

# Effect of Acclimatization Temperature and Light Intensity on the Graft-Take of Cucumber Seedlings

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## Abstract

The main aim of this work is to optimize the environmental condition for best grafting by control the temperature and light of grafting conditions. To achieve that was study the effect of ambient temperatures (20, 23, 26 and 29°C), light intensity (0, 2500 and 5400 Lux) and type of tunnel (truss and flat) on stem diameter, shoot length, leaf area, shoot dry mass, grafted-take and energy consumption. The obtained results indicated that the average temperature was 20.45, 23.61, 27.01 and 29.71°C at 20, 23, 26 and 29°C ambient temperatures in truss tunnel, while, it was 20.61, 24.21, 27.53 and 30.09°C at 20, 23, 26 and 29°C ambient temperatures in flat tunnel. The stem diameter values were 4.626 and 4.476 mm in truss and flat tunnel under study with ambient temperature 20 to 29°C and light intensity 0 to 5400 Lux. The shoot length values were 8.254 and 8.131 cm in truss and flat tunnel under study with ambient temperature 20 to 29°C and light intensity 0 to 5400 Lux. The leaf area values were 56.074 and 53.214 cm<sup>2</sup> in truss and flat tunnel under study with ambient temperature 20 to 29°C and light intensity 0 to 5400 Lux. The shoot dry mass values were 396.448 and 386.585 mg in truss and flat tunnel under study with ambient temperature 20 to 29°C and light intensity 0 to 5400 Lux. The grafted-take values were 84.525 and 78.460% in truss and flat tunnel under study with ambient temperature 20 to 29°C and light intensity 0 to 5400 Lux. The energy consumed decreased with increasing ambient temperature and decreasing light intensity.

**Keywords:** Grafting; Temperature; Light intensity; Tunnel; Graft-take; Cucumber

## Introduction

Cucumber (*Cucumis sativus* L.) is one of the most popular vegetables in the world, and annually about 71.4 million tons are produced [1]. Cucumber is a favorite commodity exports for markets and local consumption and represents one of the most important and economic vegetables in Egypt. It is grown in Egypt in the open field from March to November and under plastic houses from September to May. The total cultivated area of cucumber in Egypt was about 62073 feddan (25863.8 ha). This area produced about 587612 Mg in 2015 according to [2]. Cucumber is also an important vegetable crop for greenhouse production in many countries. Continuous cultivation in greenhouses leads to some problems, including soil-borne diseases, soil nutrient imbalances, salty or alkaline soil conditions, spread of weeds, etc. To alleviate these problems, grafting is recommended. Grafting is an important technique for vegetable production in many countries where intensive and continuous cultivation is performed. Vegetable grafting has been used to improve yield, fruit quality and disease resistance in *Solanaceae* and *Cucurbitaceae* [3-6]. In recent years, grafting has been found effective in overcoming abiotic stresses.

Grafting is a horticultural technique whereby tissues from one plant are joined with another to obtain a combination of rootstock and scion genotypes that are more desirable than those contained in a single plant. Vegetable grafting is considered a sustainable pest and disease management practice that can improve fruit yields and quality as well as reduce environmental impacts with fewer chemical fumigants applied than in a non-grafted cropping system. Moreover, according to [4-7], grafted vegetables can exhibit excellent tolerance to both biotic stresses (e.g., soil-borne pathogens, foliar pathogens, arthropods and weeds) and abiotic stresses (e.g., low/high temperature, drought/flooding, heavy metal and nutrition). Even though grafting has been practiced in fruit trees for thousands of years, vegetable grafting has only recently been adopted on a commercial scale [8]. Interest in the use of grafted fruit vegetables has increased in Korea, Japan, and throughout Asia and

Europe, under intensive cropping systems. The purpose of vegetable grafting is to improve resistance to soil-borne pests and pathogens, adaptation to abiotic stresses, and growth and yield by promoting the absorption of nutrients [9,10]. Almost all cucurbits such as cucumbers, melons, and watermelons for greenhouse cultivation are being grafted in Korea. There is also an increasing trend in the grafting of solanaceous crops such as eggplants, peppers, and tomatoes [9]. In Egypt, about 10% of watermelon seedlings are grafted into various rootstocks and about 3% of cucumber seedlings are grafted in 2013. The successful production of grafted transplants requires highly technical grafting skills and environmental control during healing and acclimatization period. Grafted transplants are produced by: 1) raising scions and rootstocks; 2) grafting; 3) healing and acclimatization; and 4) raising the grafted seedlings before transplanting. Healing and acclimatization are very important processes that are necessary for grafted plants to survive [9].

The use of grafting in fruit and vegetable production has been expanded in order to control pathogens and to enhance the plants' tolerance against abiotic stresses [5-7]. Highly technical grafting skills and environmental controls during the healing and acclimatization period are required for the successful production of grafted plants. Grafted plants were usually healed and acclimatized in the past under specific environmental conditions such as high relative humidity (RH  $\geq$  95%) and low light intensity in order to produce a healthy plant that survived and grew [11]. However, several recent papers have reported

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that the photosynthesis, growth, and quality of grafted plants were improved by increasing the light intensity under highly controlled conditions during the healing and acclimatization periods [12,13].

After grafting, it is important to control the environments around grafted seedlings for the robust joining of a scion and rootstock. Usually the shading materials and plastic film are used to keep the high relative humidity and low light intensity around grafted seedlings in greenhouse or tunnel. It is quite difficult to optimally control the environment for healing and acclimation of grafted seedlings under natural light. Therefore the farmers or managers rely on their experience for the production of grafted seedlings with high quality [14]. For successful grafting, control of the nursery's climatic conditions should be taken. A temperature of 25°C and 85-95% relative humidity should be provided within the growing conditions for good callus formation [15]. Several other environmental factors also affect the growth and development of the plants [16]. The most important of these factors are light, temperature, water (humidity) and nutrition. Light and temperature are two important parameters that affect the physiology of the grapevine. Plants need light and temperature for basic physiological processes such as photosynthesis, respiration, transpiration and carbohydrate assimilation [17,18]. Light is an essential factor for plant growth. Many studies have shown that both the light intensity and the light quality are important for the growth, development, pigmentation, and shape of plants [19,20]. Various types of artificial light have been used in plant production including fluorescent, metal halide, and high-pressure sodium lamps [21].

A non-grafted plant suffers a great deal of stresses from soil and foliar pathogens, weeds, low and high temperatures, drought and flooding, which in turn affect the growth and productivity. Grafting is the better solution to improve the resistance of plant to the stresses and also increase the plant tolerance for the inverse conditions as the grafting conditions is ensured. Therefore, the main aim of this work is to optimize the environmental conditions for best grafting by controlling the temperature and light of grafting conditions.

