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Effect of ultra violet light (UV-C) in different times and heights on adults stage of whitefly (*Trialeurodes vaporariorum*)

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Abstract
The whitefly, *Trialeurodes vaporariorum* (west wood) is a polyphagous and cosmopolitan species. In, the present study, effect of UV-irradiation on adult of *T. vaporariorum* was investigated. Adults insect in three heights 70, 80 and 90 cm in eight times include 0.5, 1, 2, 4, 6, 8, 10 and 12 minutes at 27±2 ºC, 65±5 % RH and photoperiod of 16: 8 (L: D) conditions by UV-irradiation (254 nm wavelength) were exposed and mortality counted after 24 and 48 hours. The results indicated that all exposure periods of UV-irradiation increased mortality of adults. With increase in time of exposure irradiation and decreasing distances caused a gradual increase in percentage of mortality. LT_{50} value after 24 hours in 70, 80 and 90 heights in 0.5, 1, 2, 4, 6, 8, 10 and 12 minutes' exposers period were (29.77, 39.99, 42.22, 49.99, 57.77, 61.1, 70.74, 75.55), (28.33, 32.22, 34.17, 45.59, 50.87, 54.94, 66.13, 70.47) and (21.81, 26.66, 29.81, 40, 49.33, 50.14, 56.19, 60.83), respectively. The result of present study showed that we can use ultra- violet light in integrated pest management greenhouse and stored products.

Keywords: Ultra- violet light, *Trialeurodes vaporariorum*, greenhouse, pest, IPM

1. Introduction
The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) which has its origin in tropical or subtropical America is an economically important pest of horticultural and ornamental crops worldwide [21]. The greenhouse whitefly is a polyphagous species colonizing more than 250 hosts plants [26, 20]. Under greenhouse conditions this pest can multiply quickly many generations [29], All life stages apart from pupae cause crop damage through direct feeding; as a byproduct honeydew is excreted that constitutes a secondary source of damage since it encourages infestations of molds and fungi [11]. The third and potentially most damaging characteristic is the ability of adults to transmit several 'clostero'-like plant viruses [32]. All life stages are difficult to control with insecticides because of the rapid reproductive rate, their preferred habitat on the under-surface of leaves, wide host rang pesticide resistance in insects and mites is a serious worldwide problem in agriculture [2]. Chemical insecticides have showed numerous environmental problems such as depletion of atmospheric ozone [19, 17], development of resistance in insects [30], mammalian toxicity, disruption of the food chain, proliferation of more harmful insects and sensitive species [25]. Consequently, environmental concerns led to the development of alternative control tactics [4]. Among the alternative control tactics, radiation technique is one of the most promising methods. Much research has been conducted into the use of radiation to control stored-product pests [9, 10, 28, 15, 3, 5, 6]. The advantages of irradiation as a pest control measure include the absence of undesirable residues in the foods treated, no resistance development by pest insects and few significant changes in the physicochemical properties or the nutritive value of the treated products [1, 33]. Irradiation can also extend the shelf life of various products and maintain the quality of the product over a longer period of time [24] however depending on the dose of ionizing energy applied; high doses of radiation may affect the quality of foods [31, 8].
For this aim in this research work, effect of ultra violet light (UV-C) in different times and heights on adults of whitefly *T. vaporariorum* was evaluated.

2. Materials and Methods
The experiments were carried out in the Department of Plant Protection (July 2016), Faculty of Agriculture, Urmia University. Plant growth were under greenhouse conditions at 27±2 ºC,

65±5% RH and photoperiod of 16: 8 (L: D). The colony of *T. vaporariorum* were reared on green bean (Sanderi variety) that provided from research center of west Azarbaijan province and was planted in greenhouse conditions. *T. vaporariorum* adults were collected by aspirator from Verbena and Alcea in greenhouse of horticulture at Urmia University. The collected adults were transferred for experiments, so they put upon the beans with 6-8 leaves. To prevent the possible effects of applied pesticides in the collecting location on results, all experiments were conducted after three generations of *T. vaporariorum* reared without pesticides. In all experiments to access a cohort, according to [23], small leaf cages with a little change were used.

