# Growth response of eggplant (*Solanummelongena L.)* toshading and cultivation inside greenhouseinatropical region.

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**Abstract**— Shading is one of the cooling methods in the hot and sunny regions to modify microclimate and optimize crop growth. This study intended to investigate the effect of shading treatments at different growth stages of eggplant growth under greenhouse condition.

The experiment was carried out at the Institute of Sustainable Agrotechnology field, University Malaysia Perlis (UniMAP), Padang Besar, Perlis, Malaysia. Eggplant used in the experiment was of the purple and long variety type (F1 Hybrid). The experimental treatments include shading outside greenhouse, control outside greenhouse (no shade), control inside greenhouse (no shade), shading inside greenhouse for first plant growth stage only (from transplanting until 50% bloom), shading throughout plant growth, and shading inside greenhouse for last plant growth stage only (from 50% of bloom until harvest). The experimental design used was a factorial experiment with randomized complete block design.

The results showed that the eggplant growth under greenhouse condition especially under shading was improved to the ones grown in the open field in the context of plant height, leaf number, total leaf area, individual leaf area, fresh plant weight and node number.

**KEYWORDS:** Eggplant, Shading, Greenhouse, Tropical.



## 1. Introduction

Eggplant (*Solanummelongena* L.), also known as aubergine, guinea squash or brinjal, is an economically important crop in tropical and subtropical regions. Eggplant cultivars produce fruits that vary in shapes, sizes, and colors. It isreported to have the highest content of antioxidants[15]. It has become increasingly appreciated vegetable due to its considerable dietary value, as well as the possibility of its versatile usage, it is cultivated mainly in greenhouses and in foil tunnels[1].

Greenhouses are used in many tropical regions around the world to produce vegetables. However, the high ambient temperature in a greenhouse is also its main problem in vegetable production[5].The increasing demand by world markets for highquality yield has led to more and more horticultural crop production systems to adopt protected environments for improving production.Eggplant production from greenhouses reports an annual increased in tandem with theapplication of improved agricultural technologies, where eggplant is fourth highest greenhouse product, after tomatoes, peppers, and cucumbers[4].

Although sunlight is essential to greenhouse production, only ~5% of it is used for photosynthesis while the unused radiation generatesheat that could damage the leaves' surface. Basically, light requirements and climatic effects are vital factors that need to be taken into account when designing greenhouses[2].[22]found that intense solar radiation during the day increasedthe internal temperature of the greenhouse, which lowers its total yield.However, inscreenhouses or net-houses, the crops are covered by a porous screen,preventing excess heat or sun damage from afflicting the plants.

Many studies reported that for the majority of greenhouse crops, a 1% light increment can result in a 0.5–1% increase in the harvested product, while extreme light intensity, combined with excessive radiation, can do the exact opposite.The most common methodof reducingthe incoming solar radiation is the use of shade screens. Shading helps limit the temperature increase in a greenhouse. A 10% increase in marketable yield of tomatoes was reported when a mobile shade was used for a couple of hours of intense sunlight in Spain [9].[17]foundthat the yield per plant was higher in a shadenet house compared to an open field. Hence, growing tomatoes, eggplants, chillies, cucumbers, radishes, amaranthus, and coriander under shade house conditions will be more profitable regardless of the seasons.In the case of eggplant, high temperatures increase thegrowth of the plants,however, very high temperaturesare unsuitable for growth [13].

Efforts to reduce heat in tropical greenhouses often result in a reduction of light intensity within the structure, since theamount of light (photosynthetically active radiation, PAR) required for photosynthesis depends on the type of crop grown andgrowth stages[5]. This study intends to evaluateeggplant growthin a greenhouse with shadingsat different stages of plant growthcompared to the open field ina tropical regionin the context of improving theproduction of locally grown vegetables.

## 2. Materials and methods

The experiment was conducted at theInstitute of Sustainable Agrotechnology field, University Malaysia Perlis (UniMAP), Padang Besar, Perlis, Malaysia.The eggplant used in the experiment is of the purple and long varietytype (F1 Hybrid), procured from the Green World Company, Malaysia.

The experimental treatments wereas follows:

- T1:Shading outside greenhouse
- T2:Control outside greenhouse (no shade)
- T3:Control inside greenhouse (no shade)
- T4: Shadinginside greenhouse, from transplanting until 50% bloom.
- T5: Shading throughout plant growth.
- T6: Shadinginside greenhouse, from 50% bloom until harvest.

The treatments were arranged in a factorial experiment with randomized complete block design in six replicates. Duncan's test was used to evaluate differences among the means. Significance was reported at $P < 0.05$ when using SAS version 9.2 [19].The greenhouse measures 6 by 18 meters.Three shading treatments (three plant growth stages) and the control treatment (no shade) were distributed inside the greenhouse and divided into fourcompartments. Thecompartmentswere 2 m high, 2 m wide and 4 m long.Two treatmentswere outside greenhouse,controltreatment (no shade) and shade treatment. The shades outside the greenhouse were constructedusing an iron structure, measuring2 m high, 2 m wide and 4 m long, covered with shading nets.

A drip irrigation system was used in the experiment, 30 cm between the drippers, and 60 cm between the plants. The amount of water used throughout experiment was 106 L/plant. The seedlings were transplanted in white plastic bags(size20 L) andarranged alternately along the drip tube.The characteristics of the soils used in the experiment are shown in Table 1.

