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Bio-residual Effect of Some Insecticides on Development of Whitefly, *Bemisia tabaci* (Gennadius) on Cotton

Abdullah N. M. M.* and Joginder Singh**

* *Department of Plant Protection, College of Agriculture, Sana'a University, (Maen Post Office), P.O. Box 13609, Sana'a, Yemen*

E-mail: abd.nasher@yahoo.co.in (Corresponding author)

** *Department of Entomology, Punjab Agricultural University (PAU), Ludhiana, India*

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Abstract. This study was conducted during 2002 cotton crop season at the Entomological Research Farm, Punjab Agricultural University, Ludhiana (Punjab, India). Quinalphos (250, 375 and 500 g), carbaryl (625, 938 and 1250 g), acephate (750, 1125 and 1500 g), endosulfan (438, 656 and 875 g) and fenvalerate (25, 38 and 50 g ai/ ha) were repeatedly sprayed for 5 times at 7-day interval on potted plants of American cotton (var. LH 1556). Five pairs' whitefly adults were confined in micro leaf cages on treated plants after 3 days from the spray. Adults were removed along with leaf cage after 24 hours. The leaf portion under each leaf cage was marked and observed under stereomicroscope binocular using 25X for the number of eggs laid. Only 20 eggs were kept and the remaining was removed. The leaf cage was attached again to the leaves on the marked area, which was observed daily under stereomicroscope binocular (25X) for recording different biological parameters. The obtained results reveal that the incubation period ranged between 5.5 to 8.8 days with non-significant differences between different treatments. Similarly, none of the insecticidal treatment has shown adverse effect on egg survival. All insecticides except the tested doses of fenvalerate resulted in significant prolongation of nymphal duration and caused adverse effect on nymphal survival as will as growth index. None of the treatments showed any significant effect on pupal duration and survival. Total developmental period and total survival on treated plants with all doses of fenvalerate and low doses of acephate were completed as normal as untreated control, whereas other treatments resulted in prolongation of developmental period and significant reduction in total survival.

Keywords: *Bemisia tabaci,* Insecticides, Development, Cotton.

Introduction

Over 1400 species of whitefly have been repented, *Bemisia tabaci* considered to be the most important one. It attacks more than 600 host plants causing economic damages to many crops either through sucking the sap of the plants or contaminating plants and fruits with honeydew in addition to affecting plant photosynthesis. The economic damage of this pest has further increase being a vector of more than 110 viral diseases that cause serious damages and yield losses in significant agricultural crop [1]. Since 1990, whitefly has emerged as a serious pest on cotton in North India. It became one of the important limiting factors for successful growing of cotton in Punjab [2]. The economic damages caused by this pest estimated to range between 10.6 to 92.2 per cent in seed-cotton yield in Punjab (India) by spreading cotton leaf curl virus disease [3]. Resurgence of whitefly in the recent years has been attributed to many factors including indiscriminate use of insecticides [4-6]. However, the mechanism by which these chemicals favor the whitefly is not well known. Therefore, there is a need for understanding how these chemicals favored this pest and lead to its outbreak. Keeping above in view, the studies were conducted as a part of research work on hormoligosis of insecticides in *Bemisia tabaci* for investigating the changes in life history of this pest in response to repeated application of insecticides that is widely used for controlling cotton bollworms in Punjab.

Material and Methods

The study was carried out in screenhouse on *Gossypium hirsutum* Cotton var. LH.1556 during August and September 2002 crop season at the Entomological Research Farm, Punjab Agricultural University, Ludhiana. For initiating the culture, adults of whitefly were collected from the field using single tube aspirator (20 x 0.70 cm) and released on untreated cotton plants of *hirsutum* var. LH 1556 kept in a separate screenhouse. The old plants were replaced with new ones whenever needed. Soil used in the experiment was prepared by mixing with FYM in the ratio of 1:1. After sieving the mixture, sample from the soil was taken for analysis. The mixture found to be loamy sand with 8.30 pH, 0.20 m mhos/cm, electrical conductivity, 0.87% organic carbon, 28.8 kg/hectare available phosphorous and more than 300 kg/hectare available potassium. The pots were then filled with equal quantity of this soil that ensures all pots contained soil possessing uniform properties.

The test plants were raised in pots (30 x 23 cm) using seeds of *hirsutum* variety LH-1556 obtained from Senior Cotton Breeder, Department of Plant Breeding, Punjab Agricultural University, Ludhiana. After germination, only a healthy seedling was retained in each pot which were kept in whitefly free screenhouse that prepared by spraying its walls, roof and ceiling with Hostathion 40 EC (triazophos) @ 0.6 ml per liter of water prior to transferring the pots to the cage. Further, yellow sticky traps (12 x 12 cm) were placed in screenhouse one meter apart to keep it free of whitefly.

The 50-day old plants in each experiment were split into five sets, in which the first set was given one spray, the second two sprays, the third three sprays, the fourth four sprays and the fifth five sprays of quinalphos (250, 375 and 500 g), carbaryl (625, 938 and 1250 g), acephate (750, 1125 and 1500 g), endosulfan (438, 656 and 875 g) and fenvalerate (25, 38 and 50 g ai/ha), keeping, 7 days interval between two sprays. The sprayed plants were used for conducting the experiment.