2.1 UVC Lamp
The applied device has one Philips 30-watt bulb, G30T8 with a wavelength of 254 nm, length of 40 cm and width of 2 cm.

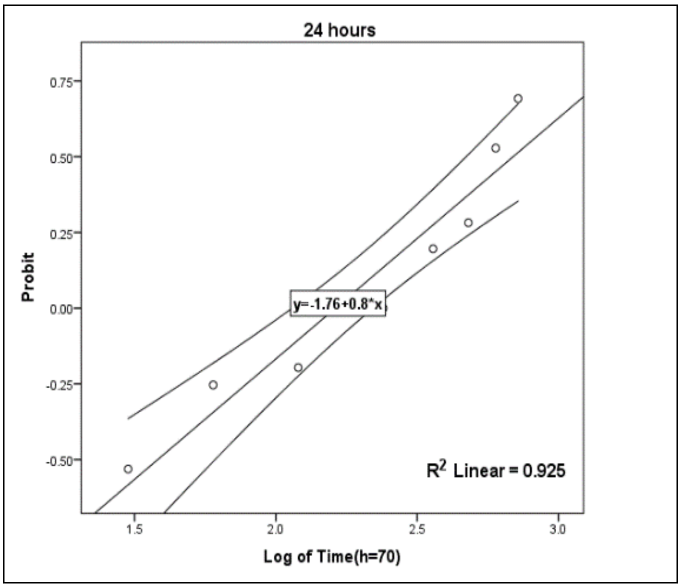
2.2 Lethal effect of UVC on adults:
The cohort adults were released on the experimental dishes containing green bean leaves that their petiole were enveloped in wet cotton in order to remain them fresh and not wilted. The experiments were carried out in plastic glasses with 9 diameters and 8 height centimeter with their lids covered with cellophanes. Each experiment was replicated three times and were irradiated with UVC ray for 0.5, 1, 2, 4, 6, 8, 10 and 12 minutes in heights of 90, 80, and 70 cm. Untreated insects served as the control treatment with three replicates. Then, they were placed under greenhouse conditions at 27±2 ºC, 65±5 % RH and photoperiod of 16: 8 (L: D). Mortality was counted after 24 and 48 hours of exposure to UVC, when no leg or antennal movements were observed, insects were considered dead [13].

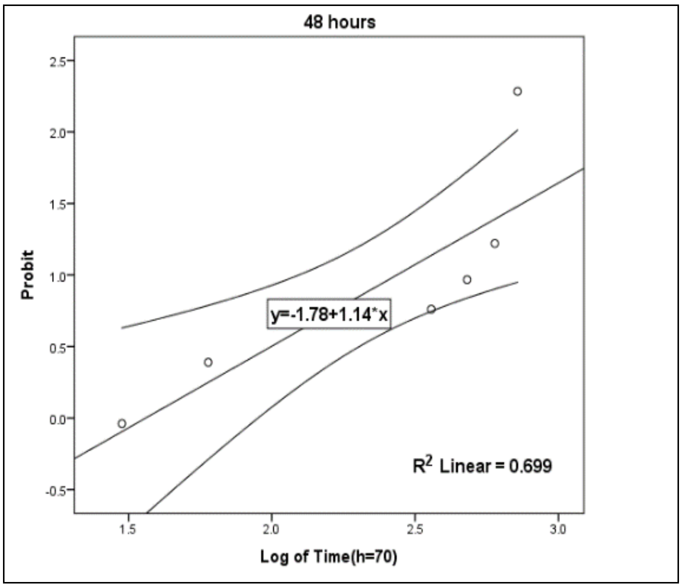
2.3 Analysis of Data
The LT_{50} and LT_{25} values (with 95% confidence limits) were calculated by using Probit Analysis Statistical Method, mortality data treatments subjected to analysis of variance (One-way ANOVA) and mean separation tests were conducted with Tukey's HSD with SPSS statistical analysis software (Version. 24.0).