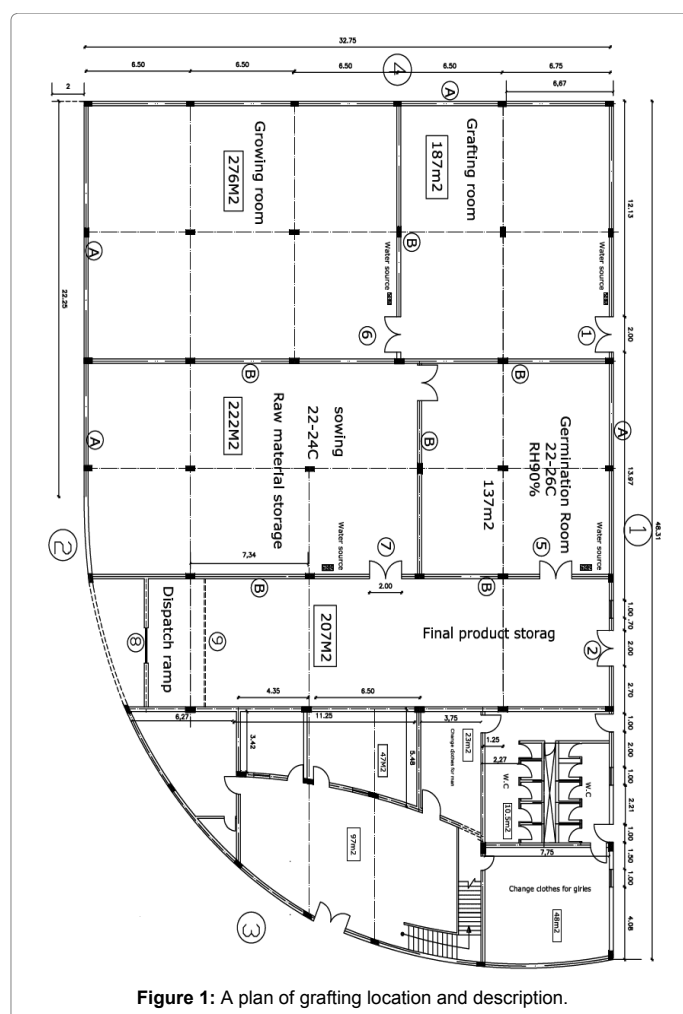
## Materials and Methods

The experiment was carried out at SEKEM Company, Belbeies, El-Sharkia Governorate, Egypt during 2015 season to study the influence of environmental parameters such as temperature and light intensity on grafting efficiency of the grafted cucumber plants.

### System description

Figure 1 illustrates the grafting system description. It shows the system which consists of germination room, acclimatization room, trolleys, seedling trays, air conditioners, air blowers and grafted plants trays.

**Germination room:** After sowing, the trays were immediately transferred to the germination room (3 days). The germination room is made of concrete which was used for seeds germination. Its area is 137 m<sup>2</sup> and has dimensions of 12.0 m long and 11.4 m wide. The room was provided with trolleys to carry the seedling trays, two air conditioners (Model Carrier 53 QH-B-Range temperature 15-40°C-RPM 2800-Power 5 hp 380 V 50 Hz, Italy) for control air temperature and sprinklers for increasing relative humidity of air. The trolley was made of galvanized steel metal of 3 mm thickness. Dimensions of trolley were 1.5 m length, 1.0 m width and 2.0 m high. The seedling tray holds 209 plants (11 rows of 19 cells) each cell measures 2.5 cm by 2.5 cm by 7.4 cm deep.



**Figure 1:** A plan of grafting location and description.

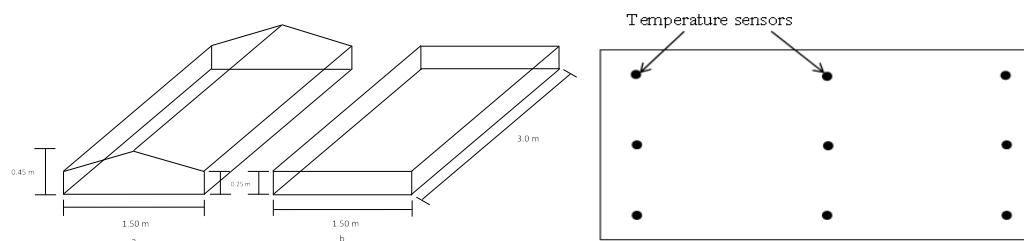
**Acclimatization room:** It is used to adapt the rootstock with scion. Its area is 276 m<sup>2</sup> and has dimensions of 19.5 m long and 14 m wide. The room was provided with 35 trolleys to carry the grafted plants trays inner two types of tunnels (truss and flat tunnel), six air conditioners for controlling air temperature and four air blowers (Model C.C.P. Parma-Flow Rate 1350 m<sup>3</sup> h<sup>-1</sup>-RPM 2800-Power 2.5 hp 380 V 50 Hz, Italy) for moving air in the acclimatization room. The trolley was made of galvanized steel metal of 3 mm thickness. Dimensions of trolley are 3.0 m long, 1.5 m wide and 2.0 m high. Each trolley is provided with six lamps (38 Watt) per shelf for lighting. The grafted plants tray holds 150 plants (10 rows of 15 cells) each cell dimensions of 4.0 × 4.0 × 6.2 cm. Figure 2 shows the dimensions of tunnels. Irrigation was carried out manually by hose. The amount of chemicals used in the irrigation system was as described by [22].

### Cucumber and rootstock seeds

Cucumbers (*Cucumis sativus* L. cv. Joeun Baekdadaki) were used as scions while pumpkins (*Cucurbita maxima* D. × *C. moshata* D. cv. New Shintozwa) were used as rootstocks for producing grafted plants.

### Treatments

The treatments include: ambient temperatures (20, 23, 26 and 29°C) nine temperature sensors were distributed in the tunnel as shown in Figure 3, light intensity were 0, 2500 and 5400 Lux, tunnel types were



**Figure 2:** Schematic diagrams of tunnels under study (a: truss tunnel and b: flat); Distribution of temperature sensors in tunnel.

truss and flat types. Relative humidity was adjusted to be  $92 \pm 2\%$  and soilless media is white peat+perlite (70:30) was used. The experimental design was a split-split plot. Each treatment was replicated three times.

