

Residual Effectiveness of certain Insecticides for Controlling Whitefly on Cucumber Plants

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ABSTRACT

The residual effectiveness of insecticides (pirimiphos-methyl, chlorpyrifos, cypermethrin and fenvalerate) was compared for control whitefly *Bemisia* spp on cucumber plants grown outdoor. Three sprays were applied of 15 days intervals. Reduction of whitefly population was estimated after each spray. The highest reduction of *Bemisia* spp population was 83.2, 83.0, 73.9 and 56.6 at pirimiphos-methyl, chlorpyrifos, cypermethrin and fenvalerate treatments, respectively after one day post the first spray. The reduction percentage declined afterwards and reached approximately 8-10 % after 15 days post treatments. The same trend was observed after the second and the third spray in which the highest reduction was achieved at the first day after insecticide applications. In the meantime inadequate reduction was observed after three days from treatment. The remaining residues of cypermethrin on the cucumber leaves were more than that of pirimiphos-methyl. However, the rate of decay of cypermethrin on cucumber leaves was slightly higher than that of pirimiphos-methyl. Moreover, the $t_{1/2}$ was 2.1 and 3.15 day for cypermethrin and pirimiphos-methyl, respectively, under the field conditions.

INTRODUCTION

Bemisia spp erupted as the major pest of a spectrum of crops (Bellows *et al*, 1994). The recent and rapid rise of the whitefly as a major pest of many crops suggested that control of this species is difficult (Prabhaker *et al*, 1989). Chemical control is the primary method to manage *B. tabaci* (Gennadius) field population has been inadequate in California (Prabhaker *et al*, 1985). The control of this pest has depended on virtual year-round insecticide use. The overlapping of crops that serve as hosts of this species throughout the annual cropping cycle encourages high population densities. As a result of this and the use of insecticides, selection pressure for resistance development is probably high (Prabhaker *et al*, 1996). Two major factors that contribute to this whitefly's annual resurgence are the development of resistance to various organophosphorus and pyrethroid compounds and ineffective coverage of aerially applied insecticide on lower surfaces leaves (Jonson *et al*, 1982). The high levels of resistance to many organophosphorus and pyrethroids have been reported in field populations of *B. tabaci* in various regions (Dittrich *et al*, 1985, Horowitz *et al*, 1988 and Cahill *et al*, 1995). Although many insecticides remain effective against whitefly populations, the demonstration of the genetic potential in whiteflies to develop high level of insecticide resistance reinforces concerns that some insecticides will become ineffective if resistance management strategies are not implemented (Prabhaker *et al*, 1998). However, management of whiteflies is difficult compared with the other insect pests. Successful management of whiteflies requires an integrated program that focuses on prevention and relies on cultural and biological control methods when possible. While insecticides will be required in most programs, they should be selected carefully and used only when shown to be needed by a regular monitoring program.

The aim of the present work is to evaluate the residual activity of some insecticides against the whitefly population under the field condition. The Kinetic parameters of decay of insecticide residues were also estimated as an indication of their efficiency to control whitefly.

MATERIALS AND METHODS

Chemicals:

The following insecticides were purchased locally and used for the field trails at the recommended rate, Actellic (pirimiphos-methyl, 50%EC and Dursban (chlorpyrifos-ethyl) 48% EC, at a rate of 2.0 ml/liter, Cypermethrin 10% EC at a rate of 0.5 ml/l and Sumicidin (fenvalerate) 20%EC at rate of 0.75 ml/l.