The cylindrical leaf cage (3.1 cm in diameter and 2.0 cm in length) was made from cylindrical semi-transparent plastic can (empty photographic film cover) by cutting its bottom. Six circular holes (0.75 cm in diameter) were made on the sides of the tube at equal distances from each other, with the help of electrical soldering rod. Five holes were covered with muslin using Fevicol to facilitate ventilation, while one hole was kept uncovered for releasing the whitefly adults into the cage, which was later plugged with the cotton swab. Transparent sheet was glued on the cutting end of the tube with Fevicol, for helping inspection of caged insects. A sheet of sun mica (4 cm^2) covered with thin sponge piece (10 mm thickness) measuring 4 cm^2 using Fevicol was used for supporting the leaf cage. The other end of the tube was fastened on the lower surface of the cotton leaf and supported from the upper side of the leaf by the sun mica piece with the help of a simple lady's hair clip which was modified manually for proper fastening of the cage. One end of the hair clip was placed on sun mica sheet, while the other end was placed above the end of the leaf cage having transparent sheet, sandwiching the leaf between the leaf cage and sun mica sheet. Leaf cages were attached to the lower leaf surface of fully opened top leaves (three replications per treatment) of the sprayed plants. Five pairs' whitefly adults from the colonies were confined to each leaf cage for egg laying. After 24 hours, adults were removed along with leaf cage. The leaf portion under each leaf cage was marked and observed under stereomicroscope binocular using 25X for the number of eggs laid. Only 20 eggs were kept and the remaining was removed carefully with the help of a needle and a fine brush. Again the leaf cages were attached to the leaves on the marked area to prevent oviposition by *B. tabaci* from outside and moving of crawlers outside the marked area. The marked area was observed daily under stereomicroscope binocular (25X) for life history study. The duration of various developmental stages was recorded and their weighted means were calculated. The time period between the laying of eggs and the appearance of the crawlers was taken as the incubation period. Similarly, the time period between crawler stage and the appearance of red-eyed nymphs was considered as the nymphal period. The time between the appearance of pupa and adult emergence was taken as the pupal period. The period from egg laying to the appearance of adult was considered as the total developmental period. Besides, survival of eggs, nymphs, pupae and the overall survival of immature stages was also recorded. Data obtained was analyzed by Complete Randomized Design (CRD).

Results and Discussion

1. Egg stage

Duration:

The results of the bio-residual effect of different insecticidal treatments on the duration of eggs are presented in Table 1. The data revealed that the incubation period varied from 5.5 to 8.8 days in all sprays with non-significant differences between different treatments except in the pooled data (carbaryl at 1250 g/ha). Under unsprayed conditions, the incubation period has earlier been reported to range from 2 to 4 days during March-October and 7 to 8 days during November and February [7, 8]. Under Punjab conditions, the incubation period on cotton plants has been reported to range between 3-9 days [9-11]. These results support the present findings in which the incubation period ranged from 5.5 to 8.8 days.

Table 1. Duration and survival of eggs of *B. tabaci* on American cotton (Var. LH 1556) after different insecticidal treatments

Insecticide	Dose	Duration of eggs (days) after different Sprays						Percent survival after different sprays					
	(g a.i./ha)	1st	2nd	3rd	4th	5th	Pooled mean	1st	2nd	3rd	4th	5th	Pooled mean
Quinalphos	250	7.5	6.4	7.0	7.4	7.0	7.1	80.0	90.0	46.7	88.3	71.7	75.3 (63.7)
	375	7.9	7.5	6.3	6.9	7.1	7.1	81.7	76.7	90.0	91.7	73.3	82.7 (69. 4)
	500	7.9	7.3	6.6	6.7	7.0	7.1	80.0	68.3	83.3	81.7	70.0	76.7 (65.2)
Carbaryl	625	7.2	6.8	7.0	7.7	7.0	7.1	100.0	93.3	76.7	88.3	80.0	87.7 (78.6)
	938	6.6	7.1	5.9	6.9	7.0	6.9	68.3	75.0	60.0	71.7	76.7	70.0 (58.5)
	1250	8.8	6.9	6.2	7.5	7.0	7.2	73.3	75.0	56.7	93.3	60.0	71.7 (60.1)
Acephate	750	6.1	7.0	6.2	6.8	7.0	6.6	96.7	83.3	68.3	91.7	55.0	79.0 (66.9)
	1125	6.6	6.5	5.8	7.0	7.3	6.6	98.3	75.0	90.0	96.7	70.0	86.0 (73.1)
	1500	7.3	7.1	6.3	7.1	7.4	7.1	75.0	96.7	81.7	93.3	73.3	84.0 (72.1)
Endosulfan	438	7.7	6.9	5.8	6.8	7.1	6.9	73.0	73.3	93.3	78.3	51.7	74.0 (63.7)
	656	5.6	7.1	5.9	6.8	7.0	6.5	70.0	78.3	68.3	85.0	65.0	73.3 (61. 5)
	875	6.8	7.0	5.7	6.9	7.0	6.7	91.7	95.0	53.3	88.3	66.7	79.0 (67.1)
Fenvalerate	25	7.1	7.1	6.3	6.8	7.2	6.9	95.0	90.0	96.7	85.0	91.7	91.7 (77.8)
	38	6.6	6.5	5.8	7.0	7.6	6.7	96.7	90.0	96.7	98.3	63.3	89.0 (76.6)
	50	7.5	5.9	5.5	6.5	7.3	6.5	75.0	96.7	91.7	95.0	78.3	87.3 (73. 6)
Untreated control	Water spray	6.3	6.6	6.0	7.0	7.0	6.6	100.0	83.3	85.0	95.0	78.3	88.3 (74.8)
CD (p=0.05)		NS	NS	NS	NS	NS	0.5	NS	NS	NS	NS	NS	(10.8)

*Figures in parenthesis are arcsine-transformed values.