### Measurements

Temperature and relative humidity were recorded by using a HOBO Data Logger (Model HOBO U12 Temp/RH/Light-Range -20 to 70°C and 5 to 95% RH, USA) every hour. Ten cucumber seedlings representing each replicate on day 8 after grafting were taken as recommended by [13] to determine stem diameter, shoot length, number of leaves, root volume and shoot and root dry weight. Fresh shoots and roots of seedlings were weighed and placed in drying oven with circulating air at 65°C for 48 h then weighed for dry weight. Also graft-take (efficiency of grafting) was calculated as follows (equation 1):

$$\text{Graft - take} = \frac{\text{Number of surviving seedlings}}{\text{Number of grafted seedlings}} \times 100 \quad (1)$$

### Statistical analysis

The statistical analysis for the data obtained was done according to [23] and the treatments were compared using Least Significant Differences (LSD) test at 95% confidence level [24].

## Results and Discussion

### Temperature

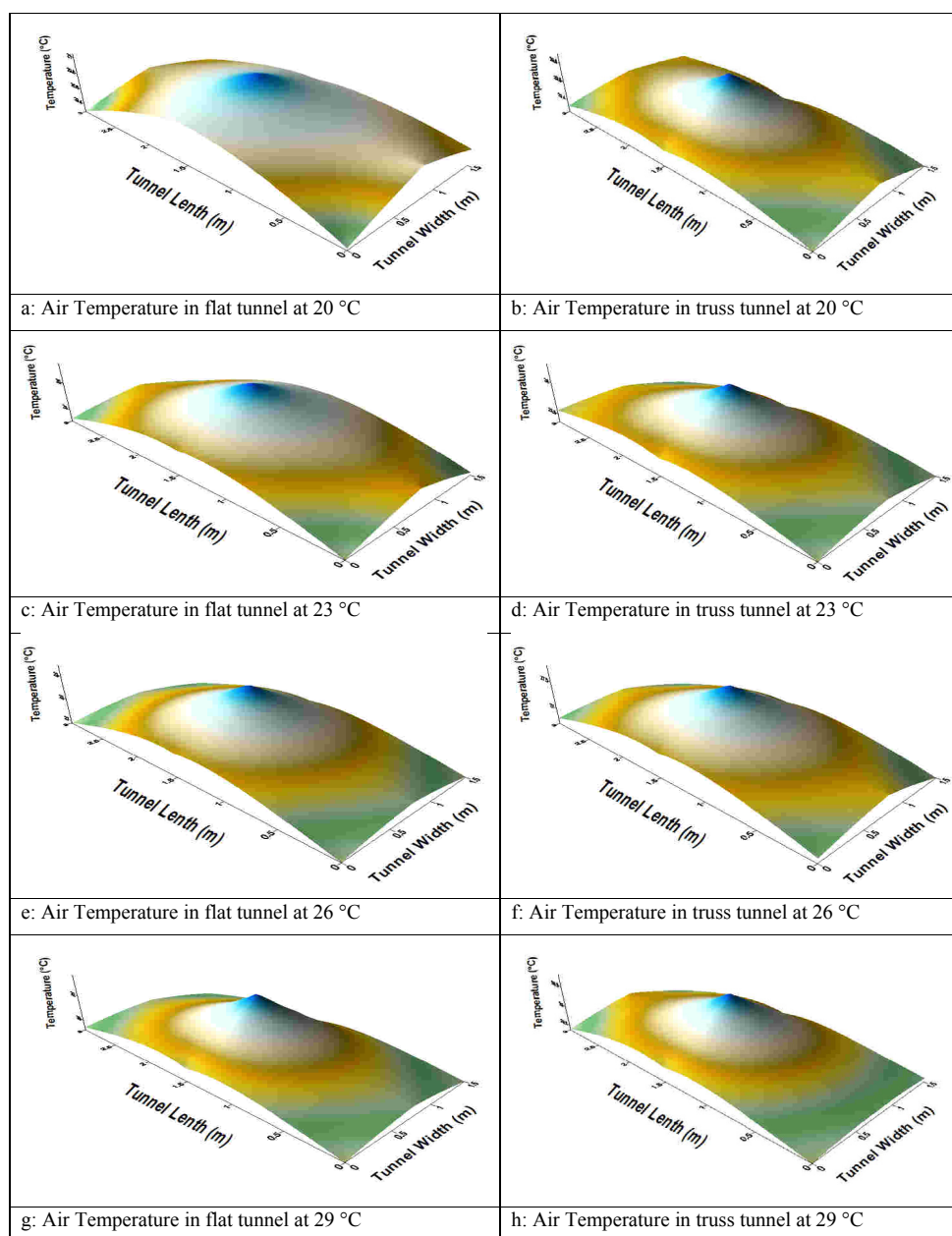
Figure 3 shows the temperature distribution inside the flat and truss tunnels at different ambient temperature (20, 23, 26 and 29°C). For flat tunnel shape, it could be seen that the temperature distribution patterns appear as a concave shape where, the temperature increased toward the center of the flat tunnel which varies slightly from 20.291 to 21.053°C at 20°C ambient temperature, 23.526 to 25.761°C at 23°C ambient temperature, 26.893 to 29.517°C at 26°C ambient temperature and 29.149 to 33.729°C at 29°C ambient temperature. For truss shape tunnel, it could be seen that the temperature distribution patterns appears as a concave shape also where, the temperature increased toward the center of the tunnel which varies slightly from 20.259 to 20.909°C at 20°C ambient temperature, 23.271 to 24.300°C at 23°C ambient temperature, 26.699 to 27.811°C at 26°C ambient temperature and 29.372 to 30.818°C at 29°C ambient temperature. This could be due to the respiration heat produced by the plants.

### Seedling parameters

**Stem diameter:** Table 1 and Figures 4-6 show the stem diameter of the grafted cucumber seedlings grown under two types of tunnels (truss and flat) as affected by ambient temperatures from 20 to 29°C and light intensities from 0 to 5400 Lux. Regarding of the effect room temperature, it could be seen that the average values of stem diameter were 4.404,

4.599, 4.735 and 4.466 mm for the grafted cucumber seedlings grown at 20, 23, 26 and 29°C ambient temperature, respectively depending on the light intensities and type of tunnel. The highest value of the stem diameter of the grafted cucumber seedlings (4.735 mm) was obtained at ambient temperature of 26°C. The results revealed that the seedling stem diameter increased with increasing the ambient temperature from 20 to 26°C. Grafting at 26°C room temperature gave the best results in terms of stem diameter for all light intensities and types of tunnel with significant differences. These results were in agreement with those obtained by [25,26]. Concerning the effect of light intensity on the stem growth, the results indicate that the average stem diameter of the grafted cucumber seedling grown under the truss was higher than that grown under flat tunnel, where, it recorded 4.381, 4.553 and 4.719 mm at 0, 2500 and 5400 Lux light intensity, respectively. The results showed that increasing of light intensity during acclimatization to improve the growth and quality of grafted cucumber seedlings. These results agreed with those obtained by [12,13] in which the stem diameter of grafted cucumber seedlings was enhanced by light during acclimatization. The results also indicate that the stem diameter ranged from 4.636 and 4.476 mm in truss and flat tunnel, respectively. The statistical analysis showed that the differences between the obtained data of stem diameter of cucumber seedlings due to the effect of ambient temperature, light intensity and type of tunnel were significant. The analysis showed also that the interaction between both AB, AC, BC and ABC were non-significant.