Table1.Soil characteristics used in the experiment.

| Total N (%) | Ava .P(ppm) | K(me %) | Ca(me%) | Mg(me %) | O.M (%) | O.C (%) | pH | C.E.C(me%) | Clay (%) | Silt (%) | Fine Sand (%) | Coarse Sand (%) | Soil Texture | N/C Ratio | EC μs/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.22 | 38 | 2.6 | 35 | 4.9 | 5.9 | 1.9 | 5.6 | 61 | 9.6 | 9.8 | 54.7 | 20 | Loamy sand | 11/95 | 720 |

The temperature and relative humidity were recorded using a data logger, where four sensorswas fixed inside and outside thegreenhouse during the experiment, in addition to mercury thermometer was used to measure the temperature under shading treatment during sunshine hours, and the average was taken. The air speed was measured using the airspeed, temperature, volume flowtelescoping AS-201Hotwire probe,procured from Ireland (Table 2).

Table2. The measurements of some environmental conditionsfor the shading treatments.

| Treatments | Temperature (°C) | Relative humidity (%) | Air speed (m/s) | Light intensity W/m$^2$ |
|---|---|---|---|---|
| Shading outside | 30.52 | 84.51 | 1.10 | 356.50 |
| Control outside | 30.66 | 78.15 | 2.63 | 639.06 |
| Control inside | 31.94 | 81.77 | 0.88 | 632.81 |
| Shading inside | 31.95 | 81.40 | 0.33 | 338.28 |



Plant measurements recorded were:

1. Height of plants

   The measuring tape was used to measure theheight of the plants.

2. Leaf Number

   Bycounting the leaf number per plant at the end of the experiment.

3. Total leaf area

   All the leaves from the plant wereremoved at the end of the experiment and measured using leafarea meter.

4. Plant weight

   Six replicates plant weight was measured at the end of the experiment after the roots were separated.

5. Stem diameter

   The measurement wasconducted with six plants as replicates, where a digital Vernier calliperwas used to measure the stem's diameter 5 cm above the soil's surface.

6. Number of nodes

   After removing the leaves at the end of the experiment to measure its area, the node number was counted for six plants as replicates.

7. Percentage of leaf dry matter

Third, fourth, and fifth mature and intact leaves were taken from the plant at the fruit stage of six plants as replicates. The leaf wet weight was immediatelyrecorded and dried in an electrical oven at 70°C until its weight was constant. The following equation was used:

$$\text{Percentage of the leaf's dry matter} = \frac{\text{Leaf dry weight}}{\text{Fresh weight}} \times 100$$

8. Measurement of chlorophyll content

The content of total chlorophyll were measured using the method reported in [7], where the mature and intact leaves were taken from the plant samples. The discs of each leaf were collected for extract, and the pigment content of the extract was determined using spectrophotometry at two characteristic wavelengths: 647 and 664 nm, which are the maximum absorption wavelengths for chlorophylls (b) and (a), respectively [16].

## 3. Results and discussion

The results showed that theeggplant yield differed significantly due to its response to the effect of the treatments.

### 3.1. Height of plant

The height of the plant grown outside the greenhouse was shorter than that grown inside the greenhouse. However the highest recorded plant height was the plants that were grown in the greenhouse under a shade.Figure 1 shows that the highest reported plant height was 156.2 cm and 154.7cm for shading throughout plant growth (T5) andshading for the last plant growth stage (T6)inside greenhouse treatments,respectively. However,the plant height under control (T3) (no shade) and the first plant growth stage (T4) inside greenhouse treatments were123.2 cm and 123.5 cm, respectively. The shortest plant height was shown by the control (no shade) treatment (T2) outside the greenhouse.

The increase in the height of the plant was accompanied by increasenode number,where a positive correlation was found between the plant height and node number (correlation coefficient = 0.94), and between the plant height and chlorophyll content (correlation coefficient = 0.84).The increased plant height under greenhouse treatmentcould be attributed to high temperatures (Table 2), which induces vertical growth of the plants, as per [18].The vigor of the plants are also susceptible to high temperatures, as confirmed by the positive correlation between plant height and chlorophyll content, this in consistent with[5].

The effect of shade treatments upon incremental plant height could be attributed to the increase of net of photosynthesis,$P^N$,alongside an increase in chlorophyll content under low light, which is confirmed by thepositive correlation between plant height and chlorophyll content. It could also be due to changes in the plant shape and growth patterns as it adapts to shade and searches for light source, which results in increased height.These are in agreement with[2],[10], [20],[21], [17],[11], and [12].The increased plant height under shades could be due to increased internodelength of the plant and number of nodes[9].

