.9)	52.48^{cB} ± 9.83 (11.0 – 89.98)	54.03^{dB} ± 4.98 (30.8 – 74.5)	67.7^{bA} ± 4.97 (40.7 – 85.9)	56.79^{c} ± 5.27 (11.1 – 89.98)	2.906
Larvin	75.7^{bB} + 11.11 (52.8 - 92.1)	77.68^{bB} - 16.1 (48.7 – 99.1)	86.21^{bA} ± 10.96 (59.3 – 99.2)	57.73^{cC} ± 23.65 (18.5 – 91.8)	74.33^{b} ± 4.35 (19.7– 99.2)	2.012
Curacron	14.61^{gC} - 9.70 (0 – 88.9)	41.65^{eA} ± 13.25 (3.5 – 100)	11.83^{gC} ± 9.07 (0 – 53.5)	23.53^{fB} ± 15.99 (0 – 93.7)	22.90^{g} ± 5.88 (0 – 100)	2.817
Mean	51.12^{B} ± 5.23 (6.1 – 98.9)	55.91^{A} ± 4.75 (3.5 – 100)	55.90^{A} ± 5.41 (0 – 99.3)	53.05^{B} ± 5.43 (0 – 99.2)	53.98 ± 6.83 (0 – 100)	
LSD	2.268	2.942	1.72	1.964	1.16	

Means in the column followed by different small litters, or in a row by different capital letters are significantly different.

On the contrary to the results the three above mentioned insecticides, the carbamate compound Larvin, had more adverse effect on the immature stages of *T. brassicae*. This adverse effect was found to be increased significantly by increasing the age of the parasitoid at the time of treatment. The percentages of adults' emergence averaged 90.12, 76.80, 37.40, 57.18 and 27.16% when treatment took place at egg stage, first instar larvae, prepupal stage, freshly formed pupae and mature pupae, respectively (Table 4). Regardless of the treated stage, there were insignificant difference between the four species when treated with water (Table, 5), as the percentages of emergence in control ranged between 94.50-95.92%. While, data reveal that the susceptibility of the parasitoids to the insecticidal effect varied, significantly, according to the wasp species and the tested compound. For example, *T. embryophagum* was significantly more tolerant to the adverse effect of Karate, Larvin and Danitol. However, *T. bactrae* was more tolerant to Curacron (the most toxic insecticide), *T. evanescens* was more tolerant to Kendo and *T. brassicae* was more tolerant to Sumi-gold. Regardless of parasitoid stage or the tested compound (Table, 5), the 4 parasitoid species could be divided into two groups. The first group included *T. embryophagum* and *T. bactrae*, which were more tolerant to the insecticidal effect and have the same average of adult emergence (55.9%). The second group included *T. evanescens* and *T. brassicae* which were less tolerant to the insecticidal effect, the overall mean percentages of emergence were 51.12 and 53.05%, respectively. On the other hand the toxicity order of the tested compounds may be arranged descendingly as follows: Curacron (Profenofose, 22.90% emergence)> Karat (Lambda-cyhalothrin, 32.66%)> Danitol (Fenpropathrin, 42.64%)> Kendo(Lambada-cyhalothrin) (53.30%)> Sumi-gold (Esfenvalerate, 56.79%)> Larvin (Thiodicarb, 74.33%).

In similar studies, many investigators indicated that the majority of insecticides that adversely affected development of freshly immature stages for different species of trichogramma in different hosts are organophosphates (Bull & House 1983, Bull & Coleman 1985, Singh & Varma 1986, Varma & Singh 1987, Brar *et al.* 1991, Abd El-Hafez *et al* 1996 and Consoli *et al.* 1998). The present results were more closely to those reported by Sarode and Sonalkara (1999) who found that insecticides belonging to pyrethroid and organophosphorus groups showed toxic effects on parasitization of *Corcyra cephalonica* eggs parasitized by *Trichogramma chilonis*. Neem seed extract and endosulfan were moderately safe to the parasitoid. .Furthermore, similar results were reported by Zhang *et al.* (1997[b]) who studied the effects of imidacloprid, buprofezin and sumithion (Fenitrothion) on *Trichogramma japonicum* eggs, larvae, pupae and post pupae of the wasp and found that sumithion caused the greatest mortality among the 3 insecticides, resulting in 48.63, 27.71, 50.21 and 25.3% mortality of the 4

developmental stages, respectively. Imidacloprid and buprofezin caused lower mortality rate of the parasitoid and was recommended for use in controlling pest insects at the time when the parasitoid is at the egg stage of the life-cycle. In Japan, Takada *et al.* (2001) tested the toxicity of six insecticides, acephate, mehtomyl, ethofenprox, cartap, chlorfluazuron, and *Bacillus thurinigiensis* (Bt) on different developmental stages of the egg parasitoid, *Trichogramma dendrolimi* (Matsumura). Ethofenprox showed the highest toxicity and cartap showed relatively higher toxicity compared with the other insecticides. The development of the parasitoids treated with these two insecticides was normal, similar to that of the control group. Only the emergence of adult wasps from *Mamestra brassicae* eggs was disturbed.