**Shoot length:** Table 2 and Figures 7-9 show the shoot length of the grafted cucumber seedlings grown under two types of tunnel (truss and flat) as affected by the ambient temperatures from 20 to 29°C and light intensities from 0 to 5400 Lux. Regarding of the effect ambient temperature, it could be seen that the average values of shoot length were 8.025, 8.252, 8.320 and 8.174 cm for the grafted cucumber seedlings grown at 20, 23, 26 and 29°C ambient temperature, respectively depending on the light intensities and type of tunnel. The results showed that the seedling shoot length increased with increasing the ambient temperature 20 to 26°C, where, grafting at 26°C ambient temperature gave the best results in terms of shoot length for all light intensity and type of tunnel with significant differences. Concerning the effect of light intensity on the shoot length, the results indicate that the average shoot length of the grafted cucumber seedling grown under the truss and flat tunnel shape decreases with increasing the light intensity. It indicates that when the light intensity increased from 0 to 5400 Lux, the average shoot length of the grafted cucumber seedling significantly decreased from 8.326 to 8.101 cm. These results agreed with those obtained by [13] in which the shoot length of grafted cucumber seedlings was decreased by light during acclimatization. The results also indicate that the shoot length ranged from 8.254 and 8.131 cm at truss and flat tunnel, respectively. The statistical analysis showed that there were non-significant differences between the temperature



**Figure 3:** Distribution of temperature in flat and truss tunnels at different ambient temperatures.

treatments, while the differences between the obtained data of shoot length due to the effect of light intensity and type of tunnel shape were significant. The analysis showed also that the interaction between both AB and ABC were non-significant. On the other hand, the interaction between the effect of both AC and BC on the data were significant.

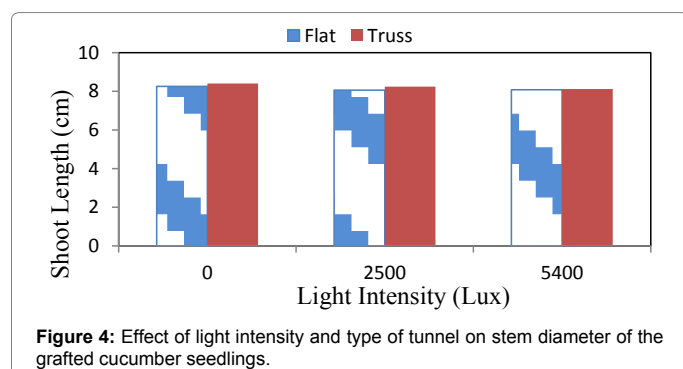
**Leaf area:** Table 3 and Figures 10-12 show the leaf area of the grafted cucumber seedlings grown under two types of tunnel (truss and flat) as affected by the ambient temperatures from 20 to 29°C and light intensities from 0 to 5400 Lux. It could be seen that the average values of leaf area were 51.098, 55.399, 58.286 and 53.793 cm<sup>2</sup> for the grafted cucumber seedlings grown at 20, 23, 26 and 29°C ambient temperatures, respectively depending on the light intensities and type of tunnel. The results showed that the seedling leaf area increased with

increasing the ambient temperature 20 to 26°C, where, grafting at 26°C ambient temperature gave the best results in terms of leaf area for all light intensities and types of tunnel with significant differences. These results were in agreement with those obtained by [25,26]. Concerning the effect of light intensity on the leaf area, the results indicate that the average leaf area of the grafted cucumber seedling grown under the truss and flat tunnel shape increases with increasing the light intensity. It indicates that when the light intensity increased from 0 to 5400 Lux, the average leaf area of the grafted cucumber seedling significantly increased from 50.682 to 59.150 cm<sup>2</sup>. Plants grown under high light intensity condition have higher photosynthetic capacity, greater leaf area, and more chloroplasts in mesophyll cells. The amount of chloroplasts increased with increasing light intensity during

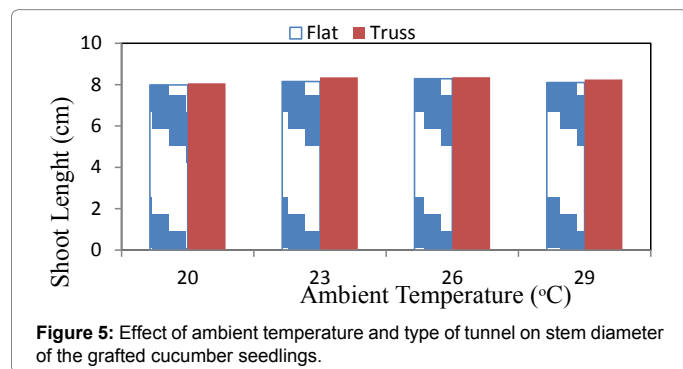


Type of Tunnel	Light Intensity, Lux	Ambient Temperature, °C				Mean
		20	23	26	29	
		stem diameter, mm				
Truss	0	4.309	4.507	4.521	4.41	4.437
	2500	4.411	4.696	4.871	4.483	4.615
	5400	4.746	4.802	4.982	4.771	4.825
	Mean	4.489	4.668	4.791	4.555	
Flat	0	4.214	4.333	4.503	4.247	4.324
	2500	4.253	4.659	4.68	4.371	4.491
	5400	4.491	4.597	4.854	4.512	4.614
	Mean	4.319	4.530	4.679	4.377	
Mean of ambient temperature (A)		4.404 <sup>a</sup>	4.599 <sup>b</sup>	4.735 <sup>c</sup>	4.466 <sup>a</sup>	
Mean of light intensity (B)		4.381 <sup>a</sup>	4.553 <sup>b</sup>		4.719 <sup>c</sup>	
Mean of type of tunnel (C)		4.626 <sup>b</sup>		4.476 <sup>a</sup>		
LSD <sub>0.05</sub>	A	B	C	AB	AC	BC
	0.074	0.071	0.068	N.S	N.S	N.S

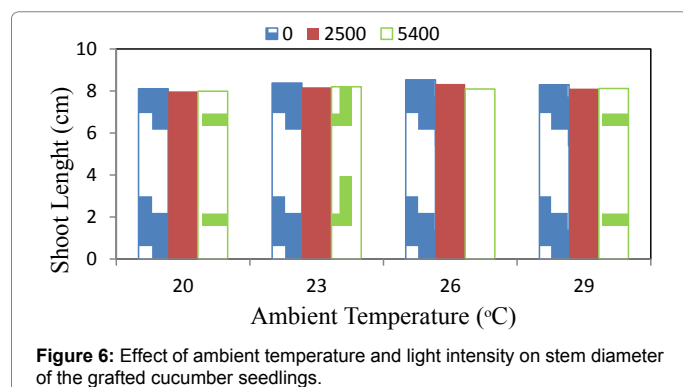
**Table 1:** Effect of ambient temperature, light intensity and type of tunnel on stem diameter of the grafted cucumber seedlings.



