

Research Article

Biological parameters of *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) exposed to lethal and sublethal concentrations of Calypso[®]

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Abstract: Efficacy of the neonicotinoid insecticide, Calypso[®] was studied on eggs, nymphs and adults of *Trialeurodes vaporariorum* Westwood, using a leaf disc bioassay method. Concentrations from 0.15 to 0.8 ml/l were applied by systemic-contact method. Nymphs were more susceptible than eggs and adults, and LC₅₀ and LC₃₀ values were estimated to be 0.465 and 0.263 ml/l, respectively. Also, the longevity and fecundity of exposed females was reduced compared to control. Moreover, the demographic parameters were adversely influenced compared to control. The intrinsic rate of increase (*r_m*) was significantly decreased to 0.132 and 0.139 day⁻¹ at LC₅₀ and LC₃₀ level, compared to control (0.152 day⁻¹). Other life table parameters (*R₀*, λ , *T*, and *DT*) were also significantly lower in the treated insects. Sublethal concentrations of Calypso[®] may reduce the insecticide residuals on greenhouse crops and reduce the resistance development in greenhouse whiteflies. Therefore, these concentrations may be applicable in the management of *T. vaporariorum* after complementary studies.

Keywords: life table parameters, whitefly, Calypso®, sublethal concentrations

Introduction

The greenhouse whitefly (GW), *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) is one of the most serious pests of many horticultural and greenhouse crops worldwide (Helgesen and Tauber, 1974; Zabel *et al.*, 2001). Large populations of this insect can consume high quantities of plant phloem sap which can result in reduction of plant growth and yield (Johnson *et al.* 1992). Adults can transmit some plant viruses like beet pseudo yellow virus (BPYV), tomato yellow leaf curl virus (TYLCV) and bean golden mosaic virus (BGMV) (Liu et al., 1993; Bi et al., 2002; Karatolos et al., 2010). Also, adults and nymphs cause damage by producing honeydew that encourages the growth of sooty molds and contamination of leaves and fruits (Gerling, 1992; Liu et al., 1993; Coffin and Coutts, 1995; Guzman et al., 1997). The greenhouse whitefly is a noxious polyphagous pest; so its control is very hard and for a long time has been accomplished by variable success. Use of synthetic insecticides has a long history and is the primary mode of its control; however, there are several reports on the development of genetic resistance in populations of GW against many of the chemicals being used both in the greenhouses and fields (Elhag and Horn, 1984; Omer et al., 1992; Sanderson and Rousch, 1992; Gorman et al., 2002; Karatolos et al., 2010, 2012).

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Indiscriminate and injudicious use of pesticides has posed a major problem of developing insecticidal resistance. This pest had already been reported to have developed resistance to pyrethroids, carbamates and organophosphate including dimethoate (Zheng and Gao, 1995; Rufinger *et al.*, 1999; Sood *et al.*, 2003).

Neonicotinoid insecticides are compounds agonistically nicotinic acting on insect acetylcholine receptors (nAChR). They are especially important to agriculture because of their activity against not only sucking hemipteran insects such as aphids, whiteflies, and plant-hoppers, but also against many coleopteran and some lepidopteran pest species (Nauen et al., 2003; Iwasa et al., 2004). Calypso[®] [(Z)-3-(6-chloro-3-pyridylmethyl)-1, 3-thiazolidin-2-ylidenecyanamide; Calypso[®]] is systemic insecticide that like other а chloronicotinyl insecticides acts selectively on the insect nervous system as an agonist of the nicotinic acetylcholine receptor. It is a highly active novel insect control agent with broad spectrum efficacy against sucking and biting insects depending on crop, pest and application type (Elbert et al., 2008; Saimandir et al., 2009).

Sood et al. (2006) reported that the insect is also quickly acquiring resistance even to neonicotinoid insecticide imidacloprid and suggested its restricted use. The ongoing introduction of new compounds (e.g., acetamiprid, thiamethoxam, thiacloprid, dinotefuran, and clothianidin), unless carefully regulated and coordinated, seems bound to increase exposure to neonicotinoids and to enhance conditions favoring appearance of resistant phenotypes (Nauen and Denholm, 2005). In order to postpone the resistance development in GW against a specific insecticide, it is important to find an alternative approach which is effective and environmentally compatible (Avery et al., 2015).