Field Trials:

The experiment was carried out at the King Faisal Agriculture Research Station at Al-Hassa. KSA. The experiment was designed in randomized block design. Cultural practices were applied as recommended for commercial production of cucumber. The effect of the four different insecticides against the adults of whiteflies *Bemisia* spp were evaluated under the field conditions. Insecticide was applied three times at 15 days intervals. Three replicates were set up for each treatment. A hand operated knapsack sprayer was used to apply the insecticides. Treatments were evaluated by counting the adult stage on ten leaves, taken at random from each plot. Insect counts were taken just before and after treatment at zero (an hour), 1,3,7 and 15 days. The reduction percentage in the whitefly population was estimated using Henderson and Teleton equation (1965). Statistical analysis was carried out according to Snedecor and Cochran (1967) after transformation of the data to values of square root for $(x+1)$.

Insecticide residue analysis:

Sampling, Extraction and Clean up:

Samples were extracted and cleaned-up according to the methods adopted by Bullock (1984) and Alsarar (1996). About 200g of treated leaves was collected at random from each treatment, then put in perforated cardboard boxes and transferred to the laboratory. The representative samples of non-treated and treated leaves were taken from each treatment at different intervals after treatment (zero, 1,3,7 and 15 days). The leaves were cut into small pieces and three sub samples (20g

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of each) was weighed into polyethylene sacs and kept deep-frozen until extraction.

Samples were extracted by blending with 50 ml acetonitriles for pirimiphos-methyl or acetone for cypermethrin at high speed for 2 min. The whole extract decanted through a glass wool plug in a glass funnel, containing 5 gm anhydrous sodium sulfate. The filtrate was concentrated to about 25 ml using rotary evaporator. The filtrate was shaken vigorously for 2 min. with 75 ml petroleum ether in a separatory funnel. The aqueous layer was taken and another 25 ml of petroleum ether was added and shaken again for 2 min. The two organic layers were taken and concentrated using rotary evaporator to about 5-10 ml

Twenty gm of activated florisil 60-100 mesh at 130°C for 16 hours was packed in 300 mm X 25mm chromatographic column in small portions, while tapping the column. A layer of 5gm anhydrous sodium sulfate was added to the top of florisil. The column, pre wet by allowing 40-50ml of petroleum ether. Samples extract was transferred to the column. A total of 70 ml of the eluting mixtures (15 and 50% diethylether in petroleum ether for pirimiphos-methyl) and 80% benzene in petroleum ether for cypermethrin were used. The eluent was concentrated to 5 ml.

Determination

Determination of insecticides was carried out by gas liquid chromatography (GC-14 Shmiadzo) equipped with FPD and ECD detectors. A series of gradient concentrations, ranged from 2.5 to 10 g/l of reference standard insecticides in acetone were prepared for establishing the calibration curves. The following chromatographic conditions for OP compound (pirimiphos-methyl) were: column [RTX-50 (crossband 50 % phenyl-50% methyl polysiloxane) L 30 m ID 0.53 mm DF 0.25 M], 220 °C, injector and detector 250 °C. Same conditions were used for cypermethrin except for column [(4% OV-210 on chromosorb WHP80-100 mesh), diameter 1x2mx5mm OD x 3m ID)], 230 °C. Nitrogen as carrier gas was (99.99% purity) at flow rate of 60 ml/min. A mixture of hydrogen and air was used as combustion gases at rate of 45ml and 50 ml/min. The pressures were 0.7 and 0.6 atm. The

residue analysis was calculated according to the method of Goodspeed and Chestnut 1991. The average rates of recovery of each insecticides was determined and the quantification of the residues was corrected according to the rate of recovery. The average recovery of samples at 1.0 ppm were 91.5 and 86.8 for pirimiphos-methyl and cypermethrin, respectively. The data was subjected to statistical analysis.

RESULTS AND DISCUSSIONS

Effect of insecticide treatments on *Bemisia* spp infestation.