Egg survival:

The data obtained on the survival eggs revealed non-significant differences in different treatments in all the sprays except in pooled data (Table 1). The survival eggs in pooled data varied from 70.0 to 91.7%. Decrease in egg survival was observed in quinalphos (250 g/ha), carbaryl (938 and 1250 g/ha) and endosulfan (438 and 656 g/ha) compared with untreated control. The survival eggs on acephate treated plants varied from 79 to 86% in the present studies is in agreement with that recorded earlier [9]. Similarly, the survival eggs (87.7 to 91.7%) in fenvalerate treatments is in agreement with that reported earlier (73.0 to 92.5%) by Saini [12]. Non-significant differences observed in survival eggs in different treated and untreated plants in the present studies might be attributed to the fact that as the eggs were laid by female on treated plants after spray in which the chance of contact between eggs and insecticides was comparatively less.

2. Nymphal stage

Duration:

Different insecticides have shown significant residual effect on the duration of nymphs (Table 2). After the 1st spray, the nymphal duration varied from 9.3 to 12.4 days (carbaryl at 1250 and 938 g/ha) with non-significant differences between various treatments. After the 2nd spray, minimum nymphal period was observed in fenvalerate 38 and 50 g/ha (9.9 and 10.0 days, respectively), which were at par with untreated control (9.7 days). Maximum nymphal period was recorded in all the treatments of endosulfan, followed by carbaryl at 1250 g/ha, quinalphos at 500 and 375 g/ha and acephate at 750 g/ha. The rest of the treatments were at par with untreated control. Almost similar trend of results was observed after the 3rd, 4th and 5th sprays with minor changes. The pooled data revealed that all the doses of endosulfan and carbaryl at 938 and 1250 g/ha, quinalphos at 500 and 375 g/ha and acephate at 1500 g/ha significantly prolonged the duration of the nymphal stage as compared with untreated control. The prolongation of the nymphal duration in the above treatments confirmed their adverse effects. Similar results have been reported earlier in the case of fenvalerate 50 g/ha [12] acephate 1500 g/ha [9].

Survival:

The data presented in Table 2 revealed that different treatments have shown significant differences on the nymphal survival. Nymphal survival did not vary significantly in different treatments after the 1st and 2nd sprays except significant reduction in higher dose of carbaryl and endosulfan after the 2nd spray. The significant increase in the nymphal survival was observed only in lower dose of quinalphos (250 g/ha) and acephate (750 g/ha) after the 3rd spray. This trend of results has changed after the 4th spray. It indicated a significant reduction in the nymphal survival in endosulfan treatments (656 and 875 g/ha). After the 5th spray, all the doses of endosulfan, carbaryl and higher doses of quinalphos as well as the low dose of fenvalerate significantly reduced the nymphal survival, whereas other treatments remained at par with untreated control.

Table 2. Duration and survival of nymphs of *B. tabaci* on American cotton (Var. LH 1556) after different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Duration of nymphs (days) after different sprays						Percent survival after different sprays					
		1st	2nd	3rd	4th	5th	Pooled mean	1st	2nd	3rd	4th	5th	Pooled mean
Quinalphos	250	11.5	10.9	11.9	13.0	11.2	11.7	60.3 (51.40)	61.0 (51.49)	54.8 (47.79)	80.0 (68.04)	75.8 (61.66)	66.4 (56.08)
	375	10.6	11.1	12.7	13.3	11.7	11.9	49.2 (44.89)	70.0 (56.82)	35.7 (36.26)	68.5 (56.51)	60.0 (51.66)	56.7 (49.23)
	500	11.1	11.1	13.2	13.3	11.7	12.1	61.9 (51.89)	72.1 (58.29)	35.0 (36.26)	72.7 (58.60)	53.9 (47.25)	59.1 (50.48)
Carbaryl	625	10.8	10.1	12.7	12.3	11.3	11.5	45.0 (42.01)	66.7 (54.86)	30.6 (33.49)	75.8 (61.44)	55.0 (47.89)	54.6 (47.94)
	938	12.4	10.9	12.8	12.8	11.0	12.0	62.1 (53.13)	63.6 (53.00)	41.1 (39.82)	78.1 (63.40)	72.2 (58.44)	63.4 (53.55)
	1250	9.3	11.4	13.5	13.5	11.8	11.9	43.3 (40.92)	47.1 (43.29)	28.5 (32.05)	56.7 (48.82)	63.7 (52.97)	47.8 (43.61)
Acephate	750	11.1	11.0	12.7	12.8	10.7	11.7	61.8 (52.11)	74.7 (60.27)	51.5 (45.85)	74.4 (60.38)	94.1 (78.48)	71.3 (59.42)
	1125	11.0	10.0	13.4	12.3	11.0	11.6	61.1 (51.81)	80.0 (63.52)	28.3 (32.13)	71.7 (57.84)	74.8 (64.67)	63.2 (53.99)
	1500	11.3	10.6	12.7	13.3	11.6	11.9	51.0 (45.55)	55.0 (48.06)	26.3 (30.84)	70.8 (57.70)	77.6 (62.67)	56.2 (48.97)
Endosulfan	438	11.0	11.3	12.9	12.6	11.9	11.9	44.5 (41.87)	88.3 (70.09)	21.2 (27.16)	81.6 (64.62)	50.5 (45.37)	57.2 (49.82)
	656	11.9	11.9	13.5	13.1	12.6	12.6	41.1 (39.23)	58.3 (50.46)	27.2 (31.38)	45.5 (42.49)	52.2 (46.29)	44.9 (41.97)
	875	11.2	11.5	13.5	14.4	13.4	12.8	61.9 (51.99)	44.3 (41.65)	23.4 (28.66)	48.1 (43.83)	54.4 (47.87)	46.4 (42.80)
Fenvalerate	25	10.9	10.5	12.5	11.8	10.0	11.1	70.2 (57.10)	72.1 (58.16)	31.8 (34.11)	90.8 (75.56)	68.5 (56.51)	66.7 (56.29)
	38	10.8	9.9	12.2	10.9	9.3	10.6	59.9 (51.35)	72.4 (58.63)	39.4 (38.85)	81.6 (65.61)	77.6 (66.40)	66.2 (56.17)
	50	10.5	10.0	12.0	12.2	10.1	11.0	80.4 (68.26)	70.0 (56.82)	36.7 (37.13)	72.9 (58.96)	78.0 (63.30)	67.6 (56.89)
Untreated control	Water spray	11.7	9.7	12.4	11.6	10.2	11.1	88.3 (70.47)	71.6 (58.45)	33.4 (35.10)	77.4 (62.22)	91.2 (79.68)	72.4 (61.19)
CD (p=0.05)		NS	1.2	0.7	1.3	1.3	0.6	NS	(12.64)	(8.49)	(16.02)	(21.03)	(7.26)