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التأثير الجانبىلبعض المبيدات الموصي بها لمكافحة ديدان اللوز علي أربعة أنواع من طفيليات الترايكوجراما:

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تم تنفيذ دراسة معملية لتقدير حساسية الأطوار الغير كاملة لأربعة أنواع من الترايكوجراما لبعض المبيدات الموصي بها لمكافحة ديدان اللوز في مصر وذلك بهدف إطلاق الطفيل وأيضا ترشيداستخدام المبيدات الموصى بها حتى تعطي فرصة للطفيليات بالقيام بدورها. والمبيدات المختبرة هي كارات (Lambda-cyhalothri) ، كندو ، دانيتول (Fenpropathrin) ، سومي جولد (Esfenvalerat) ، لارفن (Thiodicarb) ، كوراكرون (Profenofose) . أما أطوار الطفيل وقت المعاملة فكانت طور البيضة ، اليرقة ، طور ما قبل العذراء ، طور العذراء حديثة التكوين ، طور العذراء المتقدم (٣ ساعات، ١، ٣، ٥و ٧ أيام بعد وضع البيض بواسطة أنثى الطفيل على درجة حرارة ٢٥ °م) وجميع هذه الأطوار داخل بيض دودة اللوز القرنفلية. ووجد أنه بغض النظر عن الطور المعامل وجدت اختلافات غير معنوية بين الأربعة أنواع من الترايكوجراما عندما عوملت بالماء كمقارنة حيث تراوحت نسبة خروج الحشرات الكاملة من بيض العائل ما بين ٩٤,٥٠و ٩٥,٩٢ %. بينما أوضحت النتائج أن حساسية الترايكوجراما تختلف معنويا باختلاف النوع وأيضا المبيد المستعمل، علي سبيل المثال، طفيل ترايكوجراما امبريوفاجم كان أكثر تحملا للتأثير المعاكس لمبيدات كارات و لارفن و دانيتول ، بينما طفيل ترايكوجراماتويديا باكترى كان أكثر تحملا للمبيد كوراكرون (أكثر المبيدات سمية) ، ووجد أن طفيل ترايكوجراما افانسنس أكثر تحملا للكندو ، وترايكوجراما براسيكا أكثر تحملا للسومي جولد. وبغض النظر عن الطور المعامل أو المبيد المستخدم ، أمكن تقسيم الأربعة انواع المعاملة بالمبيدات المختلفة إلى مجموعتين اعتمادا علي نسبة الخروج للحشرات الكاملة بعد المعاملة: المجموعة الأولى تشمل طفيل ترايكوجراما امبريوفاجم و ترايكوجراماتويديا باكترى اللذين كانا أكثر تحملا لتأثير المبيدات وكان لهما نفس نسبة الخروج للحشرات الكاملة (٩، ٥٥ %) ، ،المجموعة الثانية تشتمل على ترايكوجراما افانسنس و ترايكوجراما براسيكا اللذين كانا أقل تحملا لتأثير المبيدات واختلفوا فيما بينهم اختلافا غير معنويا في نسب الخروج (٥١,١٢ و ٥٣,٠٥% ،على التوالي). وطبقا للنتائج المتحصل عليها أمكن ترتيب المبيدات المختبرهطبقا لسميتها و من ثم تأثيرها على نسبة الخروج تنازليا كالأتي: كوراكرون (معدل خروج ٢٢,٩٠ %)> كارات (معدل خروج ٣٣,٦٦%) > دانيتول (معدل خروج ٤٢,٦٤ %) > كندو (معدل خروج ٥٣,٣ %) > سومى جولد (معدل خروج ٧٩، ٥٦%)> لارفن (معدل خروج ٣٣، ٧٤ %). ويتراوح المتوسط العام لخروج الحشرات الكاملة بعد المعاملة عند طور البيضة ، اليرقة ، ما قبل العذراء و العذراء حديثة التكوين و طور العذراء المتقدم٤٠,٦٤، ٨٠,٥٩، ١٤,٥٧، ٣٤,٤٦، ٢١,٤٢ % ،على التوالي، مما أثبت عامة أن تأثير المبيدات السابقة مرتبط بالتقدم في النمو للأطوار الغير كاملة النمو وقت المعاملة.