**Figure 4:** Effect of light intensity and type of tunnel on stem diameter of the grafted cucumber seedlings.



**Figure 5:** Effect of ambient temperature and type of tunnel on stem diameter of the grafted cucumber seedlings.



**Figure 6:** Effect of ambient temperature and light intensity on stem diameter of the grafted cucumber seedlings.

acclimatization compared with that of dark condition. These results agreed with those obtained by [13,27] in which the leaf area of grafted cucumber seedlings was increased by light during acclimatization. The results also indicate that the leaf area ranged from 56.074 and 53.214 cm<sup>2</sup> at truss and flat tunnel, respectively. The statistical analysis showed that there were significant differences between the temperature treatments, light intensity and type of tunnel shape. The analysis showed also that the interaction between both ABC were non-significant. On the other hand, the interaction between the effect of both AB, AC and BC on the data were significant.

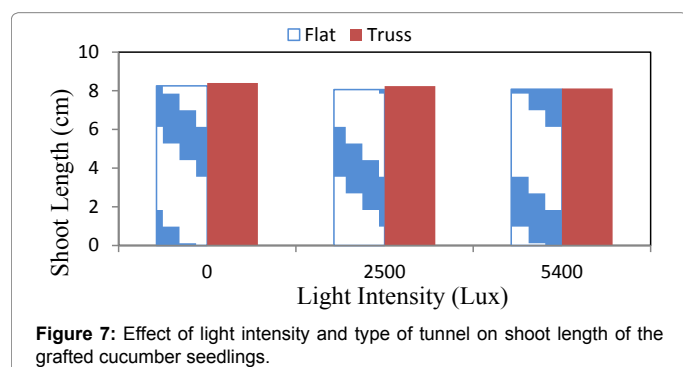
**Shoot dry mass:** Table 4 and Figures 13-15 show the shoot dry mass of the grafted cucumber seedlings grown under two types of tunnel (truss and flat) as affected by the ambient temperatures from 20 to 29°C and light intensities from 0 to 5400 Lux. It could be seen that the average values of shoot dry mass were 379.522, 393.247, 402.247 and 390.601 mg for the grafted cucumber seedlings grown at 20, 23, 26 and 29°C ambient temperature, respectively depending on the light intensities and type of tunnel. The results showed that the seedling shoot dry mass increased with increasing the ambient temperature 20 to 26°C, where, grafting at 26°C ambient temperature gave the best results in terms of shoot dry mass for all light intensity and type of tunnel with significant differences. Concerning the effect of light intensity on the shoot dry mass, the results indicate that the average shoot dry mass of the grafted cucumber seedling grown under the truss and flat tunnel shape increases with increasing the light intensity. It indicates that when the light intensity increased from 0 to 5400 Lux, the average shoot dry mass of the grafted cucumber seedling significantly increased from 378.286 to 408.228 mg. The results also indicate that the shoot dry mass ranged from 396.448 and 388.585 mg in truss and flat tunnels, respectively. The statistical analysis showed that there were significant differences between the temperature, light intensity and type of tunnel shape treatments. The analysis showed also that the interaction between both AB and ABC were non-significant. On the other hand, the interaction between the effect of both AC and BC on the data were significant.

### Grafted-take

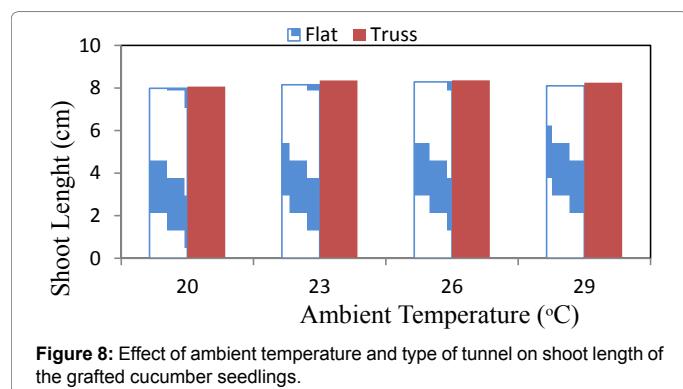
Table 5 and Figures 16-18 show the grafted-take (efficiency of grafting) of the grafted cucumber seedlings grown under two types of tunnel (truss and flat) as affected by the ambient temperatures from 20 to 29°C and light intensities from 0 to 5400 Lux. Regarding of the

Type of Tunnel	Light Intensity, Lux	Ambient Temperature, °C				Mean
		20	23	26	29	
		stem diameter, mm				
Truss	0	4.309	4.507	4.521	4.41	4.437
	2500	4.411	4.696	4.871	4.483	4.615
	5400	4.746	4.802	4.982	4.771	4.825
	Mean	4.489	4.668	4.791	4.555	
Flat	0	4.214	4.333	4.503	4.247	4.324
	2500	4.253	4.659	4.68	4.371	4.491
	5400	4.491	4.597	4.854	4.512	4.614
	Mean	4.319	4.530	4.679	4.377	
Mean of ambient temperature (A)		4.404 <sup>a</sup>	4.599 <sup>b</sup>	4.735 <sup>c</sup>	4.466 <sup>a</sup>	
Mean of light intensity (B)		4.381 <sup>a</sup>	4.553 <sup>b</sup>	4.719 <sup>c</sup>		
Mean of type of tunnel (C)		4.626 <sup>b</sup>			4.476 <sup>a</sup>	
LSD <sub>0.05</sub>	A	B	C	AB	AC	BC
	0.074	0.071	0.068	N.S	N.S	N.S

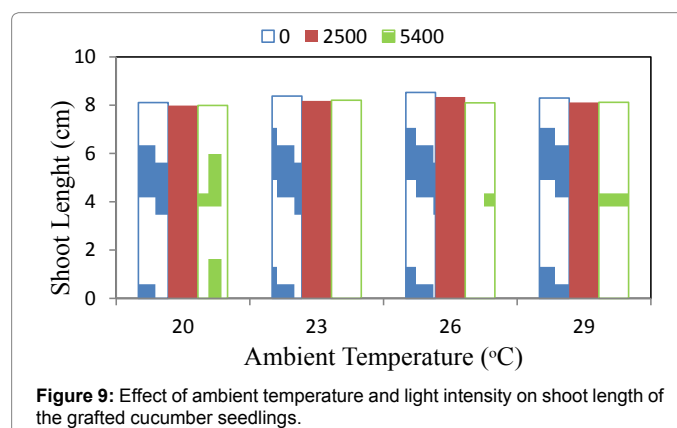
**Table 2:** Effect of ambient temperature, light intensity and type of tunnel on stem diameter of the grafted cucumber seedlings.