*Figures in parenthesis are arcsine-transformed values.

The pooled analysis of the data revealed that all the doses of endosulfan and carbaryl as well as the higher doses of quinalphos caused significant reduction in the nymphal survival, whereas other treatments remained at par with untreated control. These results clearly indicate the absence of adverse effect of fenvalerate on the survival of the nymphal instars which being as normal as untreated control. Saini [12] compared the nymphal survival in fenvalerate (50 and 100 g/ha) with untreated control, observing non-significant differences in all the treatments. However, *B. tabaci* is reported to be susceptible to endosulfan under Punjab condition [13].

Nymphal growth index:

The data presented in Table 3 revealed that significant effects of different insecticidal treatments started appearing after the 2nd spray, with significant reduction in carbaryl (1250 g/ha) and endosulfan (656 and 875 g/ha) as compared with untreated control. These changes were rather inconsistent for both the 3rd and 4th sprays. However, significant reduction in growth index over untreated control was observed in all the doses of endosulfan, higher doses of quinalphos (357 and 500 g/ha) and carbaryl (625 and 1250 g/ha) after the 5th spray. The pooled analysis of the data revealed that all doses of endosulfan, carbaryl, higher doses of quinalphos and acephate (1500 g/ha) resulted in significant reduction in nymphal growth index, whereas all doses of fenvalerate and low doses of acephate (750 and 1125 g/ha) and quinalphos (250 g/ha) were at par with untreated control. The similarity in the growth index values on all the doses of the fenvalerate with untreated control further indicated non-adverse effect on nymphal stage of *B. tabaci*.

Table 3. Nymphal growth index of *B. tabaci* cotton (Var. LH 1556) after different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Growth index* after different sprays					Pooled mean
		1st	2nd	3rd	4th	5th	
Quinalphos	250	5.2	5.7	4.6	6.2	6.8	5.7
	375	4.7	6.3	2.8	5.2	5.3	4.8
	500	5.9	6.5	2.7	5.5	4.7	5.0
Carbaryl	625	4.1	6.6	2.4	6.2	4.8	4.8
	938	5.3	5.9	3.2	6.2	6.6	5.4
	1250	4.9	4.2	2.1	4.2	5.4	4.2
Acephate	750	5.5	6.8	4.1	5.9	9.0	6.2
	1125	5.6	8.0	2.1	5.9	6.8	5.7
	1500	4.5	5.2	2.1	5.3	6.7	4.8
Endosulfan	438	4.1	7.8	1.7	6.5	4.3	4.9
	656	3.5	4.9	2.1	3.5	4.2	3.6
	875	5.7	3.8	1.7	3.4	4.1	3.8
Fenvalerate	25	6.5	6.9	2.6	7.7	6.9	6.1
	38	5.6	7.4	3.2	7.6	8.6	6.5
	50	7.7	7.2	3.1	6.0	7.7	6.3
Untreated control	Water spray	7.6	7.4	2.7	6.8	9.1	6.7
CD (P=0.05)		NS	2.2	1.1	1.8	2.8	1.1

$$\text{* Nymphal growth index} = \frac{\text{Percent survival of nymphs}}{\text{Duration of nymph}}$$

3. Pupal stage

Duration:

The pupal duration varied from 1.5 to 3.4 days with minimum being in acephate 1125 g and 1500 g/ha and maximum in quinalphos 250 g/ha, but without significant differences between different treatments (Table 4). Saini [12] recorded non-significant effect of cypermethrin, fenvalerate at 50 and 100 g/ha for both and deltamethrin at 10 and 20 g/ha on the duration of the pupa of *B. tabaci* on cotton, with average duration ranged between 1.52 to 4.95 days. Similarly, Kaler [9] reported non-significant differences in the pupal duration between acephate treated plants at 1500 g/ha with untreated control.