3. Results
3.1 Lethal effect of UVC on adults
The results of the probit analysis, LT_{50} and LT_{25} values of difference exposure times of UV irradiation and heights on adult stage in 24 and 48 hours are shown in Table 1. The LT50 show that the 70 cm heights were more lethal as compare to 80 and 90 cm heights after 24 and 48 hours.

Table 1: LT_{50} and LT_{25} values calculated from difference in exposure times of UV irradiation and distances (70, 80 and 90 cm) from UV source on adult stage of *T. vaporariorum* within 24 and 48 hours.

Heights	Time Hours	Chi-square	Slope ±SE	Intercept (a) ±5	Lethal concentration		
					LT_{25} 95% confidence interval	LT_{50} 95% confidence interval	LT_{90} 95% confidence interval
70	24	5.25	0.79±0.09	3.26	23.12 (37.83-10.68)	163/52 (211.71-122.28)	6725.71 (21409.56-3278.34)
	48	15.37	0.94±0.1	3.6	5.885 (0.37-17.71)	30.25 (6.70-59.02)	685.58 (2550.87-373.2)
80	24	7.26	.077±0.09	3.14	34.21 (53.2-17.15)	252.2 ((335.19-193.43)	11223.31 (43339.91-4922.83)
	48	7.33	1.04±0.1	3.19	14.29 (22.51-7.44)	63.25 (44.99-81.94)	1067.08 (1743.08-751.98)
90	24	2.35	0.76±0.1	3	54.28 (79.66-30.06)	410.64 (591.03-310.35)	19192.66 (93242.04-7477.1)
	48	17.44	0.82±0.09	3.35	15.41 (40.39-1.04)	101.35 (174.06-37.45)	3631.53 (74869.53-1248.97)