It has been revealed that the acute mortality of insect pests is not the only determinant of insecticidal efficiency. On the other word, in addition to direct mortality caused by insecticides, some biological traits of insect pests may be also affected by sublethal doses (Jafarbeigi *et al.*, 2014). It has been recommended to use demographic toxicology for evaluation of both lethal and sublethal influences of a toxicant on host population because stable population parameters especially r_m take into account not only host survivorship, but also fecundity of targeted females (Stark *et al.*, 2004).

In this research, we evaluated the lethal efficiency of Calypso® as chloronicotinyl neonicotinoid insecticide controlling for greenhouse whitefly on common bean. Moreover, sublethal influences of Calypso® were studied on some biological properties and life table parameters of GW. Our results may improve T. vaporariorum control efficiency in greenhouses meanwhile using reduced concentrations of this insecticide. These may contribute in hindered host resistance to Calypso® and reduced residuals on greenhouse crops.

Materials and Methods

Insect culture

The population of T. vaporariorum was originated from the greenhouse of Urmia University, Iran in summer of 2013. They were collected, using an aspirator, from Phaseolus vulgaris L, which was never exposed to any insecticide. After determination precise (Hodges and Evans, 2005), insects were reared in cages ($50 \times 50 \times 35$ cm) on young common beans planted in pots (20 cm height and 15 cm diameter) for up to three successive generations and kept at 28 \pm 2 °C, 60 \pm 10% RH and a photoperiod of 16:8 (L: D) h (air conditioningequipped glasshouse). To achieve homogeneous nymphal populations in bioassays, newly green bean plants with two or four leaves were placed into large and transparent cylindrical cages (with 30 cm height and 20 cm diameter) with organdy sleeve (300 µm) and then infested by introducing 150 young adult whiteflies (sex ratio \approx 1: 1). Adults were allowed to oviposit for 24 h on leaves. Then, adults were removed and plants with whitefly eggs were transferred to other insect-free cages. Cages were divided into three groups. The first group was used for egg bioassays and next two groups were applied for bioassay of young nymphs, and adults.

Insecticide

The insecticide used in this research was Thiacloprid (Calypso[®] 480 SC, Bayer CropScience Limited, Germany), applied at various concentrations on different life stages of the pest after preliminary bioassays. Required concentrations were prepared as serial dilutions of the insecticide in distilled water.

Bioassays

The lethal effect of Calypso® was assessed on eggs, nymphs (2nd and 3rd instars), and adults. preliminary bioassays, Based on the concentrations of Calypso[®] experimental involved 0.15, 0.2, 0.3, 0.4, 0.6 and 0.8 ml/l. For each treatment 14 individuals were used. Control insects were treated with distilled water. A leaf disc (5.5 cm in diameter) with 40 eggs were cut off from fully expanded bean leaves and immersed for 20s in the 20 ml of each given concentration or distilled water. Treated leaves were placed in laboratory conditions for 20-30 min until dry. The leaf discs were placed with their adaxial surface downwards (to simulate the normal feeding orientation of the whiteflies) onto a thin layer of 5% water-agar (Agar-agar, Merck KGaA) in 90 mm diameter plastic Petri dishes. Petri dishes were sealed with Parafilm® and kept in an incubator at 25 \pm 2 °C, 75 \pm 5% RH, and 16: 8 (L: D) h. A circular opening (0.5 cm in diameter) covered with thin insect-proof net was opened on the lid of each Petri dish. Mortalities (insect individuals desiccated and/or discolored) were recorded for 5 days (on nymphs) and 8 days (on eggs) in daily intervals.

For adult bioassays, briefly, bean leaf discs (5.5 cm in diameter) dipped in different concentrations of insecticide solution for 20s, and placed on the water–agar medium in Petri dishes with their adaxial surface downwards. CO₂-anaesthetized adult whiteflies (in the same age) were then transferred onto the treated leaf

discs using a fine brush. Each Petri dish was then covered with a ventilated lid and stored upside down. Water vapor condensation and static electricity that may hinder the movement of the whiteflies inside the sealed Petri dishes were minimized by covering the internal surface of the lids with a thin layer of absorbent paper (Pappas and Migkou, 2013). Mortalities were scored for the next 8 days. Experiments were replicated four times.