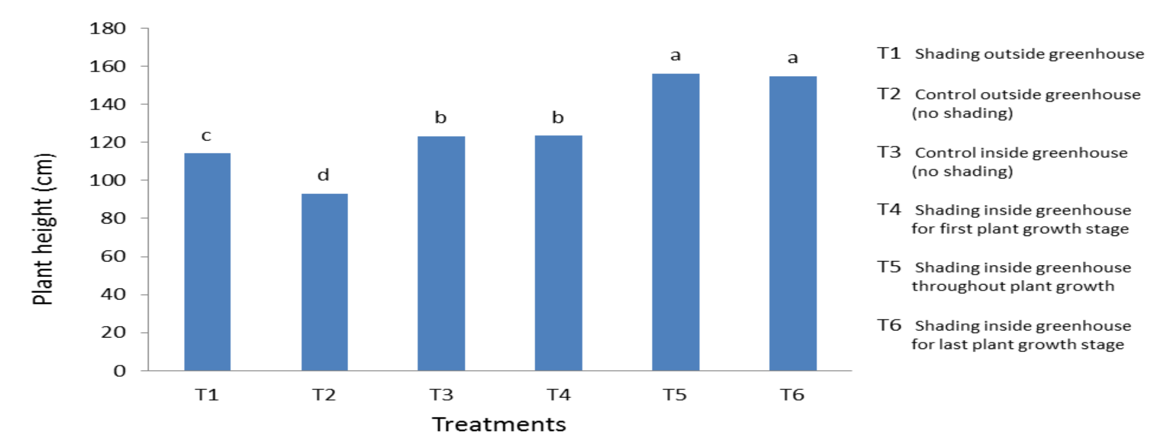


Fig.1. Plant height as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at P≤0.05).

### 3.2. Leaf Number

As shown inFigure 2, the total number of leaves of plants in the greenhouse was significantly higher, especially those under the shades, where the highest leaf number was for plants under the shade for thelast plant growth stage inside greenhouse (T6) (56 leaf/plant), while the lowest leaf number were that of plants grown outside the greenhouse, where it was 40.3 and 41leaf/plant for shade (T1) and control (T2) treatments, respectively.

There was a positive correlation between the leaf number and plant height (correlation coefficient = 0.89). This could be attributed to increased plant vigor at high temperatures inside the greenhouse, which induces vertical growth, culminating in increased plant height and leaf number, as per[5] and [18].In terms of the shading treatments, the results agreed with those reported by[21] and [17],but disagreedwith [3].

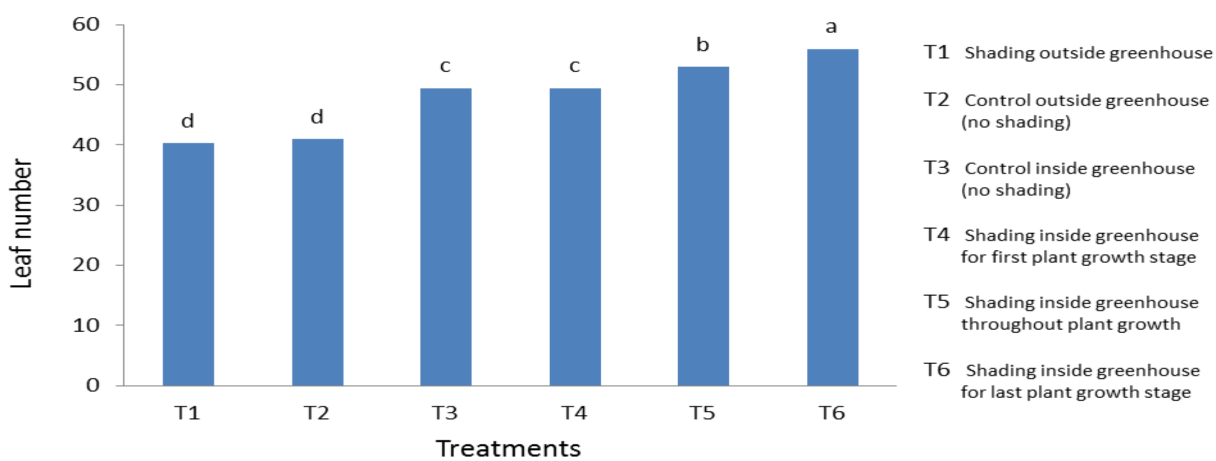


Fig.2. Leaf number as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at P≤0.05).

### 3.3. Total leaf area

The results showed that the treatments significantly affectedthe total leaf area trait of eggplant, as per(Figure 3). The plants grown outside greenhouse showed significantly lower total leaf area (5425 $cm^2$ and 4664 $cm^2$) for shade (T1) and control (T2) treatments, respectively. However, shading throughout plant growth (T5) and shading for last plant growth stage (T6) inside the greenhouse (13199.3 $cm^2$ and 12946.2 $cm^2$), respectively, were significantly higher than (T3) control (no shade) and shading for first plant growth stage (T4), (8435.5 $cm^2$ and 8813.8 $cm^2$) inside the greenhouse,respectively.

There was a positive correlation between the total leaf area and plant height (correlation coefficient = 0.97), between the total leaf area and leaf number (correlation coefficient = 0.95),and between total leaf area and individual leaf area (correlation coefficient = 0.927). This could all be due to the high temperature of the greenhouse, which increase plant vigor, leaf expansion rate, and ultimately, increased leaf size, which is consistent with[5], who reported that when the rate of leaf growth is lower, the leaf sizes decreases in plants grown at low night temperatures.

