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The impact of light angle on the life table parameters of *Frankliniella occidentalis* (PERGANDE) (Thysanoptera: Thripidae) hosted by fruit cucumber under the laboratory conditions

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Abstract

Western flower thrips*, Frankliniella occidentalis* (Thripidae) is a polyphagous pest and recorded from a very wide range of plant species, extending severe damages to many crops worldwide, both through feeding damages particularly in young buds, and vectoring tospoviruses. In 1961, the first chemical control failure of *F. occidentalis* was reported so the other methods had to be applied to IPM program reducing application of pesticides. In this study one cucumber was put in each plastic containers and cucumber was put with an angle 60° in the first treatment and in the second treatment cucumber was put with a zero degree (0d). Experiment was performed with 52 replications. There was significant difference in intrinsic rate of increase Net Reproductive Rate (R_o), mean generation time (T), values of finite rate of increase (λ), gross reproduction rate (GRP) between angle 60° and zero degree cucumber with horizon. It can also be used as a new method for improving *F. occidentalis* control program.

Key words: Fecundity, western flower thrips, control program.

Introduction

Frankliniella occidentalis (western flower thrips; WFT) is the most serious pest species in this genus worldwide. WFT originated from the western US, but is now widely distributed throughout the world (KIRK & TERRY 2003). It is a pest on various agricultural crops, and is an important vector of tospoviruses (PETERS et al. 1996). At least TSWV, tomato chlorotic spot virus (TCSV), groundnut ring spot virus (GRSV), and impatiens necrotic spot virus (INSV) were proven to be transmitted by this thrips. These viruses are recognized as limiting factors in the production of a large number of horticultural crops. In these years many studies have been made on WFT because of its importance. There are over 6,000 thrips species in the world. Also WTF had one third of the publications on all Thysanoptera in the past 30 years (Reitz 2009), and this pest has been included in greenhouse pest control brochures since 1949 (CLOYD 2009).

One important way of pest control is using pesticides. This way is the Common way to control pests and they are used in pest control being able to effectively control it when it is used at low application frequency and low dosages but in these years, populations of many insects and mites have become resistant to insecticides. Resistance has been recorded in over 500 arthropod species (GEORGHIOU 1990). Through these insects we can point to WTF, in 1961, the first chemical control failure of *F. occidentalis* was reported (RACE 1961). So the other methods had to be applied to integrated pest management program reducing application of pesticides like cultural, biological control and physical ways. It can be noted sanitation practices, screening greenhouse openings, over-head irrigation or misting, use of ultraviolet (UV) absorbing plastic films (CLOYD 2009). Generally environmental factors such as temperature, light and humidity plant affect on growing insects, life table studies that provide the most comprehensive portrayal of the survival, development, and reproduction capabilities of a population under varying conditions (LEWIS 1942, BIRCH 1948). This is the first study to evaluate specifically the effect of angle of light on WFT life table and is expressed different angle perhaps can be different effects on life table parameters. It can also be used as a new method for improving WTF control program.

Material and methods

The first instar thrips were collected from alfalfa farms in Fars province (Iran) in order to prepare a colony and cucumber fruits were used as the host for rearing WFT.

After being disinfected (in ethanol 70 % for 1 min) and rinsed, the cucumbers were put in plastic containers with the dimensions of 7×11×18 cm (length × width × height). 5 × 8 cm holes were created on the lid and then covered by nets to make desirable ventilation possible. Several generations of thrips were reared in vitro (MADADI et al. 2006) and pollens were used to feed the larvae (MORITZ et al. 2004). The rearing containers were kept in the germinator in 25±2 ºC, humidity of 60±10 % and light period of 14:10 hours light/dark).(STUMPF.& KENNEDY .2005, 2007).

In this study, one cucumber was put in each plastic container with the dimensions of 30 ×20×10 cm (length × width × height). Cucumber was put with an angle 60° (60d) with horizon level in the first treatment and in the second treatment cucumber was put with a zero degree (0d) (Fig. 1). The plastic containers were kept in the growth chamber in 25±2ºC, humidity of 60±10% and light period of 14:10 hours light/dark) (STUMPF & KENNEDY 2005, 2007).

Experiment was performed with 52 replications and a small and equal size of cucumber was used in the experiment. At the start of the experiment, every female thrips was put close to a male thrips and the data recording continued as far as they laid eggs and died (FEKRAT et al. 2009, ZHANG et al. 2007). Every five days the fruit cucumber was replaced by a new one.