Effect of Calypso[®] on life table parameters

In this experiment, life table parameters of T. vaporariorum were studied under two concentrations of Calypso[®] including LC₅₀ (= 0.465 ml/l) and LC₃₀ (= 0.236 ml/l). Ten female adult whiteflies were transferred on untreated and insect-free bean plants (2-4 leaves) with suitable ventilation. After 24 hours, adults were removed leaving just eggs. Adults produced from these eggs were the same age and were used in life table experiments. Newly emerged bean leaves (4-6 cm) were cut and after dipping for 20 s in each concentration, left for 30 minutes to dry. A number of adult insects were released on treated leaves. After 24 hours, twenty of females survivorship were randomly selected and each transferred on a new leaf in a cage (130 mm height and 70 mm diameter). Leaves were replaced every day until death of the last individual. The number of eggs per cage and resulting nymphs were recorded on daily basis. Control insects were treated with sterile distilled water.

Statistical analysis

Mortality data, including four replicates data were handled by probit analysis in SPSS 22 (SPSS Inc., 2013) using the common logarithm (Log₁₀) of the concentration value. Probit regression analysis and x^2 goodness–of–fit tests were used to determine specific lethal concentration (LC₃₀ and LC₅₀) values. Analysis of variance and mean comparison (Tukey, P < 0.01) of percent mortalities were performed using SPSS (Norusis, 1993). Longevity and fecundity data were used to construct a life table according to age-specific method described by Carey (1993). Pseudo-values of the life table parameters were calculated by jackknife procedure to estimate their means and standard errors (Maia *et al.*, 2000). All curves were drawn by MS Excel (2013).

Results

Bioassays

Shapiro-Wilk test for normality of mortality data in different developmental stages of whitefly showed a normal distribution of data using the skewness and kurtosis indices (Finney, 1971). All concentrations of insecticides caused mortality on T. vaporariorum eggs, nymphs and adults under experimental conditions and mortality percentages were significantly different (P < 0.01) within each stage of whitefly. However, nymphs were much more sensitive to insecticide. As, their corrected mortalities varied from 36.87 to 96.87 percent in concentrations ranging from 0.15 to 0.8ml/l of Calypso[®], respectively. In the same concentrations of the insecticide, 17.5 and 59.37 percent mortality was recorded for pest eggs. Furthermore, survival of adult insects decreased from 18.75 to 70 percent, respectively in 0.15 and 0.8 ml/l of experimental doses (Table 1).

Probit analysis revealed that the median lethal insecticidal concentration (LC_{50}) of Calypso[®] was 0.684, 0.186 and 0.465 ml/l on egg, nymph and adults, respectively (Table 2). According to Chi–square values, observed

and expected data were homogenous, therefore, no heterogeneity factor was used in calculation of confidence limits. Comparison confidence limits of LC₅₀ values of demonstrated that nymphs were remarkably more susceptible to Calypso[®] than eggs and adults. However, there was no considerable difference in LC50 values between pest eggs and adults (Table 2). LC₃₀ values were used sublethal concentrations for further as experiments on life table parameters. The estimated values of LC₃₀ were 0.275, 0.103 and 0.236 ml/l on whitefly eggs, nymphs and adults, respectively (Table 2).

Life table parameters

Results showed that age-specific survivorship and realized fertility $(l_x m_x)$ of T. (l_x) vaporariorum were affected by LC₃₀ (0.263 ml/l) and LC₅₀ (0.465 ml/l) concentrations of Calypso[®] (Fig. 1) compared to those of control insects. Moreover, the mean longevity of adult whiteflies was considerably (F = 27.29, df = 2, 17: P < 0.001) decreased in the treated compared to control insects (Table 3). Additionally, the number of eggs deposited by each treated female insect in each day (F =48.25; df = 2, 17; P < 0.001) and the total number of eggs produced by each female whitefly in both Calypso[®] treatments (F = 12.39; df = 2, 17; P < 0.001) were negatively influenced in comparison with untreated individuals (Table 3).

	Mortality (%) (Mean \pm SE) ¹			
Doses (ml/l)	Egg	Nymph	Adult	
0.8	59.37 ± 0.625^{a}	96.87 ± 0.625^{a}	70.00 ± 1.020^{a}	
0.6	46.87 ± 0.625^{b}	88.12 ± 0.625^b	57.75 ± 0.721^{b}	
0.4	39.37 ± 0.625^{c}	80.00 ± 1.020^{c}	48.75 ± 0.721^{c}	
0.3	31.25 ± 0.721^d	66.87 ± 1.196^{d}	34.75 ± 0.625^{d}	
0.2	23.12 ± 0.625^e	$57.50 \pm 1.020^{\text{e}}$	25.62 ± 0.625^{e}	
0.15	$17.50\pm0.000^{\rm f}$	$36.87\pm1.196^{\rm f}$	$18.75 \pm 0.721^{\rm f}$	

Table 1 Mean percentage mortalities of different developmental stages of *Trialeurodes vaporariorum*, caused by varying concentrations of Calypso[®].