Shade treatment could improve the growth conditions and increase $P^N$andchlorophyll content (positive correlation, where its correlation coefficient = 0.777), which results in increased plant growth, followed by increased total leaf area.This conforms to those reported by[10],[21],[11] and [17], while also agreeing with[20], who observed that the gradual increase of $P^N$ andchlorophyll content where the leaf expands in low light conditions, signifying the excellent development of the photosynthetic apparatus, such as electron transport andcarbon assimilation process. This also indicates the viability of using low irradiance to gradually enhance leaf expansion and gradual adaptation to low light conditions. However, this does not agree with the facts reported in[3] whom mentioned that low light supply might cause significant reduction in the leaf area of *Dioscoreophyllumcumminsii*.

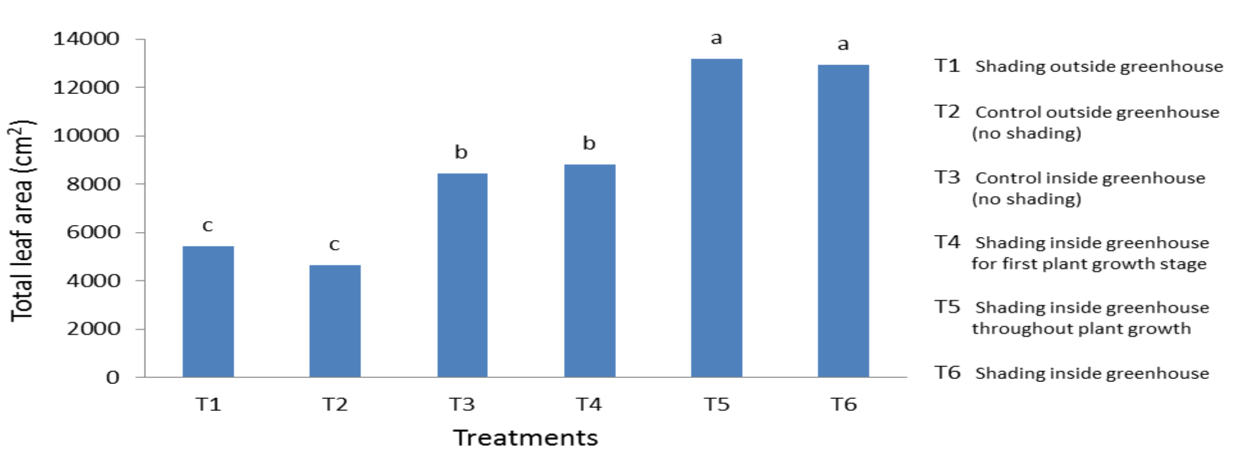


Fig.3. Total leaf area as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at $P \leqslant 0.05$).

### 3.4. Individual leaf area

Figure 4shows that the leaves ofplants grown inthe greenhouse were significantly bigger than those grown outside, regardless of whether it wasshaded inside the greenhouse or not. The plants grownunder the shade, whether inside or outside the greenhouse,were significantly superior in its individual leaf area,where the plants under shading throughout plant growth (T5) and shading for last plant growth stage (T6) inside the greenhouse reported the highest values (264.5 $cm^2$and 274.8 $cm^2$), respectively, while the lowest value was reported by the plantsgrown in the open field (T2) treatment,at 128.9$cm^2$.There was a positive correlation between the individual leaf area and chlorophyll content (correlation coefficient = 0.94).

This could be due to the high temperature in the greenhouse, which increases the leaf expansion and the leaf size, as per [5].Improved growth conditions under the shade treatment could be the result of the development of photosynthetic apparatus. The positive correlation between the two confirms the increase of the$P^N$ and individual leaf area, which is consistent with[20].

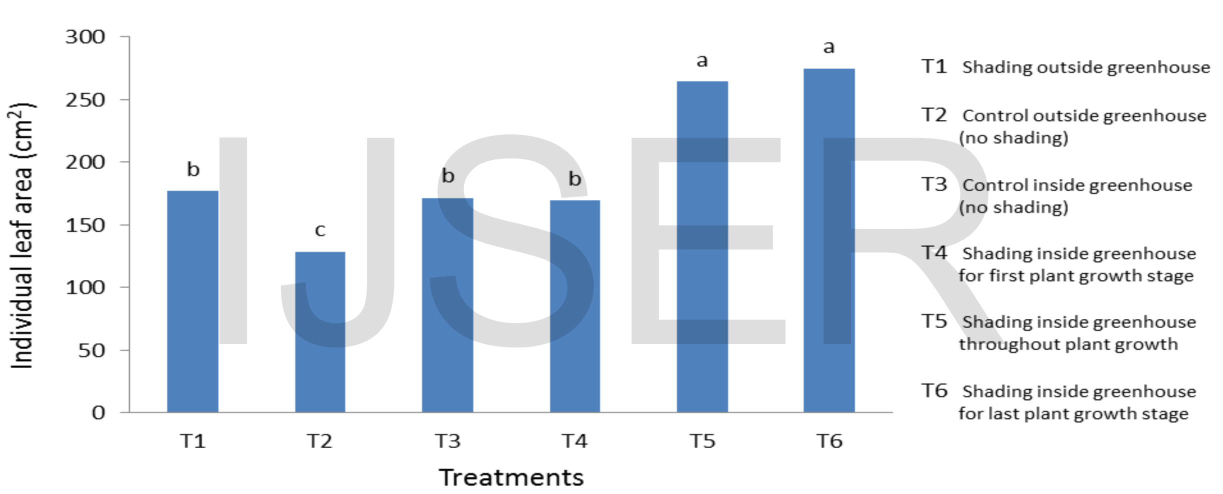


Fig.4. Individualleaf area as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at $P \leqslant 0.05$).