The effect of certain insecticide treatments on *Bemisia* spp was studied under the field condition. Four insecticides were applied, two of them belong to organophosphorus group (pirimiphos-methyl and chlorpyrifos ethyl) and the others belong to synthetic pyrethroids (fenvalerate and cypermethrin). These insecticides were applied at the vegetative stage of cucumber. Three sprays were performed. The period between two sequential spray treatments was 15 days. The mean numbers of *Bemisia* spp at different intervals; an hour, 1, 3, 7 and 15 days after the first spray of insecticides is recorded in Table (1). The data showed that the mean number after one hour was 13.1, 14.7, 19.1 and 29.9 adult per leaf at chlorpyrifos-ethyl, pirimiphos-methyl, cypermethrin and fenvalerate, respectively. While the mean number was 56.2 adult per leaf at the control. The data showed that the number of *Bemisi* spp was declined in all insecticide treatments after one hour of application compared with the control. By the time, the mean number of whiteflies increased gradually. Meanwhile the recorded number of whiteflies was more in the control compared with all the insecticide treatments at the various intervals of inspection. Along the fifteen days, the statistical analysis showed a significant difference between the control and the insecticide treatments. In the meantime no significant difference was estimated between cypermethrin and fenvalerate or between pirimiphos-methyl and chlorpyrifos-ethyl in their effects on the number of whiteflies. Furthermore, organophosphorus insecticides were more effective than synthetic pyrethroids at the applied concentrations. The data reflected

that, the effect of insecticide treatments against *Bemisia* population was adequate within the first three days post treatments, then the effect declined afterwards. The reduction in the insecticide activities against whitefly might due to the effects of environmental factors on these insecticides.

Table (1): Mean number of *Bemisia* spp per leaf throughout fifteen days after 1st spray of insecticide treatments

Treatment	No of whitefly/leaf					
	One hour	1 day	3 days	7 days	15 days	Mean
Control	56.2	78.3	74.2	84.4	93.8	77.32 ^c
Pirimiphos-methyl	14.7	14.1	26.2	48.5	81.6	37.02 ^a
Chlorpyrifos-ethyl	13.1	13.3	32.8	26.2	85.8	34.24 ^a
Cypermethrin	19.1	20.4	54.2	78.8	83.2	51.14 ^b
Fenvalerate	29.9	34.0	44.0	78.0	86.0	54.38 ^b
LSD _{0.05} = 10.5						

The same trend was recorded after the second and third sprays in which a significant difference was estimated between the insecticide treatments and the control in their effect on *Bemisia* spp population (Tables 2 and 3). The reduction percentages of *Bemisia* population was calculated using Handerson and Teleton equation (1965) for the three sprays along 15 days after treatments (Fig. 1-3). The data showed that the highest reduction was observed during the first three days of inspection.

Table (2): Mean number of *Bemisia spp* per leaf throughout fifteen days after 2nd spray of insecticide treatments.

Treatment	No of whitefly/leaf					
	One hour	1 day	3 days	7 days	15 days	Mean
Control	63.2	76.0	56.4	92.0	80.8	73.68 ^c
Pirimiphos-methyl	22.6	22.6	17.8	64.8	89.8	43.92 ^{ab}
Chlorpyrifos-ethyl	36.8	33.4	34.4	91.6	58.4	50.92 ^b
Cypermethrin	14.2	38.6	48.4	70.0	77.0	49.64 ^b
Fenvalerate	6.4	26.6	16.6	67.4	68.6	37.12 ^a
LSD _{0.05} - 9.86						

Table (3): Mean number of *Bemisia spp* per leaf throughout fifteen days after 3rd spray of insecticide treatments

Treatment	No of whitefly/leaf					
	One hour	1 day	3 days	7 days	15 days	Mean
Control	119.2	88.0	92.4	113.2	96.0	59.28 ^c
Pirimiphos-methyl	35.6	11.6	31.6	52.0	86.8	43.52 ^a
Chlorpyrifos-ethyl	40.4	38.6	54.0	110.4	74.4	63.56 ^b
Cypermethrin	44.6	35.6	62.6	68.4	85.2	59.28 ^b
Fenvalerate	36.8	40.0	57.2	58.8	72.8	53.12 ^{ab}
LSD _{0.05} - 11.9						