Survival:

Pupal survival ranged between 56.2 to 100% in different treatments with non-significant differences (Table 4). This may be attributed to the fact that the pupal stage is non-feeding and an immovable stage that reduces the contact with insecticide residues left on the leaves of the sprayed plants. Similar results were also obtained earlier [12].

4. Total developmental period

Duration:

The data presented in Table 5 revealed that different insecticidal treatments have shown significant residual effect on duration of total developmental period except after the 1st spray. After the 2nd spray, the maximum duration of the developmental period was recorded with endosulfan doses and higher doses of quinalphos, whereas other treatments remained at par with untreated control (19.3 days). The trend of the results was not stable after the 3rd, 4th and 5th sprays. The pooled analysis of the data of all the sprays revealed that the developmental period was completed on sprayed plant with fenvalerate and the lowest doses of acephate as normal as untreated control. However, all the doses of endosulfan, quinalphos and higher doses of carbaryl (938 and 1250 g/ha) and acephate (1500 g/ha) caused significant prolongation in the total developmental period of *B. tabaci* which in turn indicated the absence of hormoligosis by these insecticides. The shortest developmental period was also observed on the plants treated with deltamethrin, cypermethrin, fenvalerate and alphamethrin [12, 14] and acephate, cypermethrin and monocrotophos [9] compared to untreated control. Similarly, prolongation of the developmental period due to insecticides has been reported in case of Neemazal, Rakshakgold and ICIPE neem compared with untreated control [15].

Total survival:

Different insecticidal treatments have shown significant differences on the total survival of whitefly except after the 1st spray (Table 5). After the 2nd spray, only endosulfan at 875 and 438 g/ha and carbaryl at 1250 g/ha caused significant reduction in total survival (25.0, 31.7 and 28.3%, respectively), whereas all other treatments remained at par with untreated control (56.7 %). Almost a similar trend of results was observed after the 3rd, 4th and 5th sprays except higher dose of quinalphos (500 g/ha) and carbaryl (938 g/ha) that caused significant reduction in total survival after the 5th spray.