### 3.5. Plant weight

The weight of the plant in the greenhouse increased compared to those grown outside, especially the ones being shaded, which incidentally reported the highest values (826.20 g and 819.2 g) forshading throughout plant growth (T5) and shading for last plant growth stage (T6) inside greenhouse treatments, respectively, as per(Figure 5). Thelowest reported values were 370.9 g and 378.1 g for shade (T1) and control (T2) outside greenhouse treatments, respectively.The increased weight of the plant was due to its increased height,number of leaves, total and individual leaf area. There was a positive correlation between plant weight and the aforementioned factors, with correlation coefficients of0.93, 0.98, 0.98, and 0.85, respectively. These results could be attributed to the high temperature in the greenhouse, which inducesthe plants to grow rapidly and vertically. The results agree with those reported by [5] and [18].Moreover, the excellent effect of shade treatments on plant growth condition that increased the $P^N$also increased plant growth and weight, which is consistent with[20].

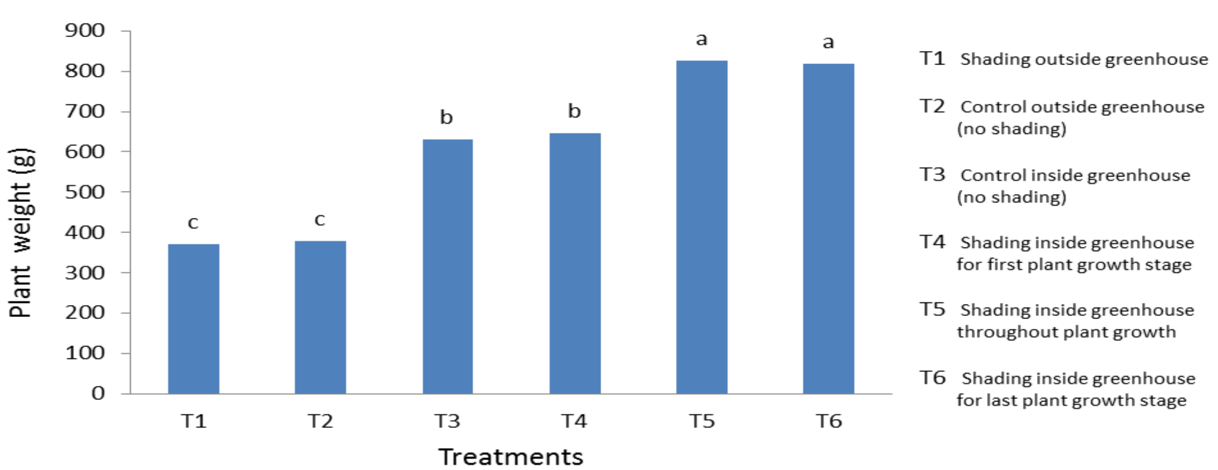


Fig.5. Plant weight as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at $P \leqslant 0.05$).



### 3.6. Stem diameter

The results in Figure 6 shows significant difference among the treatments on stem diameter, whereit grew significantly inside the greenhouse(16.11 mm) for no shade treatment (T3) compared to for the open field (T2) treatment (15.20 mm).The significantly thinner stem diameter (14.78 mm and 14.97 mm) was reported for shades outside the greenhouse (T1) and shading for the first plant growth stage inside the greenhouse (T4) treatments, respectively.Shading for the last plant growth stage inside the greenhouse (T6) treatments was16.1mm, which was significantly thicker than T1, T2, and T4 treatments. Thedecrease of stem diameter subjected to shading could be attributed to genetic traits, especially at the first stage of the plant, which is consistent with[12], who reported that the response of stem diameter to light intensity depends on genetic traits, as per[10], who reported decreased stem diameters under shade treatments, because the plants were taller.

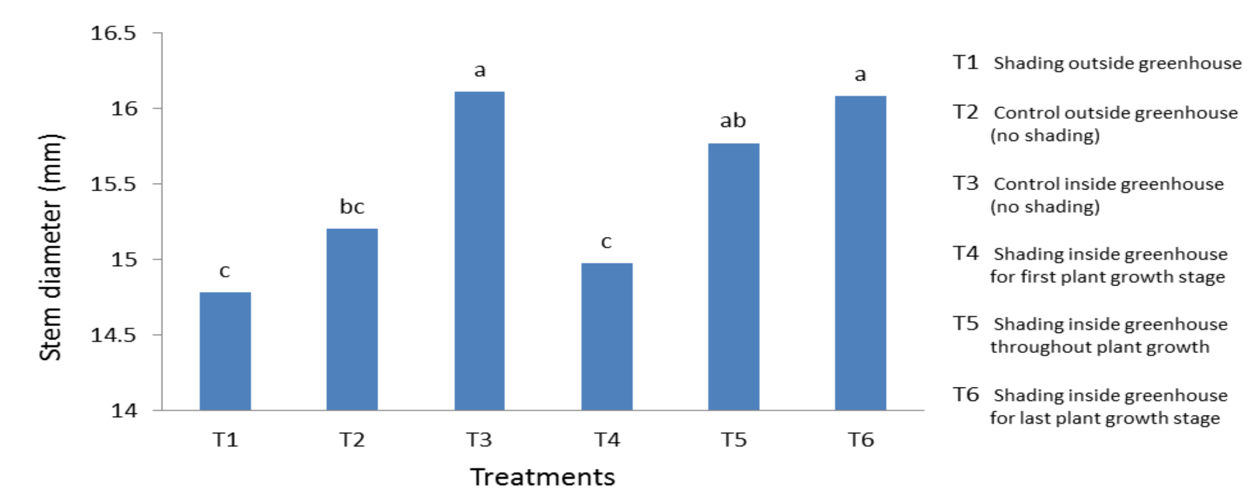


Fig.6. Stem diameter as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at P≤0.05).