Fig.1. Reduction percentage of *Bemisia* spp on cucumber plant at different intervals of insecticide treatments (1st spray)

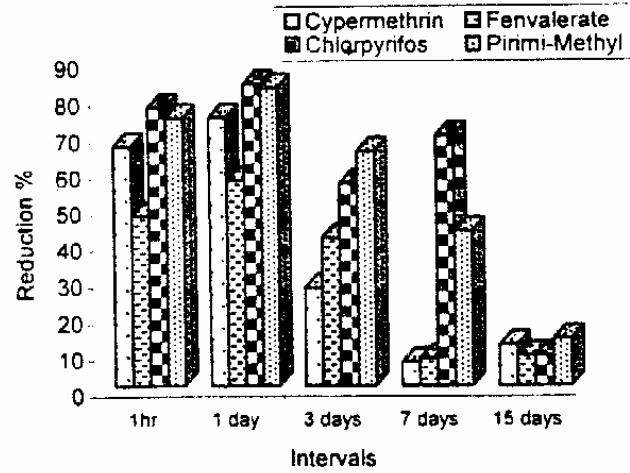


Fig.2. Reduction percentage of *Bemisia* spp on cucumber plant at different intervals of insecticide treatments (2nd spray)

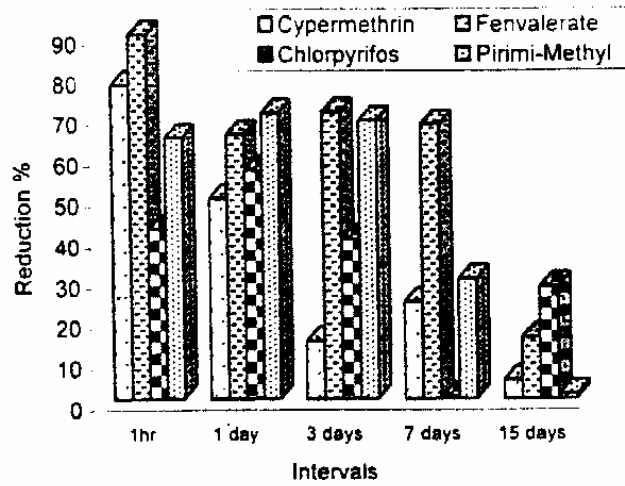
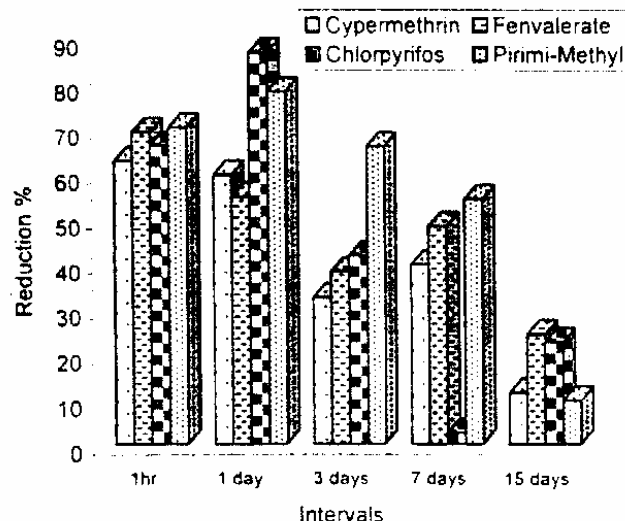


Fig.3 Reduction percentage of *Bemisia* spp on cucumber plant at different intervals of insecticide treatments (3rd spray)