**Figure 7:** Effect of light intensity and type of tunnel on shoot length of the grafted cucumber seedlings.



**Figure 8:** Effect of ambient temperature and type of tunnel on shoot length of the grafted cucumber seedlings.



**Figure 9:** Effect of ambient temperature and light intensity on shoot length of the grafted cucumber seedlings.

effect ambient temperature, it could be seen that the average values of grafted-take were 77.998, 82.107, 84.973 and 80.892% for the grafted cucumber seedlings grown at 20, 23, 26 and 29°C ambient temperature, respectively depending on the light intensities and types of tunnel. The results showed that the seedling grafted-take increased with increasing the ambient temperature 20 to 26°C, where, grafting at 26°C ambient temperature gave the best results in terms of grafted-take for all light intensity and type of tunnel with significant differences. The grafted-take increased by 5.39%, when the ambient temperature increased from 20 to 29°C in truss tunnel, where, it increased by 1.60%, when the ambient temperature increased from 20 to 29°C in flat tunnel. Meanwhile the light intensity has diverse effect on the grafted-take, where it was 88.651 decreased to 80.069%, when the light intensity increased from 0 to 5400 Lux in truss tunnel, where, it decreased from 82.235 to 74.844%, when

the light intensity increased from 0 to 5400 Lux in flat tunnel. Darkness pushes the plant to the vegetative growth, this in turn affect the healing of seedlings during grafting process. These results were in agreement with those obtained by [26]. The statistical analysis showed that there were significant differences between the temperature, light intensity and type of tunnel shape treatments. The analysis showed also that the interaction between ABC were non-significant. On the other hand, the interaction between the effect of both AB, AC and BC on the data were significant.

Regression analysis was carried out to find a relation between the grafted-take and both ambient temperatures and light intensities. Equations (2, 3 and 4) show the most appropriate form for the relationship between the grafted-take and ambient temperatures at different light intensities.

For 0 Lux light intensity:

$$GT = 68.877 + 14.484AT - 2.619AT^2 \quad R^2 = 0.97 \quad (2)$$

For 2500 Lux light intensity:

$$GT = 68.426 + 8.174AT - 1.521AT^2 \quad R^2 = 0.89 \quad (3)$$

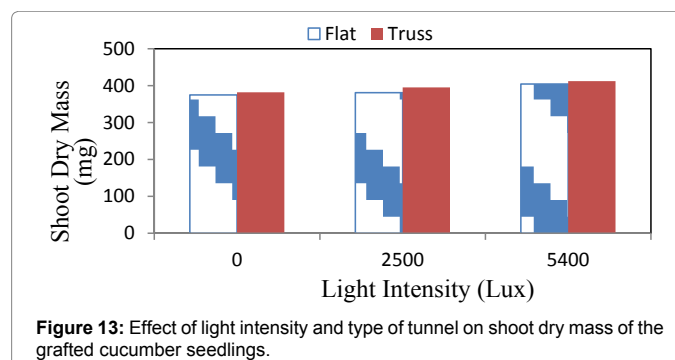
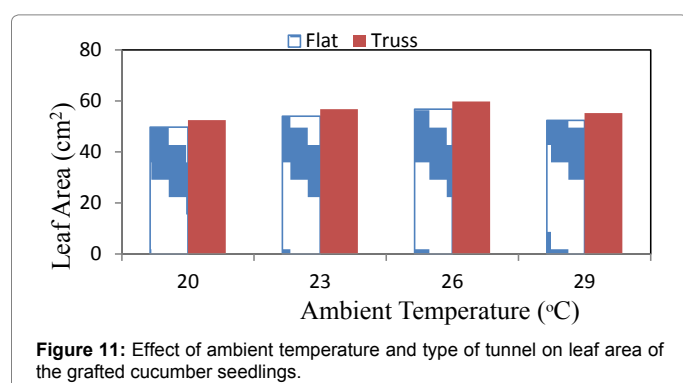
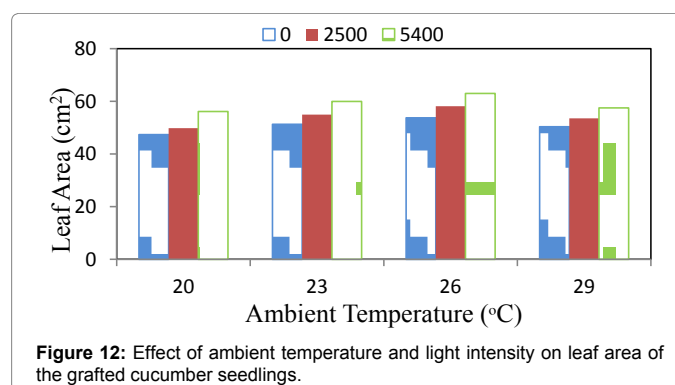
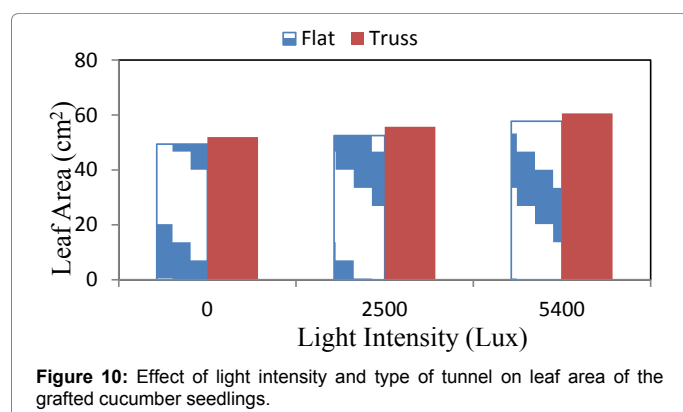
For 5400 Lux light intensity:

$$GT = 68.426 + 8.174AT - 1.521AT^2 \quad R^2 = 0.89 \quad (4)$$

where, GT is the grafted-take of grafted cucumber seedlings, %; AT is the ambient temperature, °C.