Energy Saving Bulbs of 11 watt were used (model XRMU015, Xiamen Xinrui Lighting Co., Ltd, voltage: 220-240V, Frequency: 50-60Hz) http://www.made-in-china.com. The artificial light sources were turned on at 08:00 and turned off at 22:00 daily. Distance between the light source and each plastic container was 90 cm. source of light was set at an angle of 60 degrees with plastic containers of cucumber.

The data was statistically analyzed using Chi & Liu's software (CHI & LIU 1985, CHI 1988, 2012) and the graphs were drawn by Sigma Plot 12 software. The Students *t*-test was performed by SPSS 18 software to determine the differences in life table parameters between 60d and 0d treatments.

Results

The life table parameters, Net Reproductive Rate (R_o), mean generation time (T), values of finite rate of increase (λ), gross reproduction rate (GRP), intrinsic rate of natural increase (r_m) and standard error estimated, are shown on the Table 2. There were significant differences in the life table parameters between 0d and 60d treatments at the 5% significance level (Tab. 2).

The development time of the egg, L1, L2, prepupal, and pupal stages of WFT in the first treatment did not differ significantly from those on second treatment when using the *t*-test at the 5 % significance level (Tab. 3). Mean life time fecundities were 19.13 eggs/female in the first treatment and 64.48 eggs/female in the second treatment (Fig. 1). Generally, angle 60° (60d) has more fecundity than that of the zero degree (0d), the 27^{th} is the highest fecundity of all days in angle 60° (60d).

Life expectancy of different stages on cucumber fruits is presented in Figures 2 and 3. Female life expectancy in the first and second treatments are 52 days and that is more than that of male. Age specific survival rate (l_x), are shown in Figure 4, it gives the probability that a new born egg will survive to age *x* (Kavousi et al., 2009). Age specific survival rate (l_x) decreases with the increasing age and eventually gets down to zero about the 52^{th} in both treatments (fig. 5).

Discussion

The results of this study showed significant differences in the life table parameters between 0d and 60d treatments at 5 % significance level which associated oviposition.

Environmental factors such as angle of light can be affected on oviposition, is justifiable according to the radiation heat transfer among surfaces that depending on the orientation of the surfaces relative to each other as illustrated in Figure 6. Figure 1 can be considered as figure 7. Lamp is A_1 and cucumber A_2, respectively radiator and receiver, transferred heat per second ($\dot{Q}$) from A_1 to A_2 is calculated by the equation 1 (ÇENGEL 2007).

$$\dot{Q}A_1 \rightarrow A_2 = \int_{A_2} \dot{Q}_{A_1} \rightarrow dA_2 = \int_{A2} \int_{A1} \frac{I_1 \cos\theta_1 \cos\theta_2}{r^2} dA_1\, dA_2 \qquad (1)$$

I_1 is constant intensity of surface 1.

Tilted surface will receive more radiation.

It can be supposed that the lamp is similar to the sun. Geometric factor R_b is defined as the ratio of beam radiation on tilted surface to that on a horizontal surface. R_b is calculated by the equation 2 (DUFFIE & BECKMAN 2006).

$$R_b = \frac{\cos\theta}{\cos\theta_z} = \cos\beta + \tan\theta_z \cos(\gamma_s - \gamma) \sin\beta\, A_2 \qquad (2)$$

Figure 8 shows used angles.

The variations of β versus R_b for the conditions of this study are presented in figure 9. The increasing of surface tilt angle leads to the increasing of radiation on tilted surface but it has a limit and R_b will decrease with further increase in β; the angle 60°(β=60°) is in the range that R_b increases.

The increase of transferred heat caused increasing the temperature in microenvironments of leave surface layer and if temperature is optimum, fecundity of WFT will increase, influence of temperature on the life table parameters of insects has been observed by a number of authors. It has been reported by WILLIAMS (1990) that temperature is an important factor with a strong influence on the oviposition rate and brood developmental times of certain ant species.

In Conclusion adjusting the angle of the beam can be the right solution for damaging greenhouse production although there is a need to further study. It can be a good way in IPM and be used in conjunction with other methods.

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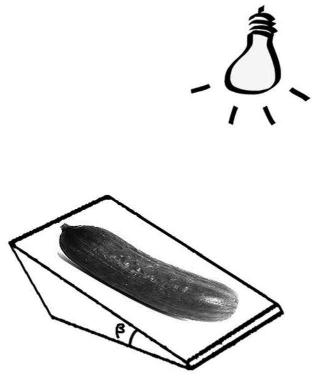

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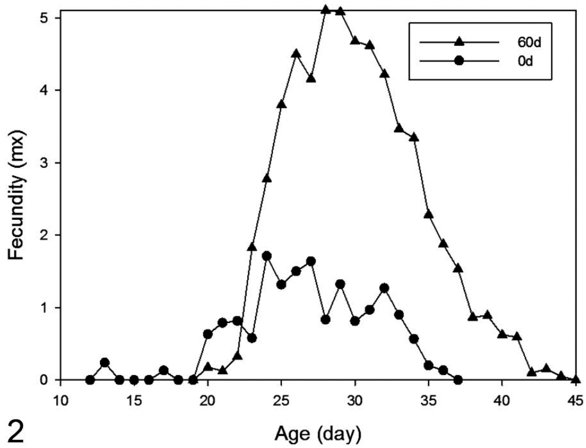

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Fig. 1. Cucumber subject at lamp radiation. **Fig 2**. Age-specific fecundity (mx) in 0d and 60d.