The highest reduction percentages were 83% and 82% after one day of chlorpyrifos-ethyl and pirimiphos-methyl treatments, respectively. The lowest reduction percentages were after 15 days of application for all the insecticide treatments. The same trend was observed after the second and the third sprays. Generally, the highest reduction percentages achieved was less than 90%, in other words non of the insecticide treatments gave 100% reduction of *Bemisia* spp population. Moreover, most of the tested insecticides failed to give an adequate reduction of the *Bemisia* spp population after one week of treatments. The results are consistent with those of Tkachuk *et al* (1983), they reported that fenvalerate at 0.1-0.2% reduced the whitefly population in greenhouse by 89-99.6%, while pirimiphos-methyl reduced the population by only 40.6%. Moreover, Horowitz *et al* 1988, reported that , the highest mortality of *Bemisia tabaci* was (99.2%) obtained with single application of a mixture of

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cypermethrin and DEF. While DEF alone gave 77.3-81.1% kill. In the meantime cypermethrin with sodium chlorate gave the lowest mortality recorded (20.4-54.4%). Furthermore, Ishaaya *et al* 1987, reported that cypermethrin toxicity to whitefly under the field condition was strongly synergized by adding an equal weight of monocrotophos or acephate. The reduction of whitefly infestation is verified by determining the remaining residues of two of the tested insecticides pirimiphos-mehtyl and cypermethrin.

Table (4): Pirimiphos-methyl and cypermethrin residues on the cucumber leaves at different intervals from insecticide application

Time	Insecticide			
	Pirimiphos-methyl		Cypermethrin	
	Residue level (mg/kg)	Residue%	Residue level (mg/kg)	Residue%
1 hr	9.6 ± 2.3	100	31.7 ± 2.11	100.0
1 day	6.4 ± 1.1	66.7	19.2 ± 1.72	60.56
3 days	3.8 ± 0.81	39.6	13.67 ± 0.06	43.12
7 days	2.8 ± 0.62	29.2	8.4 ± 0.02	26.50
15 days	0.3 ± 0.04	3.1	1.1 ± 0.01	3.3