Type of Tunnel	Light Intensity, Lux	Ambient Temperature, °C				Mean			
		20	23	26	29				
		Leaf Area, cm²							
Truss	0	48.651	52.226	55.327	51.659	51.966 <sup>a</sup>			
	2500	51.550	56.515	59.642	55.048	55.689 <sup>c</sup>			
	5400	57.294	61.591	64.384	59.003	60.568 <sup>cd</sup>			
	Mean	52.498 <sup>a</sup>	56.777 <sup>b</sup>	59.784 <sup>bc</sup>	55.237 <sup>b</sup>				
Flat	0	46.029	50.367	52.181	49.018	49.399 <sup>a</sup>			
	2500	48.069	53.358	56.611	52.006	52.511 <sup>ab</sup>			
	5400	54.994	58.338	61.573	56.023	57.732 <sup>c</sup>			
	Mean	49.697 <sup>a</sup>	54.021 <sup>ab</sup>	56.788 <sup>b</sup>	52.349 <sup>a</sup>				
Mean of ambient temperature (A)		51.098 <sup>a</sup>		55.399 <sup>b</sup>		58.286 <sup>c</sup>		53.793 <sup>b</sup>	
Mean of light intensity (B)		50.682 <sup>a</sup>		54.100 <sup>b</sup>		59.150 <sup>c</sup>			
Mean of type of tunnel (C)		56.074 <sup>b</sup>			53.214 <sup>a</sup>				
LSD <sub>0.05</sub>	A	B	C	AB	AC	BC	ABC		
	2.591	2.927	2.044	3.063	3.810	2.918	N.S		

**Table 3:** Effect of ambient temperature, light intensity and type of tunnel on leaf area of the grafted cucumber seedlings.



## Energy consumption

Figure 19 shows the effect of room temperature and light intensity on the energy consumption. It is clear that the energy consumed in production grafted cucumber seedlings decreased with increasing ambient temperature from 20 to 29°C and decreased light intensity from 5400 to 0 Lux. It could be seen that the energy consumed decreased from 44.052 to 32.532, 50.356 to 38.836 and 56.660 to 45.140 kW per 1000 seedlings at 0, 2500 and 5400 Lux light intensities, respectively, when the ambient temperature increasing from 20 to 29°C. Meanwhile the energy consumed increased from 44.052 to 56.660, 40.212 to 52.820, 36.372 to 48.980 and 32.532 to 45.140 kW per 1000 seedlings at 20, 23, 26 and 29°C ambient temperatures, respectively, when the light intensity increasing 0 to 5400 Lux.

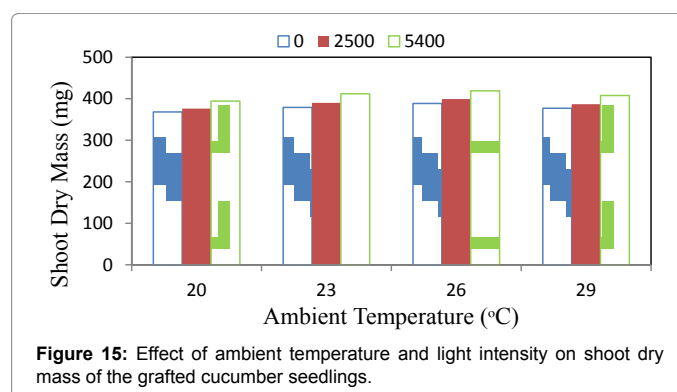
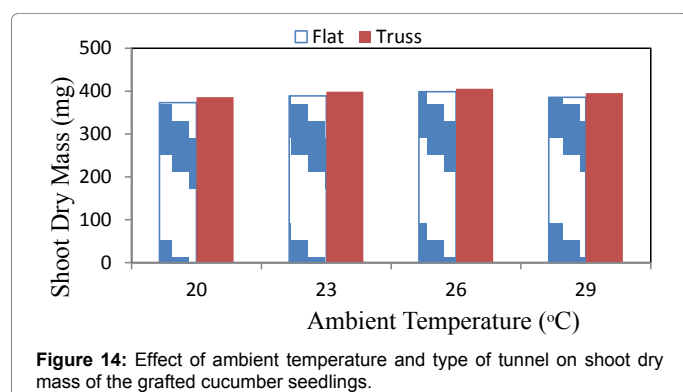
## Conclusion

The experiment was carried out to optimize the environmental condition for best grafting by control the temperature and light of grafting conditions. To achieve that was study the effect of ambient temperatures (20, 23, 26 and 29°C), light intensity (0, 2500 and 5400 Lux) and type of tunnel (truss and flat) on stem diameter, shoot length, leaf area, shoot dry mass and grafted-take. The obtained results can be summarized as follows:

- The temperature distribution patterns appear as a concave shape where, the temperature increased toward the center of the flat tunnel which varies slightly from 20.291 to 21.053, 23.526 to 25.761, 26.893 to 29.517 and 29.149 to 33.729°C at 20, 23, 26 and 29°C ambient temperature, respectively and it increased from 20.259 to 20.909, 23.271 to 24.300, 27.811°C

Type of Tunnel	Light Intensity, Lux	Ambient Temperature, °C				Mean		
		20	23	26	29			
		Shoot Dry Mass, mg						
Truss	0	375.991	382.162	389.001	380.076	381.808 <sup>a</sup>		
	2500	382.416	397.738	406.335	394.561	395.263 <sup>b</sup>		
	5400	399.515	415.883	421.687	412.006	412.273 <sup>bc</sup>		
	Mean	385.974	398.594	405.674	395.548			
Flat	0	360.439	376.244	388.338	374.037	374.765 <sup>a</sup>		
	2500	369.741	382.109	392.037	379.344	380.808 <sup>a</sup>		
	5400	389.029	408.037	416.081	403.584	404.183 <sup>b</sup>		
	Mean	373.070	388.797	398.819	385.655			
Mean of ambient temperature (A)		379.522 <sup>a</sup>		393.696 <sup>ab</sup>		402.247 <sup>b</sup>		390.601 <sup>a</sup>
Mean of light intensity (B)		378.286 <sup>a</sup>		388.035 <sup>b</sup>		408.228 <sup>c</sup>		
Mean of type of tunnel (C)		396.448 <sup>b</sup>			386.585 <sup>a</sup>			
LSD <sub>0.05</sub>	A	B	C	AB	AC	BC	ABC	
	11.262	9.337	7.694	N.S	10.935	13.001	N.S	

**Table 4:** Effect of ambient temperature, light intensity and type of tunnel on shoot dry mass of the grafted cucumber seedlings.