Table 4. Duration and survival of pupae of *B. tabaci* on American cotton (Var. LH 1556) after different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Duration of pupa (days) after different sprays						Percent survival after different sprays					
		1st	2nd	3rd	4th	5th	Pooled mean	1st	2nd	3rd	4th	5th	Pooled mean
Quinalphos	250	2.0	3.4	2.3	2.1	2.7	2.5	97.6	91.7	100.0	86.7	92.5	93.7
	375	1.8	3.3	2.1	2.1	2.3	2.3	97.4	79.1	68.7	94.6	91.0	86.2
	500	2.8	3.3	2.2	1.9	2.0	2.4	80.0	97.4	57.1	91.3	92.6	83.7
Carbaryl	625	2.0	2.8	2.0	2.1	2.4	2.3	100.0	84.9	88.6	97.2	97.4	93.6
	938	2.3	3.0	1.7	1.9	2.2	2.2	89.8	88.9	75.0	94.4	91.7	88.0
	1250	2.5	2.9	1.8	1.8	2.0	2.2	100.0	81.0	88.9	97.2	84.1	90.3
Acephate	750	2.6	2.5	2.3	2.1	2.8	2.5	94.5	87.1	67.9	87.6	81.0	83.6
	1125	2.8	3.1	1.5	2.0	2.9	2.4	80.7	83.3	81.7	81.1	97.4	84.7
	1500	1.5	2.5	2.4	1.9	2.7	2.2	88.9	90.4	96.7	89.6	76.5	88.4
Endosulfan	438	2.3	3.3	2.1	1.8	2.3	2.4	83.3	77.8	88.9	81.8	88.9	84.2
	656	2.5	3.3	1.9	1.7	2.3	2.4	90.0	56.2	83.4	96.3	96.3	84.5
	875	3.1	3.3	2.1	2.1	2.4	2.6	77.8	85.4	91.7	80.4	58.3	78.7
Fenvalerate	25	2.7	2.3	1.9	1.8	2.4	2.2	97.9	100.0	90.3	80.4	81.9	90.1
	38	2.2	3.3	2.0	1.8	2.5	2.4	96.7	75.0	94.4	90.5	94.4	90.2
	50	2.8	2.8	1.8	1.9	3.4	2.5	91.1	88.5	83.3	100.0	93.8	91.3
Untreated Control	Water spray	2.5	3.1	1.7	2.2	2.2	2.3	91.0	90.4	100.0	100.0	84.0	93.1
CD (p=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Total developmental period and survival of immature stages of *B. tabaci* on American cotton (Var. LH- 1556) after different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Total duration of life cycle (days)* after different sprays						Total survival (%)* after different Sprays					
		1st	2nd	3rd	4th	5th	Pooled mean	1st	2nd	3rd	4th	5th	Pooled mean
Quinalphos	250	21.0	20.8	21.2	22.5	20.9	21.3	46.7 (43.06)	53.3 (46.89)	26.7 (30.66)	61.7 (51.67)	50.0 (45.10)	47.7 (43.49)
	375	20.3	21.9	21.0	22.3	21.0	21.3	38.3 (37.98)	43.3 (41.11)	21.7 (27.27)	58.3 (49.81)	41.7 (40.18)	40.7 (39.27)
	500	21.8	21.7	21.9	21.9	20.7	21.6	41.7 (39.98)	40.0 (39.20)	18.3 (25.30)	55.0 (48.06)	35.0 (36.12)	38.0 (37.73)
Carbaryl	625	20.0	19.7	21.7	22.1	20.7	20.8	45.0 (42.01)	51.7 (45.94)	23.3 (28.77)	61.7 (51.76)	43.3 (41.14)	45.0 (41.92)
	938	21.3	21.0	20.4	21.6	20.1	20.9	38.0 (38.07)	43.3 (40.94)	18.3 (24.80)	51.7 (45.94)	35.0 (36.06)	37.3 (37.16)
	1250	20.5	21.1	21.5	22.7	20.8	21.3	30.0 (32.99)	28.3 (31.63)	13.3 (21.33)	46.7 (43.04)	31.7 (34.22)	30.0 (32.64)
Acephate	750	19.8	20.5	21.1	21.7	20.5	20.7	46.7 (43.06)	50.0 (44.97)	25.0 (29.91)	60.0 (50.83)	43.3 (41.00)	45.0 (41.96)
	1125	20.4	19.6	20.7	21.3	21.1	20.6	58.3 (50.06)	50.0 (44.98)	21.7 (27.70)	60.0 (50.94)	43.3 (41.15)	46.7 (42.96)
	1500	20.2	20.3	21.4	22.2	21.7	21.2	35.0 (35.96)	48.3 (44.08)	20.0 (26.44)	60.0 (51.12)	41.7 (40.07)	41.0 (39.53)
Endosulfan	438	21.0	21.5	20.8	21.2	21.3	21.2	28.3 (31.13)	31.7 (33.84)	16.7 (24.04)	51.7 (45.94)	25.0 (29.91)	30.7 (32.97)
	656	20.0	22.3	21.3	21.6	21.8	21.4	23.3 (28.07)	36.7 (37.13)	16.7 (23.73)	38.3 (38.23)	31.7 (34.01)	29.3 (32.23)
	875	21.1	21.8	21.4	23.5	22.8	22.1	43.3 (40.76)	25.0 (29.67)	11.7 (19.88)	33.3 (35.20)	21.7 (27.08)	27.0 (30.52)
Fenvalerate	25	20.7	19.9	20.6	20.4	19.5	20.2	65.0 (53.82)	65.0 (53.85)	28.3 (32.08)	80.0 (64.72)	50.0 (44.98)	57.7 (49.89)
	38	19.5	19.7	20.0	19.7	19.3	19.6	56.7 (49.48)	53.3 (46.82)	36.7 (37.21)	73.3 (59.98)	51.7 (46.53)	54.3 (48.00)
	50	20.8	18.7	19.2	20.6	20.7	20.0	53.3 (46.99)	63.3 (52.89)	28.3 (32.13)	66.7 (55.05)	63.3 (52.72)	55.7 (47.96)
Untreated control	Water spray	20.5	19.3	20.1	20.7	19.4	20.0	80.0 (63.52)	56.7 (48.91)	28.3 (32.13)	71.7 (58.72)	60.0 (50.94)	59.3 (50.84)
CD (p=0.05)		NS	2.0	1.4	1.5	1.8	0.8	NS	(12.89)	(7.40)	(13.39)	(13.91)	(5.97)

*Figures in parenthesis are arcsine-transformed values.

The analysis of the pooled data revealed that the total survival of *B. tabaci* in all the doses of fenvalerate was at par with untreated control, whereas all other treatments caused significant reduction in the total survival. The present studies revealed that the total survival of *B. tabaci* in fenvalerate was as normal as in untreated control. On the other hand, endosulfan caused significant reduction in the total survival, which was followed by the highest doses of carbaryl and quinalphos. Endosulfan caused significant reduction in the survival of all the immature stages, which ultimately adversely affected the total survival. Among all immature stages, the nymphal stage was the most susceptible stage. According to Horowtiz [16], mortality of *B. tabaci* is highest during the crawlers and the young nymphal stage, with an average of 17 to 40% per cent of eggs reached the adult stage. Total survival of *B. tabaci* on cotton plants treated with deltamethrin and fenvalerate was at par with untreated control [12]. Acephate at 1500 g/ha, monocrotophos at 500 g/ha and cypermethrin at 50 g/ha increased the total survival of *B. tabaci* significantly over untreated control, whereas at triazophos 600 g/ha and chlorpyriphos at 1000 g/ha caused reduction in the total survival [9].

Growth index of immature stages:

The differences in growth index of immature stages after the 1st spray were non-significant (Table 6). After the 2nd spray, significant reduction in growth index was observed in all the doses of endosulfan and the highest dose of carbaryl in comparison with untreated control. After the 3rd spray, significant reduction in growth index was observed in the highest dose of carbaryl and quinalphos and in all doses of endosulfan. Almost a similar trend of the results was observed after the 4th and 5th sprays and pooled data of all the sprays.