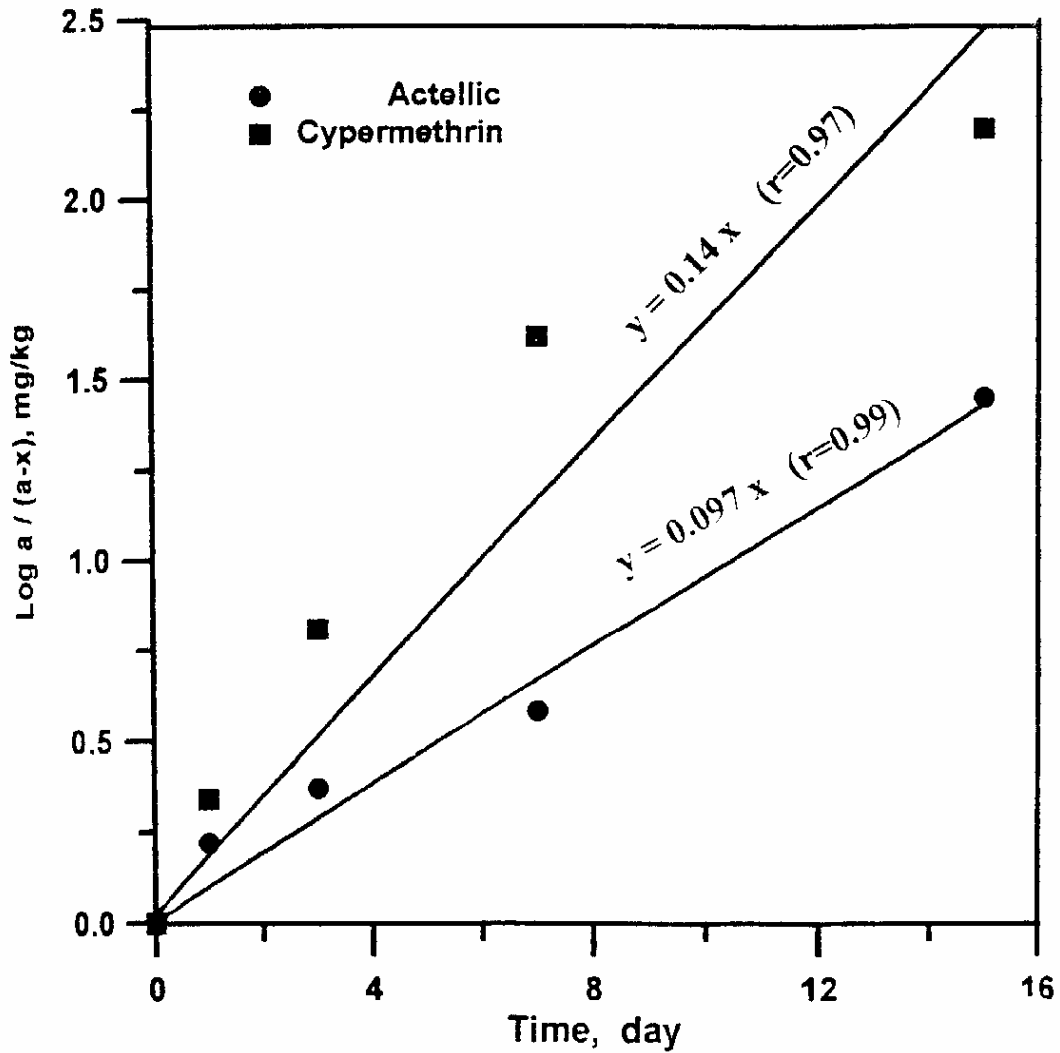


Fig (4): Linear plot of Primiphos-methyl (●) and Cypermethrin (■) residues on cucumber leaves. Where (a) is the initial residues and (a - x) the residues remain at time (t).

Determination of pirimiphos-methyl and cypermethrin residues and their kinetic parameters of degradation.

Table (4) shows the decay of pirimiphos-methyl and cypermethrin residues on the cucumber leaves at different intervals from insecticide applications. The data showed that the residues were 9.6 and 31.7 mg/kg for pirimiphos-methyl and cypermethrin, respectively, after an hour, then the residues declined afterwards and reached 0.3 and 0.28 mg/kg for pirimiphos-methyl and cypermethrin after 15 days post application. The degradation behavior of both insecticides under the field condition was deduced from the logarithmic linear relationship between insecticide residues versus the time. The data showed linear correlation whereas the correlation coefficient equal 0.99 and 0.97 for pirimiphos-methyl and cypermethrin, respectively. Thus the kinetic of degradation follow the first order reaction. The kinetic parameters of degradation for both insecticides are shown in Table (5). The results showed that the rate constants of degradation were 0.22 and 0.33 day⁻¹ for pirimiphos-methyl and cypermethrin residues, respectively.

Table (5): Kinetic parameters of pirimiphos-methyl and cypermethrin degradation on cucumber leaves.

Insecticides	Rate constant of degradation (k)	T _{1/2} (day) ⁻¹	Slope	r*
Pirimiphos-methyl	0.22	3.15	0.095	0.99
Cypermethrin	0.27	2.57	0.117	0.91

- correlation coefficient

The time require to degrade the half amount of the initial residues (t_{1/2}) was 3.15 day for pirimiphos-methyl while it was 2.10 day for cypermethrin. The data revealed that the remaining residues of cypermethrin were higher than that of pirimiphos-methyl throughout the