### 3.7. Node number

The node number of theplantsgrown in the greenhousewas higher than those grown outside, as perFigure 7. The plants grown in the greenhouse under the shade were better compared to plant that was treated without shades, regardless of whether or not it was inside or outside the greenhouse.Thehighest node number was reported for plants under shading throughout its growth (T5) and shading for last growth stage (T6) inside the greenhouse, with a node number of 42 nodes /plant, respectively, for both. The control treatment (T2) outside the greenhouse reported a significantly lower node number (30 nodes/plant) compared to other treatments.

The increased plant height was accompanied by increased number of nodes, with a positive correlation between the node number and plant height(correlation coefficient = 0.94), as per [5], [18],[2], [10],[12], and[20].

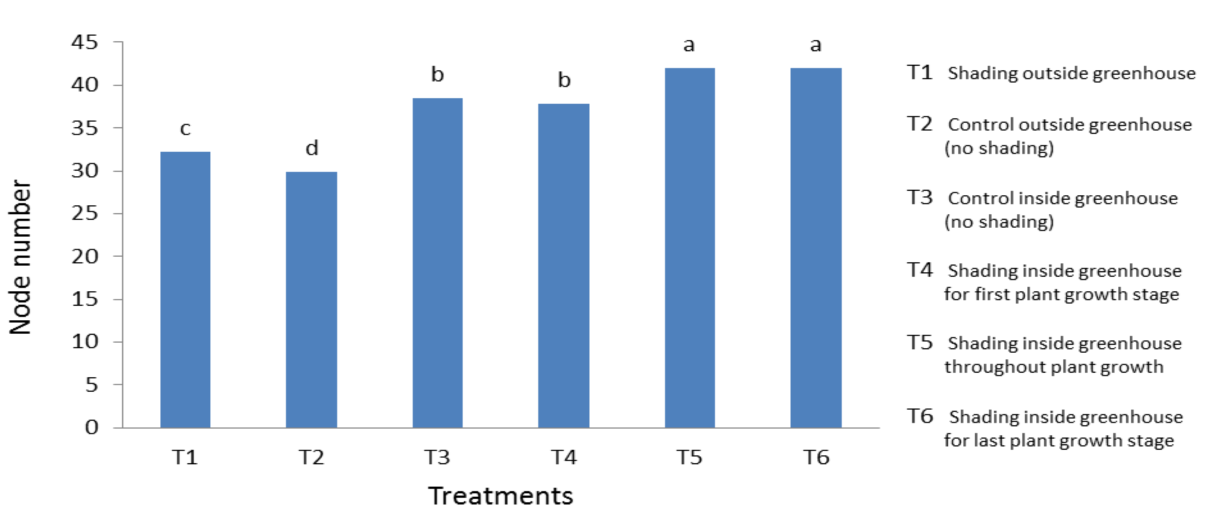


Fig.7. Node number as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at P≤0.05).

### 3.8. Percentage of leaf dry matter

Figure 8 indicated that the lowest percentage of dry matter was for leaves of plants under shades, at 16.5 %, 16.11 % and 16.3 % for shade outside greenhouse (T1), shading throughout growth (T5), and shading for last growth stage (T6) inside the greenhouse,respectively, which were significantly lower than other treatments, especially the shade treatment of the first plant growth stage inside the greenhouse (T4) that had the highest percentage of dry matter (18.4%).

The increment of percentage of dry matter of the unshaded plants compared to the shaded plants, whether inside or outside the greenhouse, could be attributed to the decrease of evapotranspiration under shade treatments due to improved growth condition, which results in the retention of water within the leaf tissue compared to samples that did not undergo shade treatment[2] and agreed with [6] who mentioned shade treatments reduced leaf temperature and excessive leaf transpiration.