The overall results revealed that fenvalerate and low doses of acephate did not affect the developmental period and survival of *B. tabaci* and remained as normal as untreated control. These treatments found to induce hormoligosis in *B. tabaci* by causing significant increase in fecundity [17] coupled with increase in total sugars and free amino acids of host plant [18]. The increase in fecundity along with no adverse effect on total survival and total developmental period may enable whitefly to produce more number per generations that ultimately may lead to resurgence of this pest as reported earlier by many workers. However, the results of the present studies have confirmed hormoligosis of fenvalerate and acephate in *B. tabaci*.

Table 6. Immature stages growth index* of *B. tabaci* on cotton (Var. LH 1556) after different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Growth index after different sprays					Pooled mean
		1st	2nd	3rd	4th	5th	
Quinalphos	250	2.2	2.6	1.2	2.8	2.4	2.2
	375	1.9	2.0	1.0	2.6	2.0	1.9
	500	2.0	1.8	0.8	2.5	1.7	1.8
Carbaryl	625	2.2	2.5	1.1	2.8	2.1	2.2
	938	1.8	2.1	0.9	2.4	1.8	1.8
	1250	1.5	1.4	0.6	2.1	1.5	1.4
Acephate	750	2.4	2.4	1.2	2.8	2.2	2.2
	1125	2.9	2.6	1.1	2.8	2.1	2.3
	1500	1.7	2.4	0.9	2.7	1.9	1.9
Endosulfan	438	1.4	1.5	0.8	2.4	1.2	1.5
	656	1.2	1.7	0.8	1.8	1.5	1.4
	875	2.1	1.1	0.6	1.4	1.0	1.2
Fenvalerate	25	3.1	3.3	1.4	3.9	2.6	2.9
	38	2.9	2.7	1.8	3.8	2.8	2.8
	50	2.6	3.4	1.5	3.2	3.1	2.8
Untreated control	Water spray	3.9	2.9	1.4	3.5	3.1	3.0
CD (P=0.05)		NS	1.1	0.5	1.0	1.3	0.5

NS = Non-significant

$$\text{* Immature stages growth index} = \frac{\text{Per cent survival of immature stages}}{\text{Duration of immature stages}}$$

References

[1] Winter, S. "Whitefly-transmitted Viruses of the World". *2nd European Whitefly Symposium Cavtat – Croatia*, 5-9 Oct. (2004).

[2] Singh, J., Singh, D., Sohi, A.S., Brar, D.S., Kapoor, S.K. and Russel, D. "Management of Resistant Insect Pests of Cotton in North India: An Analysis." *Proc ICAC – CCRI Regional Consultation Insecticide Resistance Management in Cotton*, June 29 to July 1, Multan, Pakistan, (1990), 131-142.

[3] Singh, J., Sohi, A.S., Mann, H.S. and Kapur, S.P. "Studies on Whitefly *Bemisia tabaci* (Genn.) Transmitted Cotton Leaf Curl Disease in Punjab." *J. Insect Sci.*, 7 (1994), 194-198.

[4] Jayaraj, S., Rangarajan, A.V., Murugesan, S., Santharam, S., Vijayaraghavan and Thangaraj, D. "Studies on the Outbreak of Whitefly *Bemisia tabaci* (Gennadius) on Cotton in Tamil Nadu." In: S. Jayaraj (Ed.), *Resurgence of Sucking Pests*. Tamil Nadu Agricultural University, Coimbatore, India, (1987), 103-115.

[5] Patil, B.V., Nandihalli, B.S. and Hugar, P. "Effect of Synthetic Pyrethroids on Population Build-up of Cotton Whitefly, *Bemisia tabaci* (Gennadius)." *Pestology*, 14 (1990), 17-21.

[6] Butter, N.S. and Kular, J.S. "Resurgence of Whitefly in Cotton and Its Management." *Indian J. Ent.*, 61 (1999), 85-90.

[7] Mohanty, A.K. and Basu, A.N. "Biology of Whitefly Vector, *Bemisia tabaci* (Genn.) on Four Host Plants throughout the Year." *J. Ent. Res.*, 11 (1987), 15-18.

[8] Abdullah, N.M.M. and Singh, J. "Biology of Whitefly, *Bemisia tabaci* (Gennadius) on American Cotton under Punjap Conditions." *Pest Mgt. Econ. Zolo.*, 12 (2004), 1-6.

[9] Kaler, D. "Impact of Some Insecticides on Population Build-up of Whitefly *Bemisia tabaci* (Genn.) on Cotton *(Gossypium hirsutum)*." Approved Ph.D. Thesis, Punjab Agricultural University, Ludhiana, India, 1999.

[10] Aneja, A.K. "Studies on the Biology of Cotton Whitefly *Bemisia tabaci* (Gennadius) on American Cotton, *Gossypium hirsutum* (Linnaeus)." Approved M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India, 2000.

[11] Dhawan, A.S. and Saini, H.K. "Effect of Different Synthetic Syrethroids on Longevity and Fecundity of Whitefly, *Bemisia tabaci* (Gennadius) on Cotton." *Indian J. Ecol.*, 28 (2001), 62-69.

[12] Saini, H.K. "Effect of Synthetic Pyrethroids on the Biology of Whitefly, *Bemisia tabaci* (Gennadius) on *Gossypium hirsutum* (Linnaeus)." Approved M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India, 1997.