first week after the application. However, the rate of cypermethrin degradation was slightly higher compared with pirimiphos-methyl. The results in line with that reported by Abdall *et al* 1993, in which 83.7% of pirimiphos-methyl was decayed after one day of application on tomato fruits grown outdoor. They suggested that the fast degradation of pirimiphos-methyl be depended on the environmental factors. Moreover, Antonious and Abdell-All 1988, reported that the $t_{1/2}$ of pirimiphos-methyl residues on tomato and squash was about 3 days. Also Hegazy *et al* 1989, reported that the $t_{1/2}$ of pirimiphos-methyl residues on tomato fruits was about 3 days under the indoor conditions. Furthermore, Al-Sarar 1996 reported that the rate of decay of cypermethrin residues on tomato fruits was higher than that on cucumber fruits. While the $t_{1/2}$ of cypermethrin was 0.88 and 2.95 day on tomato and cucumber fruits, respectively. In the meantime he reported that the $t_{1/2}$ of pirimiphos-methyl was 2.31 and 0.47 day on tomato and cucumber fruits, respectively. The results might support the field evaluation data in which pirimiphos-methyl was more effective against whitefly at the used rate of application. Moreover, the data reflect that within three days, approximately half of both insecticides decayed, which refer to the need for repeating the application of insecticide or another controlling agent or alternate insecticide after a period of three days to control or reduce the whitefly population. The possible explanation of the fast reduction of insecticide effectiveness might due to fast degradation of these compounds under the field conditions; the immigration of whitefly individuals; the development of resistance to all classes of insecticides and /or existence of new biotype of whitefly.

The present investigation suggests that the control of whitefly should not depend mainly on insecticides alone since inadequate control was achieved after three days of insecticide applications. The integration of many methods or disciplines under the umbrella of IPM may be useful to control this serious pest in the near future. Moreover, the strategies should be fulfilling to manage or delay resistance in whitefly.

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الملخص العربي

فعالية متبقيات بعض المبيدات في مكافحة الذبابة البيضاء على نباتات الخيار

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تم دراسة فعالية بعض متبقيات المبيدات الحشرية (البيريثروس ميثايل، الكلوربيريفوس، السبير مثرين، الفنفاليريت) في مكافحة الذبابة البيضاء على نباتات الخيار في مرحلة النمو الخضري والمنزوع تحت ظروف الحقل المكشوف. حيث تم تطبيق ثلاث رشقات بين كل رشوة ١٥ يوما. وأظهرت النتائج أن أعلى نسبة خفض في أعداد الذبابة البيضاء وصلت إلى ٨٢,٢%، ٨٣%، ٧٣,٩%، ٥٦,٧% على النباتات المعاملة بالبيريثروس ميثايل، الكلوربيريفوس، السبير مثرين، الفنفاليريت على الترتيب بعد يوم واحد من الرشوة الأولى ثم قلت نسبة الخفض بعد ذلك في الأيام التالية حيث وصلت نسبة الخفض إلى حوالي ٨-١٠% عند اليوم الخامس عشر من الرشوة الأولى. كما لوحظ نفس السلوك في نسبة خفض أعداد الذبابة البيضاء بعد الرشوة الثانية والثالثة حيث كانت أعلى نسبة خفض في أعداد الذبابة البيضاء بعد اليوم الأول من رش معظم المبيدات المختبرة. في كلتا الرشقتين ومن ناحية أخرى لم يلاحظ انخفاض كبير في أعداد الذبابة البيضاء بعد اليوم الثالث من أي من الرشقات الثلاث.

كما درست العلاقة بين متبقي السبير مثرين والبيريثروس ميثايل على أوراق نباتات الخيار والتأثير على الذبابة البيضاء حيث أوضحت النتائج أن كمية متبقي السبير مثرين خلال أسبوع من الرش كانت أعلى من متبقيات البيريثروس ميثايل مع أن ثابت معدل تحطم مبيد السبير مثرين كان أعلى نسبيا من ثابت معدل تحطم مبيد البيريثروس ميثايل على أوراق نباتات الخيار. حيث كان الزمن اللازم لتحطم نصف كمية المتبقي حوالي ٢,١٥، ٢,١٠ يوم لكل من السبير مثرين والبيريثروس ميثايل على التوالي تحت ظروف الحقل المكشوف.