^{$\overline{1}$} Means in each column followed by the same letter are not significantly different (Tukey HSD test, P < 0.01).

Table 2 Results of probit analysis on mortalities of different stages of *Trialeurodes vaporariorum* exposed to various concentrations of Calypso[®].

322 ± 0.151 0.218 ± 0.080 4 2.700 0.609	
042 ± 0.157 1.490 ± 0.096 4 5.388 0.250	
500 ± 0.150 0.416 ± 0.081 4 2.248 0.690	
.($)42 \pm 0.157 1.490 \pm 0.096 4 5.388 0.250$ $500 \pm 0.150 0.416 \pm 0.081 4 2.248 0.690$

¹ Confidence intervals are in parenthesis.



Figure 1 Age-specific survivorship (l_x) and realized fertility $(l_x m_x)$ of *T. vaporariorum* females in control and two treatments (LC₃₀ and LC₅₀) of Calypso[®].

The expected total time for living of an individual of age x is explained by life expectancy curves. The expected life span was 18 days for control insects. However, this

value was 16.7 and 16.1 days when treated at LC_{30} and LC_{50} doses, respectively (Fig. 2).

Furthermore, there were remarkable differences between life table parameters of control insects and both tested treatments of Calypso[®]. Net reproductive rate (R_0) of treated insects was remarkably decreased (F = 45.26; df = 2, 17; P < 0.001). Moreover, intrinsic rate of increase (r_m) was 0.152 per day in control insects compared to 0.132 per day for LC₅₀ treatment (F = 78.94; df = 2, 17; P < 0.001). Also, the same trend was recorded for the finite rate of increase (λ) (F = 96.07; df = 2, 17; P < 0.001). As expected mean generation time (T) was statistically higher in treated females concentration wise and in comparison with control (F = 21.18, df = 2, 17; P < 0.001). Additionally, doubling time (DT) was increased in Calypso[®] treatments compared to control individuals (F = 32.56; df = 2, 17; P < 0.001).



Figure 2 Life expectancy (e_x) of adult *T*. *vaporariorum* females in control and two treatments (LC₃₀ and LC₅₀) of Calypso[®].

Discussion

Insecticides are used extensively in agriculture to reduce the crop losses by pests (Maredia *et al.*, 2003). However, they should be used cautiously, because of their persistence, damage to the environment and/or their toxicity to mammals and non-target organisms (van Emden and Service, 2004).

In this research, both lethal and sublethal effects of Calypso[®] were considered on T. vaporariorum. Bioassays showed that eggs, nymphal stages and also adults of greenhouse whitefly were affected markedly by Calypso® concentrations. Eggs were influenced less than other life stages; however, about 59% of them were killed by the highest concentration of Calypso[®]. Adults suffered more death than eggs exposed the same when to Calypso[®] concentrations. Our results showed that nymphs were the most susceptible individuals to the insecticide. Similarly, Bi and Toscano (2007) observed that nymphs especially their early instars were the most susceptible individuals to some conventional insecticides such as chlorpyrifos, fenpropathrin and malathion as well as some neonicotinoid insecticides including imidacloprid, thiamethoxam and acetamiprid. Moreover. nymphs of Τ. vaporariorum were highly susceptible to spiromesifen, but moderately to diafenthiuron, buprofezin and chlorfenapyr (Kumar and Singh, 2014). Studies by Wang et al. (2003) on the susceptibility of immature and adult stages of greenhouse whitefly to six insecticides showed that abamectin was the most toxic insecticide to eggs and nymphs, followed by neonicotinoids, acetamiprid. imidacloprid and However, imidacloprid was the most toxic insecticide to by Τ. vaporariorum adults, followed acetamiprid, buprofezin, abamectin, fenpropathrin and profenofos.

Neonicotinoids have proved relatively resilient to the development of resistance. However, resistance has been confirmed in some populations of the whitefly, *Bemisia tabaci* (Gennadius) (Hem.: Aleyrodidae) (Nauen and Denholm, 2005). Furthermore, the acute mortality of insect pests is not the only determinant of insecticide efficiency. Therefore, demographic toxicology was considered in this study to combine ecological and toxicological parameters (Sedaratian et al., 2013). Sublethal effects are particularly prevalent in some insecticides and may produce higher rates of physiological and behavioral effects rather than acute ones (Studebaker and Kring, 2001; He et al., 2013). Sublethal effects of botanical and chemical insecticides have been investigated on T. vaporariorum (Omer and Leigh, 1995; Simmods et al., 2002; Heidari et al., 2005) and B. tabaci (He et al., 2011; Sohrabi et al., 2011; Jafarbeigi et al., 2014; Esmaeily et al., 2014a; Esmaeily et al., 2014b).