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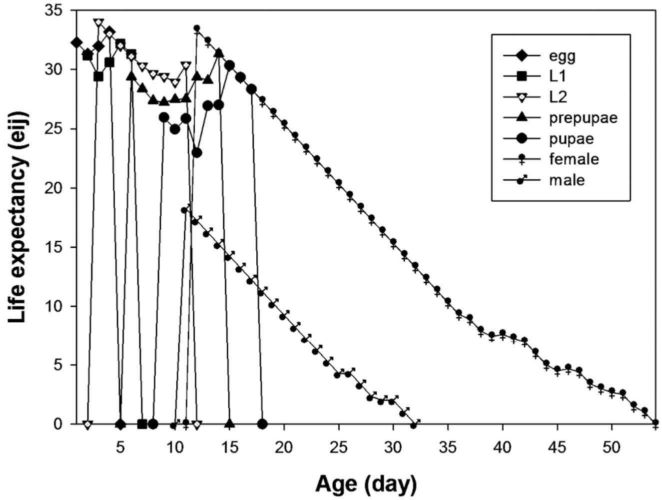

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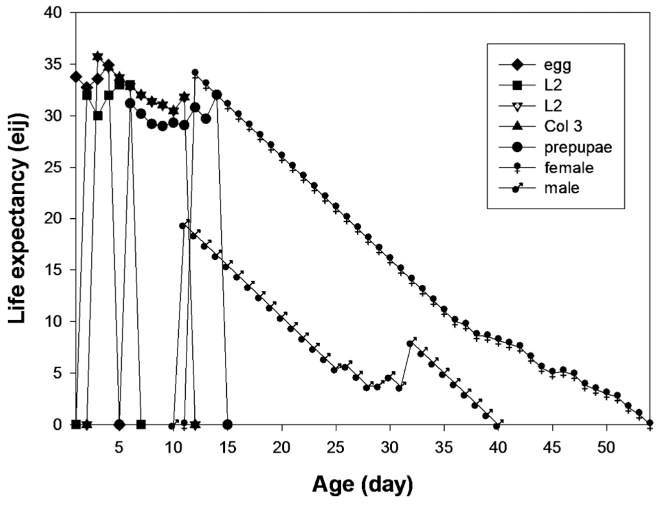
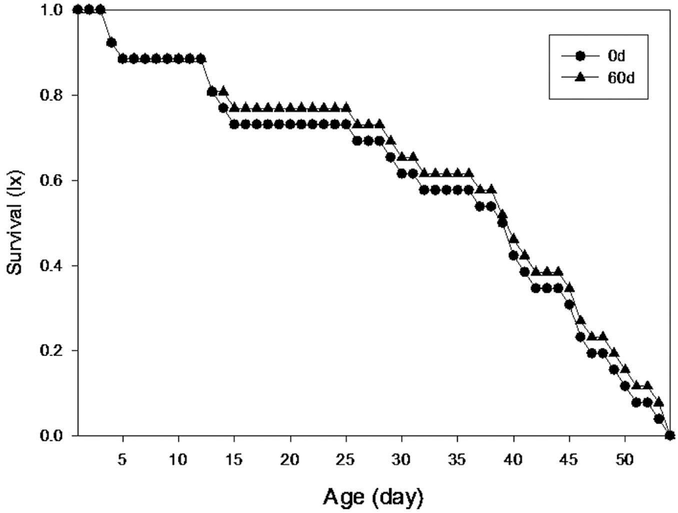


Fig. 3. Life expectancy of different stages on cucumber fruits in 60d. **Fig 4**. Life expectancy of different stages on cucumber fruits in 60d.