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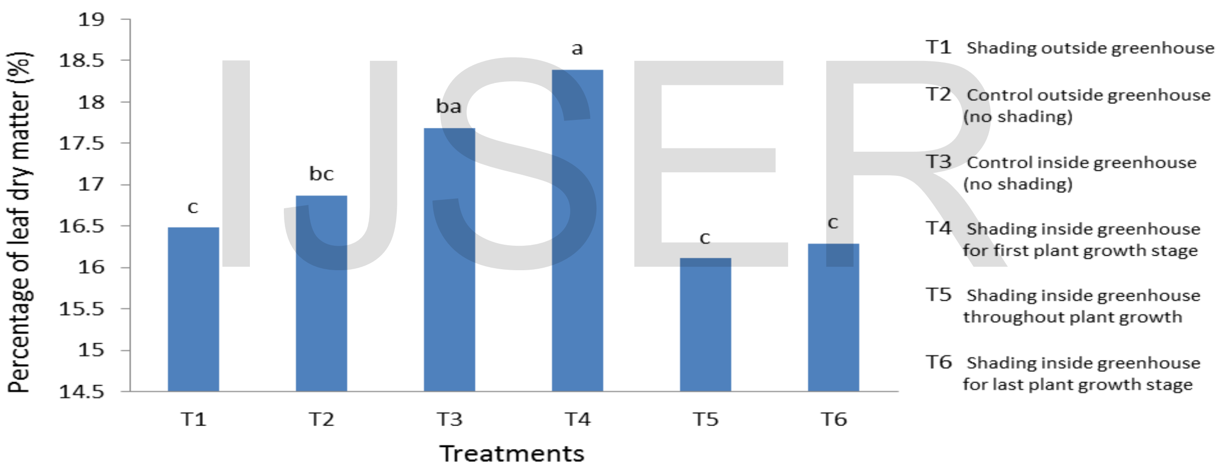


Fig.8. Percentage of Leaf dry matter as affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at $P \leq 0.05$).

### 3.9. Total chlorophyll content

Figures 9 indicated that leaves withsignificantly higher values of total chlorophyll contentwere those from plants subjected to shading and greenhouse treatment.

The highest values were 24.2mg/g and 24.1mg/g for shading throughout growth (T5) and shading for the last growth stage (T6) inside the greenhouse, respectively, followed by shade outside greenhouse (T1) treatment, 20.3 mg/g. Thelowest reported values were18, 18.3 and 17.5 mg/g for control outside greenhouse(T2), control inside greenhouse(T3), and shade treatment of first plant growth stage inside the greenhouse (T4), respectively.

These values could be attributed to the development of the chloroplast in leaves being enhanced as a result of good growth condition under shading.[20]found that the synthesis of chlorophyll and the development of chloroplast increased in mature leaves,wherethe chlorophyll content was higher at low light as opposed to optimal light conditions.This agrees with [20]and [21],both of whom reported an increase of chlorophyll content under shade compared to its respective control samples. However, this is not in line with the results reported by[8], who noted an increase in the amount of the SPAD value of chlorophyll content from increased light intensity,where the sun leaves were thicker and usually have a higher total amount of chlorophyll per leaf area unit, as per [14].

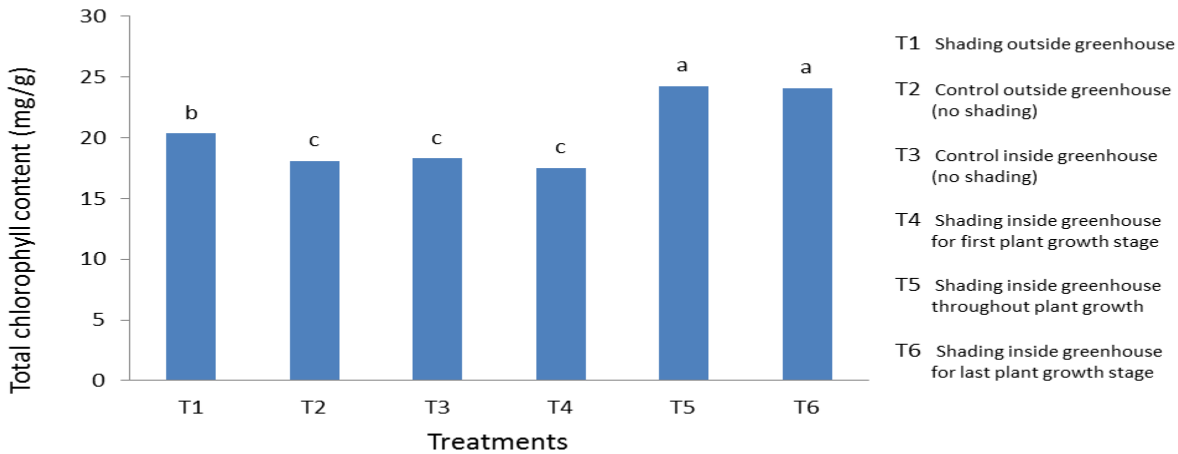


Fig.9. Total chlorophyll contentas affected by different shading treatments.

(Treatments which have the same letter are not significantly different according to Duncan test at $P \leqslant 0.05$).



## 5. Conclusion

The results indicated that the plant traits significantly responded to cultivation under greenhouse and shade treatments.Most plant growth traitswere significantly ameliorated under shade treatments, especially under greenhouse conditions.The plant height, number ofnodes, leaf number, plant weight, individual leaf area,total leaf area andtotal content of leaf chlorophyll wereameliorated while thepercentage of leaf dry matter was negatively correlated to the shade treatment regardless of whether or not it is inside the greenhouse.

Although the results indicated improved plant growth in the greenhouse and shading treatments, this was not necessarily an indication of improvement to eggplant yield. There might be anegative correlation between theconditions that are unsuitable for flowering and fruit set.

## References

[1]Adamczewska-Sowińska, K., &Krygier, M. (2013). Yield Quantity and Quality of field cultivated eggplant in relation to its cultivar and the degree of fruit maturity. *ActaScientiarumPolonorum-HortorumCultus*, *12*(2), 13-23.