[13] Singh, D., Denholm, I., Russel, D., Sharma, N. and Sarao, P.S. "Insecticide Resistance Pattern in Whitefly, *Bemisia tabaci* (Gennadius) from Punjab." In: D.R.C. Bakhetia, V.K. Dilawari, J. Singh and B.S. Joia (Eds.), *Proc Critical Issues of IPM in the Changing Agricultural Scenario in India*. Punjab Agricultural University, Ludhiana, India, (1998), 26-27.

[14] Tamilselvan, C., Sundararaj, R., Regu, K. and David, D.V. "Influence of Deltamethrin on the Biochemical Parameters of Cotton and Biology of the Whitefly *Bemisia tabaci* (Genn.)." *Pestology*, 14 (1990), 17-19.

[15] Singh, G. "Management of Whitefly, *Bemisia tabaci* (Gennadius) on Cotton with Neem Based Insecticides." Ph.D. Thesis, Punjab Agricultural University, Ludhiana, India, 2000.

[16] Horowitz, A.R., Podole, H. and Gerling, D. "Life Table Analysis of the Tobacco Whitefly, *Bemisia tabaci* (Gennadius) in Cotton Fields in Israel." *Acta Ecol-oecologia*, 5 (1984), 331-33.

[17] Abdullah, N.M.M. and Singh, J. "Hormoligosis of Insecticides in Fecundity of *Bemisia tabaci* (Genn.) on Cotton." *J. Insec. Sci.*, 4 (2004), (In press).

[18] Abdullah, N.M.M., Singh, J. and Sohal, B.S. "Effect of Repeated Application of Insecticides on Biochemical Components of Cotton Plants." *71st Annual Meeting, Society of Biological Chemistry*, 14-16 November, Ludhiana, India, 2002.

التأثير الحيوي المتبقي لبعض المبيدات في تطور حشرة الذبابة البيضاء *Bemisia tabaci* (Gennadius) على نبات القطن

عبد الله ناشر مرشد* و جوجندر سنج**

*قسم وقاية النبات، كلية الزراعة، جامعة صنعاء (ص.ب. ١٣٦٠٩، مكتب بريد معين، صنعاء، اليمن)

** قسم الحشرات، كلية الزراعة، جامعة البنجاب الزراعية، لوديانا، البنجاب، الهند.

(قدم للنشر في ١٤٢٥/١١/٢٨هـ ؛ قبل للنشر في ١٤٢٦/١٠/١٨هـ)

كلمات مفتاحية: الذبابة البيضاء؛ المبيدات؛ التطور؛ البقاء؛ القطن.

ملخص البحث. أجريت هذه الدراسة خلال موسم القطن عام ٢٠٠٢م في مزرعة قسم الحشرات في جامعة البنجاب الزراعية، لوديانا (البنجاب - الهند). تم رش كل من مبيد الكوينالفوس (٢٥٠، ٣٧٥، ٥٠٠ جم)، والكاربارايل (٦٢٥، ٩٣٨، ١٢٥٠ جم)، وأسيفيت (٧٥٠، ١١٢٥، ١٥٠٠ جم)، وإندوسولفان (٤٣٨، ٦٥٦، ٨٧٥ جم)، وفنفاليرات (٢٥، ٣٨، ٥٠ جم مادة فعالة/ هكتار) بشكل متكرر خمس مرات بفارق زمني ٧ أيام على نباتات القطن الأمريكي (صنف LH 1556) المزروعة في أصص. تم إطلاق خمسة أزواج من الحشرة الكاملة للذبابة البيضاء في قفص صغير ثبت على الورقة العلوية المتفتحة حديثا للنباتات المعاملة بعد ٣ أيام من الرش. وتم إزالة الحشرات الكاملة مع القفص بعد ٢٤ ساعة، وتم وضع علامة على المنطقة التي كانت تحت القفص ثم فحصت المنطقة كاملة تحت البينوكيولر باستخدام ٢٥ قوة تكبير بغرض عد البيض عليها. تم الاحتفاظ بعشرين بيضة فقط بينما تم التخلص من كل البيض الباقي، ثم أعيد القفص على المنطقة المحددة، وتم فحص هذه المنطقة يوميا تحت البينوكيولر وتسجيل التغيرات البيولوجية للأطوار المختلفة. أوضحت النتائج المتحصل عليها أن فترة حضانة البيض تراوحت بين ٥,٥ إلى ٨,٨ أيام مع عدم وجود فروق معنوية بين المعاملات المختلفة. وبالمثل لم تظهر أي من المعاملات أي تأثيرات معنوية على بقاء البيض. أظهرت النتائج أن كل المبيدات المختبرة – باستثناء الجرعات الثلاث المختبرة للفنفاليرات– قد سببت إطالة للفترة التي تقضيها الحشرة في طور الحورية، كما أثرت كل المبيدات سلبا في بقاء هذا الطور ومؤشر النمو فيه. لم تظهر أي من المبيدات المختبرة أي تأثيرات معنوية في فترة طور العذراء ولا بقائها. إن الفترة الكاملة للتطور وكذلك البقاء الكلي كانت طبيعية تماما (مثل الشاهد) في النباتات المرشوشة بالفنفاليرات، بينما سببت المبيدات الأخرى إطالة معنوية للفترة الكلية للتطور وكذلك تأثيرا معنويا في البقاء الكلي.