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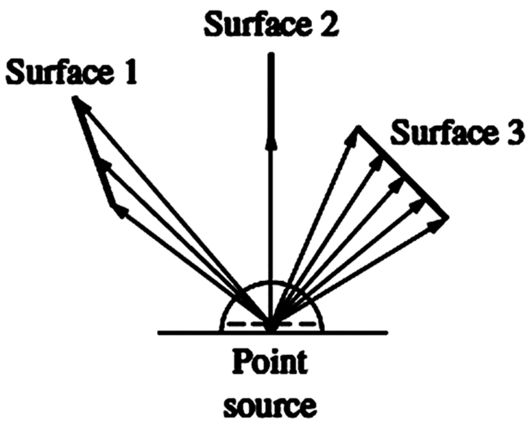

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Fig. 5. Age specific survival rate (lx) in 0d and 60d. **Fig. 6**. Radiation heat exchange between surfaces.

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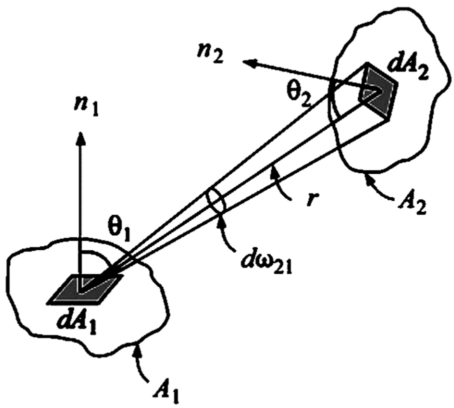

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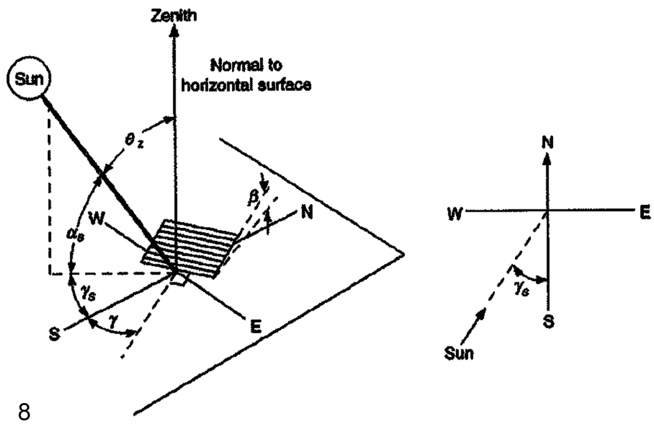

Fig. 7. Geometry for determination of received radiation by A2. **Fig. 8**. The angles of the sun and tilted surface.

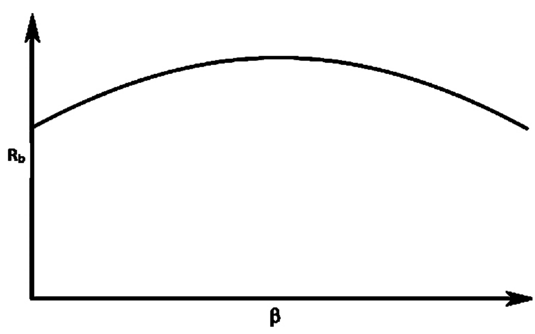

Fig. 9. Geometric factor variation versus surface tilted angle.

Tab. 1. Mean and standard errors of population parameters of *F.occidentalis* at 25°C and 70–80% RH

Population parameters	Mean ± SE		t	p	df
	0d	60d			
Intrinsic Rate of Increase (r)	0.0845± 0.008	0.1282 ± 0.005	3.683	0.019(<0.05)	102
Net Reproductive Rate (R0)	11.0385± 2.1	38.4423±5.2	4.879	0.000(<0.05)	102
Gross Reproductive Rate (GRR)	22.0175±2.6	53.0513±6.7	4.732	0.000(<0.05)	102
Mean Generation Time (T)	25.6213 ± 0.6	28.5363±0.3	4.261	0.011(<0.05)	102
Finite rate of increase (λ)	1.0969 ±0.01	1.1385 ±0.01	4.060	0.006(<0.05)	102

Tab. 2. Life history statistics (mean±SE) of *F.occidentalis* on fruit cucumber

Stage	0d	60d	t	df	p
Egg	2.08 ±0.109	2.06± 0.111	0.922	102	0.922(>0.05)
First instar	1.83±0.084	1.81±0.085	1.329	102	1.75(>0.05)
Second instar	4.52 ±0.158	4.48±0.161	0.708	102	0.357(>0.05)
Pre pupae	2.00± 0.116	2.02±0.118	-0.864	102	0.248(>0.05)
Pupae	2.84±0.096	2.9±0.1	-0.416	76	0.943(>0.05)
Female longevity	30.66±1.009	31.22±1.090	-0.374	55	0.941(>0.05)
Male longevity	17.25±0.9401	18.12±1.444	-0.508	14	0.673(>0.05)

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