Our results showed that longevity of *T*. *vaporariorum* was significantly affected by LC_{30} and LC_{50} concentrations of Calypso[®] compared to control. But there were not considerable statistical differences between LC_{50} and LC_{30} concentrations (Table 3). Studies by Omer and Leigh (1995) revealed that sublethal concentration of acephate and biphenate significantly reduced longevity of male (acephate 6.5, biphenate 7.2, control 10.7 days) but not female (acephate 11, biphenate 12.3, control 15.4 days) *T. vaporariorum*. Sohrabi *et al.* (2011) found a significant reduction in the longevity of adult *B. tabaci* exposed to sublethal concentration of buprofezin compared to control, while it was not the case for imidacloprid.

Our results revealed that the daily number of deposited eggs was significantly variable among all treatments; however, total number of eggsdid not differ remarkably between two (LC₃₀ and LC₅₀) Calypso[®] concentrations. But the control adult insects laid statistically more eggs than insecticide treatments (Table 3). Experiments by Omer and Leigh (1995) illustrated that sublethal concentration of acephate and biphenate decreased lifetime fecundity of *T. vaporariorum* by 29% and 37%, respectively. Sohrabi *et al.* (2011) showed that fecundity of *B. tabaci* females considerably decreased by sublethal concentration of buprofezin, whereas imidacloprid did not affect it significantly.

Life table parameters of greenhouse whitefly were considerably affected by Calypso[®] LC₃₀

and LC₅₀ treatments compared to control insects (Table 4). Net reproductive rate (R_0) of females was statistically varied between control and LC₅₀ treated females. In addition, intrinsic rate of decreased significantly increase (r_m) in individuals treated with LC₅₀ of Calypso[®] compared to control insects. Moreover, finite rate of increase (λ) was adversely affected by insecticide treatments. Similar to our results, Heidari et al. (2005) showed that pyriproxifen, buprofezin and fenpropathrin decreased r_m and λ values of T. vaporariorum females. Our results illustrated the considerable statistical increase in other stable population parameters including Tand DT, following pest exposure to LC₃₀ and LC₅₀ values of Calypso[®]. This trend was observed on T. vaporariorum females using pyriproxifen, buprofezin and fenpropathrin (Heidari et al., 2005). Conversely, life history and biological parameters of Bemisia tabaci treated with imidacloprid were not significantly different from control insects; however, buprofezin had great sublethal effects on stable population and biological parameters of B. tabaci at the recommended field concentration (Sohrabi et al., 2011).

Based on our experiments, it can be concluded that Calypso® decreases longevity and survival of greenhouse whitely and adversely affects other biological parameters specially fecundity of female adults. Therefore, lower concentrations of this insecticide not only cause significant decrease in the number of exposed individuals, but also decrease its progeny. Lowered concentrations of Calypso[®] are advantageous from some aspects. Our results emphasized that sublethal concentrations of Calypso[®] are suitable in greenhouse whitefly control and reduce the chemical residuals on greenhouse crops such as cucumber and tomatoes by reduced use of the insecticide. Additionally, the costs of the insecticide application in the greenhouses may be mitigated. Lastly, and more importantly these lowered concentrations of Calypso[®] may slow the resistance progress in T. vaporarioum. More research is however, needed to investigate the resistance development to Calypso® in greenhouse conditions. In addition, side effects of the insecticide on non-target organisms such as (Hymenoptera: Encarsia formosa Gahan. Aphelinidae), as the most important parasitoid of the greenhouse whitefly, should be evaluated.

1.141^c

28.661^a

5.234^a

(1.138 - 1.144)

(28.054-29.268)

(5.142 - 5.326)

Table 3 Effect of LC₅₀ and LC₃₀ concentrations of Calypso[®] on longevity and fecundity of Trialeurodes vaporariorum females.