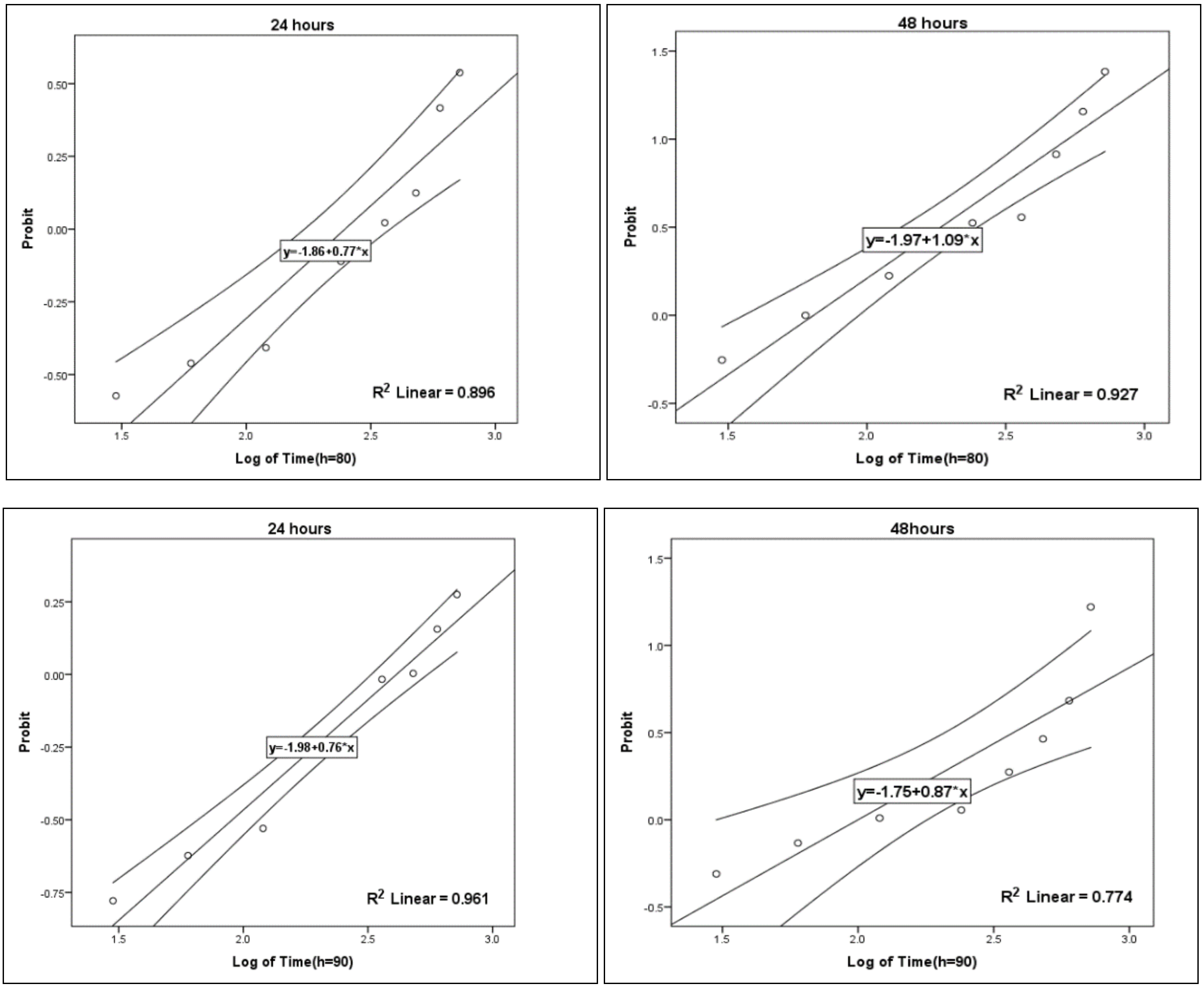


Fig 1: Relationship between log of time and Probit of percentage mortality in three heights with R square

The dose-response and R square show that the relation between heights and mortality in 90 cm heights after 24 hours and in 80 cm heights after 48 hours were had best fitted (Fig1).

Generally, mortality rates for adult stage increased with increasing exposure times and decreasing heights. All exposure periods of UV-irradiation increased adult stage in comparison to control.

3.2 Compare mortality effect UV-C in different time on adult stage of *T. vaporariorum*

Effects of treatments include eighth times 0.5, 1, 2, 4, 6, 8, 10 and 12 minutes' exposure in three heights on adult stage of *T. vaporariorum* was compared by percentage mortality index after 24 and 48 hours. The results showed that there was a significant differences between treatments exposure times in heights of 70 with 95% confidence after 24 and 48 hours with [F (8, 18) = 30.98, p=0.001)] and [F(8, 18) = 63.48, p=0.001)], respectively (Fig 2). The results showed that there was a significant differences between treatment exposure times in heights of 70 with 95% confidence after 24 and 48 hours with [F (8, 18) = 91.48, p=0.001)] and [F (8, 18) = 53.67, p=0.001)], respectively (Fig 3).

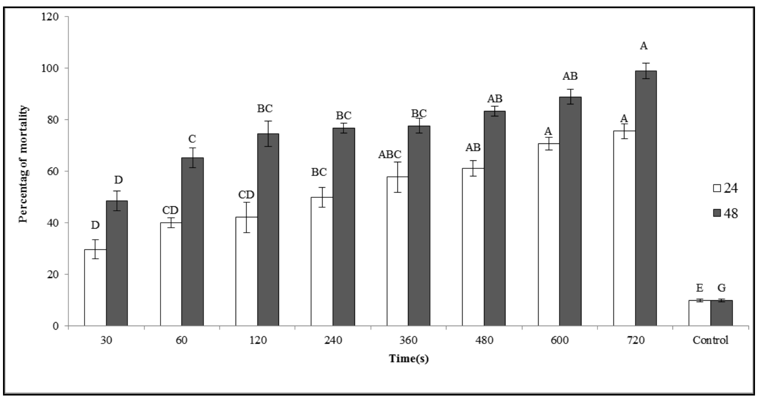


Fig 2: Percentage mortality ± SE of different treatments (times) in height of 70 on adult stage *T. vaporariorum* after 24 and 48 hours.