[2]Argus, Control Systems Ltd. (2010). Light and lighting control in greenhouses. Argus control systems. 1281 Johnston Road.White Rock, British Columbia. Canada.

[3]Bamigboye, T.O and Kayode, J. (2016).Effect of Light Intensity on the Growth of *Dioscoreophyllumcumminsii*. International Journal of biological papers, 1(1) : 36–40.

[4]Boyacı, H. F. (2007). Resistance resources and its inheritance against to fusarium wilt in eggplants, Cukurova University, Ph.D. Thesis, Natural and Applied Sciences. 108 p.

[5]DeGannes, A., Heru, K. R., Mohammed, A., Paul, C., Rowe, J., Sealey, L., &Seepersaud, G. (2014). Tropical greenhouse growers' manual for the Caribbean. *Caribbean Agricultural Research and Development Institute, Belize*.

[6]Díaz-Pérez, J. C. (2013). Bell pepper (*Capsicum annum* L.) crop as affected by shade level: Microenvironment, plant growth, leaf gas exchange, and leaf mineral nutrient concentration. *HortScience*, *48*(2), 175-182.

[7]Garousi, F., Veres, S., &Kovács, B. (2015). Non-destructive and destructive measurements' chlorophyll content in sunflower and maize plants uptaken different chemical forms of selenium. *Columella: Journal of agricultural and environmental sciences*, *2*(2), 9-15.

[8]Goldani M, NassiriMahallati M. (2011). Impact on the quantity and quality of some morphological and physiological traits of maize (*Zea mays* L.) cultivars under greenhouse conditions.*Journal of Agroecology* 3(2), 172-180.

[9]Gruda, N., &Tanny, J. (2014). Protected crops. In *Horticulture: Plants for People and Places, Volume 1* (pp. 327-405). Springer Netherlands.

[10]Huang, C. J., Wei, G., Jie, Y. C., Xu, J. J., Anjum, S. A., &Tanveer, M. (2016). Effect of shade on plant traits, gas exchange and chlorophyll content in four ramie cultivars. *Photosynthetica*, *54*(3), 390-395.

[11]Ilahy, R., R'him, T., Tlili, I., &Jebari, H. (2013).Effect of different dhading levels on growth and yield parameters of a Hot Pepper (*Capsicum annuum* L.)Cultivar 'Beldi'Grown in Tunisia. *Glob. Sci. Books*, *7*(1), 32-35.

[12]Jenabiyan, M., Pirdashti, H., &Yaghoubian, Y. (2014).The combined effect of cold and light intensity stress on some morphological and physiological parameters in two soybean (*Glycine max* L.) cultivars. *International Journal of Biosciences (IJB)*, *5*(3), 189-197.

[13]Kikuchi, K., Honda, I., Matsuo, S., Fukuda, M., & Saito, T. (2008). Stability of fruit set of newly selected parthenocarpic eggplant lines. *Scientiahorticulturae*, *115*(2), 111-116.

[14]Lichtenthaler, H. K., Babani, F., &Langsdorf, G. (2007). Chlorophyll fluorescence imaging of photosynthetic activity in sun and shade leaves of trees. *Photosynthesis Research*, *93*(1-3), 235.

[15]Lo Scalzo, R., Fibiani, M., Mennella, G., Rotino, G. L., Dal Sasso, M., Culici, M., ...& Braga, P. C. (2010). Thermal treatment of eggplant (*Solanummelongena* L.) increases the antioxidant content and the inhibitory effect on human neutrophil burst. *Journal of agricultural and food chemistry*, *58*(6), 3371-3379.

[16]Moran, R., &Porath, D. (1980).Chlorophyll determination in intact tissues using N, N-dimethylformamide. *Plant Physiology*, *65*(3), 478-479.

[17]Rajasekar, M., Arumugam, T., & Kumar, S. R. (2013). Influence of weather and growing environment on vegetable growth and yield. *Journal of Horticulture and forestry*, *5*(10), 160-167.

[18]Saha, S. R., Hossain, M. M., Rahman, M. M., Kuo, C. G., & Abdullah, S. (2010). Effect of high temperature stress on the performance of twelve sweet pepper genotypes. *Bangladesh Journal of Agricultural Research*, *35*(3), 525-534.

[19]Sas Institute. (2009). SAS Scoring Accelerator 1.5 for Teradata: User's Guide. SAS institute.

[20]Sui, X. L., Mao, S. L., Wang, L. H., Zhang, B. X., & Zhang, Z. X. (2012). Effect of low light on the characteristics of photosynthesis and chlorophyll a fluorescence during leaf development of sweet pepper. *Journal of Integrative Agriculture*, *11*(10), 1633-1643.

[21]Ulqodry, T. Z., Matsumoto, F., Okimoto, Y., Nose, A., &Zheng, S. H. (2014). Study on photosynthetic responses and chlorophyll fluorescence in *Rhizophoramucronata* seedlings under shade regimes. *Actaphysiologiaeplantarum*, *36*(7), 1903-1917.

[22]Xu, J., Li, Y., Wang, R. Z., Liu, W., & Zhou, P. (2015).Experimental performance of evaporative cooling pad systems in greenhouses in humid subtropical climates. *Applied Energy*, *138*, 291-301.