Treatments	Longevity (days) (Mean \pm SE) ¹	Total number of eggs/female $(Mean \pm SE)^1$	Number of eggs/female/day (Mean \pm SE) ¹
LC50 (0.465 ml/l)	13.67 ± 0.678^{b}	120.33 ± 6.109^{b}	$8.811 \pm 0.158^{\circ}$
LC30 (0.263 ml/l)	14.13 ± 0.780^b	130.47 ± 6.217^{b}	9.287 ± 0.131^{b}
Control	16.47 ± 0.833^a	167.84 ± 9.439^{a}	10.157 ± 0.070^a

Means in each column followed by the same letter are not significantly different (Tukey HSD test, P < 0.01).

Parameters ¹	Control ²	$LC_{30} (= 0.263 \text{ ml/l})^2$	$LC_{50} (= 0.465 \text{ ml/l})^2$
Net reproductive rate (R_0) (offspring)	79.725 ^a	46.982 ^b	37.544 ^c
	(70.305-89.144)	(41.782-52.182)	(33.348-41.739)
Intrinsic rate of increase	0.152 ^a	0.139 ^b	0.132 ^c
(r_m) (day ⁻¹)	(0.151-0.154)	(0.137 - 0.141)	(0.130-0.134)

1.149^b

27.679^b

4.981^b

(1.147 - 1.151)

(4.911 - 5.051)

(27.065-28.293)

Table 4 Life table parameters of *T. vaporariorum* females exposed to LC_{50} and LC_{30} concentrations of Calypso[®].

1.165^a

27.391°

4.535

(1.163 - 1.166)

(26.900-27.882)

² Confidence intervals are in parenthesis.

Finite rate of increase (λ) (day⁻¹)

Mean generation time (T) (day)

Doubling time

(DT) (day)

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فراسنجههای زیستی سفیدبالک گلخانه :Trialeurodes vaporariorum (Hemiptera) (Aleyrodidae) تیمار شده با غلظتهای کشنده و زیرکشندهی کالیپسو

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چکیده: کارایی حشره کش شبه نیکوتینی کالیپسو در کنترل تخمها، پوره و و حشرات کامل سفیدبالک گلخانه Trialeurodes vaporariorum Westwood گلخانه گردید. غلظتهای مختلف حشره کش از ۲/۱۵ تا ۲/۱۰ میلیلیتر بر لیتر به صورت تماسی-سیستمیک استفاده شدند. درصد مرگ ومیر سفیدبالک گلخانه نشان دهنده یحساسیت بیشتر پوره ها در مقایسه با سایر مراحل زیستی بود. مقادیر محال و ۲۵۵۵ به ترتیب ۲۶۵۵ و ۲۶۷۰ میلیلیتر بر لیتر برآورد شدند. تأثیر این غلظتها در پارامترهای جدول زیستی سفیدبالک بررسی گردید. این غلظتها زنده مانی و باروری سفیدبالکهای تیمار شده را در مقایسه با افراد شاهد کاهش دادند. به علاوه، نتایج نشان داد که هر دو غلظت اثر نامطلوبی روی فراسنجه های دموگرافی T. vaporariorum در نز ذاتی افزایش جمعیت مقلطت اثر نامطلوبی روی فراسنجه های دموگرافی ۲۰۷۵ معنی داری در افراد تیمان داد که هر دو نازی به عنوان مهم ترین فراسنجه می حول زیستی به طور معنی داری در افراد تیمار شده با مقادیر روی این ایک ۲/۱۳۲ و ۲۰/۱۹ در روز) در مقایسه با حشرات شاهد (۲۵۰ در روز) پایین تر بود. سایر غلظت های زیرکشنده ی تیمار شده کرا در روز) در مقایسه با حشرات شاهد (۲۵۰ در روز) پایین تر بود. سایر ایم به عنوان مهم ترین فراسنجه می جدول زیستی به طور معنی داری در افراد تیمار شده با مقادیر مود. ایرا به معای میم ترین فراسنجه ماد در روز) در مقایسه با حشرات شاهد (۲۵۰/۱۰ در روز) پایین تر بود. سایر فراسنجه های جدول زیستی (۲۸ مره کرانی) نیز به طور معنی داری در حشرات تیمار شده کم تر بودند. نراسنجه های جدول زیستی (۲۸ مره مره در محصولات گلخانه ای و توسعه مقاومت در سفید بالک گلخانه را کاهش می دهد. بنابراین، چنین غلظته ایی ممکن است پس از بررسی های تکمیلی در برنامه های مدیریت جمعیت ۲۰۰۰ در بنابراین، چنین غلطته ایی ممکن است پس از بررسی های تکمیلی در

واژگان كليدى: فراسنجەھاى جدول زيستى، سفيدبالك گلخانه، تياكلوپرايد، غلظتھاى زيركشنده