Type of Tunnel	Light Intensity, Lux	Ambient Temperature, °C				Mean	
		20	23	26	29		
		Grafted-Take, %					
Truss	0	82.261	90.103	93.272	88.968	88.651 <sup>f</sup>	
	2500	79.696	85.207	89.568	84.944	84.854 <sup>e</sup>	
	5400	77.331	80.871	83.055	79.02	80.069 <sup>c</sup>	
	Mean	79.763 <sup>b</sup>	85.394 <sup>d</sup>	88.632 <sup>e</sup>	84.311 <sup>c</sup>		
Flat	0	79.699	83.203	85.671	80.367	82.235 <sup>d</sup>	
	2500	75.662	78.267	81.279	77.999	78.302 <sup>b</sup>	
	5400	73.336	74.992	76.991	74.056	74.844 <sup>a</sup>	
	mean	76.232 <sup>a</sup>	78.821 <sup>ab</sup>	81.314	77.474 <sup>a</sup>		
Mean of ambient temperature (A)		77.998 <sup>a</sup>		82.107 <sup>c</sup>		84.973 <sup>d</sup>	80.892 <sup>b</sup>
Mean of light intensity (B)		85.443 <sup>c</sup>		81.578 <sup>b</sup>		77.457 <sup>a</sup>	
Mean of type of tunnel (C)		84.525 <sup>b</sup>			78.460 <sup>a</sup>		
LSD <sub>0.05</sub>	A	B	C	AB	AC	BC	ABC
	1.238	1.071	1.022	1.415	1.399	1.241	N.S

**Table 5:** Effect of ambient temperature, light intensity and type of tunnel on grafted-take of the grafted cucumber seedlings.

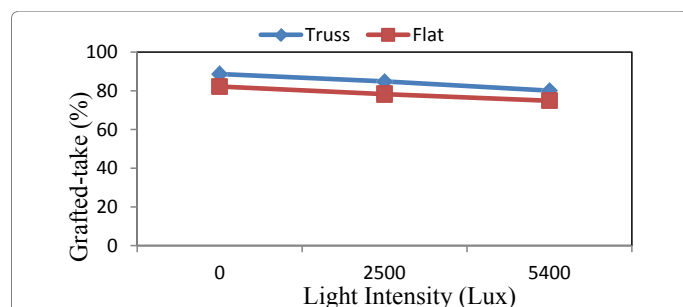
at 26 and 29.372 to 30.818°C at 20, 23, 26 and 29°C ambient temperature, respectively in truss tunnel.

- The highest value of the stem diameter of the grafted cucumber seedlings (4.735 mm) was obtained at ambient temperature of 26°C. While the highest value of the stem diameter of the grafted cucumber seedlings (4.719 mm) was found at light intensity 5400 Lux.
- The seedling shoot length increased with increasing the ambient temperature 20 to 26°C, where, grafting at 26°C

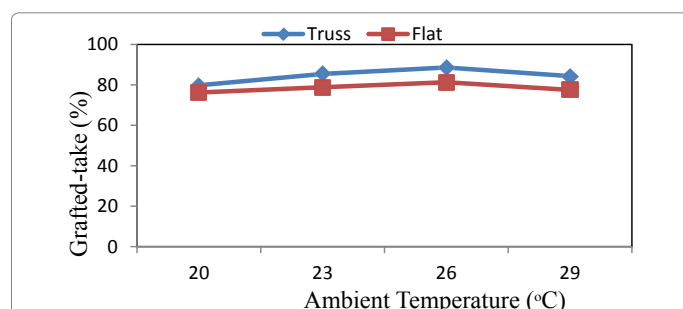
ambient temperature gave the best results in terms of shoot length for all light intensity and type of tunnel with significant differences. The shoot length ranged from 8.254 and 8.131 cm at truss and flat tunnel, respectively.

- The leaf area and shoot dry mass ranged from 56.074 and 53.214 cm<sup>2</sup> and 396.448 and 388.585 mg at truss and flat tunnel, respectively.
- The grafted-take increased by 5.39 and 1.6%, when the ambient temperature increased from 20 to 29°C in truss and flat tunnels.

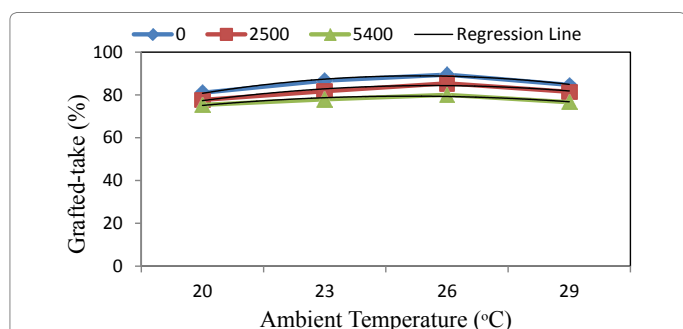




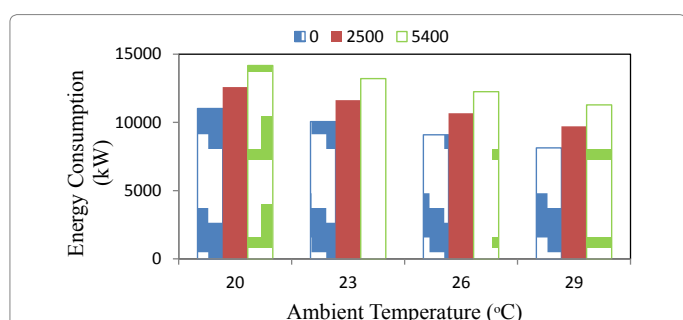
**Figure 16:** Effect of light intensity and type of tunnel on grafted-take of the grafted cucumber seedlings.



**Figure 17:** Effect of ambient temperature and type of tunnel on grafted-take of the grafted cucumber seedlings.



**Figure 18:** Effect of ambient temperature and light intensity on grafted-take of the grafted cucumber seedlings.



**Figure 19:** Energy consumed in production grafted cucumber seedlings.

Meanwhile the light intensity has diverse effect on the grafted-take, where it was decreased from 88.651 to 80.069 and 82.235 to 74.844%, when the light intensity increased from 0 to 5400 Lux in truss and flat tunnels.

The energy consumed decreased from 44.052 to 32.532, 50.356

to 38.836 and 56.660 to 45.140 kW per 1000 seedlings at 0, 2500 and 5400 Lux light intensities, respectively, when the ambient temperature increasing from 20 to 29°C.

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