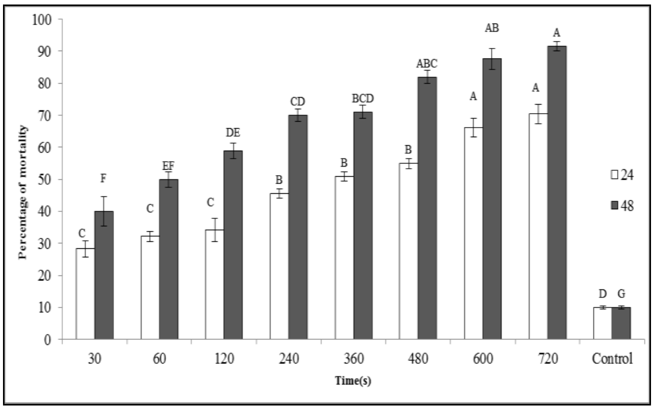


Fig 3: Percentage mortality ± SE of different treatments (times) in heights of 80 on adult stage *T. vaporariorum* after 24 and 48 hours.

The results also showed that there was a significant differences between treatment exposure times in heights of 90 with 95% confidence after 24 and 48 hours with [F (8, 18) = 15.41, p=0.001)] and [F(8, 18) = 14.73, p=0.001)], respectively (Fig 4). Increasing the exposure period at each distance significantly increased mortalities (P<0.01) of adults after 24 and 48 hours. After 24 and 48 hours 70 cm distances was more lethal as compared to other treatments (Fig 2).

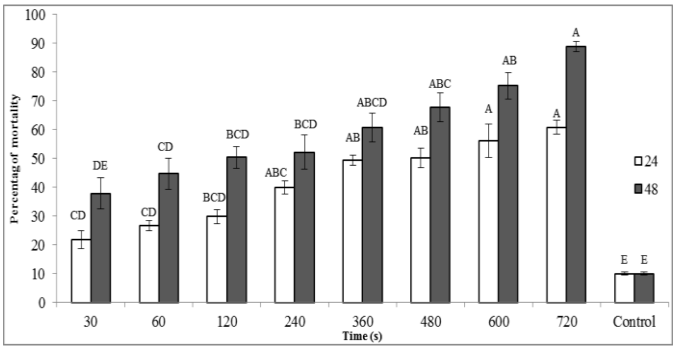


Fig 4: Mortality percentage ± SE of different treatments (times) in heights of 90 on adult stage *T. vaporariorum* after 24 and 48

4. Discussion

The present study showed that UV radiations (short-wave) have high insecticidal activity on *T. vaporariorum* adults. It was seen that depending on the decreased distance from lamp and duration of the radiation, adult mortality of *T. vaporariorum* and consequently mortality was increased. Guerra *et al* [18] reported that when eggs of *Heliothis virescens* (*Fabricius*) and *H. zea* were exposed to UV-rays, egg hatching was gradually decreased with increasing time of exposure. *Calderon et al* [12] and Faruki & Khan [14] reported that UV rays can be used to suppress the population of insects. Faruki *et al* [16] reported that egg hatching and adult emergence were significantly reduced in *Tribolium castaneum (Herbst)*, *T. confused (*Jaquelin du Val) and *Cadra cautella* (Walker) due to exposure of eggs to UV-rays. Mohan and Kumar [22] reported the UV irradiation as a promising agent for controlling the cotton stainer, *Dysdercus koenigii* (Fabr) and observed significant decrease in survival with increasing exposure time, delayed moulting into adult, and morphological deformities in adults and nymphs. In addition, it was observed in the present study that, depending on the increasing time periods, the mortality rates were increased. The enhanced mortality ratio in the insects with increased exposure times treated with UV radiation was also reported by Azizoglu *et al* [7]. The above test results with results obtained from this experiment had very similarity. Mortality rates increased from 21.28% at 0.5 min to 60.83% at 12 min exposure time in 90 heights, from 28.33% at 0.5 min to 70.47% at 12 min exposure time in 80 heights and from 29.77% at 0.5 min to 75.55% at 12 min exposure periods in 70 heights after 24 hours counting in comparison to control. So UV radiations may be promising control strategies as an alternative to chemical control. It is also important for developing a more reliable and healthy method for controlling greenhouse and stored product pests.

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