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EFFECT OF SHADING NET, PLANTING METHODS AND BIO-EXTRACT ON PRODUCTION OF MUSKMELON

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ABSTRACT. Growing vegetable transplants under shade nets are currently becoming more popular to protect high intensities of light and high temperature. This study was undertaken to evaluate the influence of shading net at 30% shading and an unshaded control, methods of the planting, direct sowing, transplanting, and foliar application of a biozyme fertilizer at 0 and 0.5 ml L^{-1} production, and quality of muskmelon. These treatments were laid out in a randomized complete block design (RCBD) and were arranged in a split-split plot with three replications. Results showed that 30% shading treatment produced the highest leaf chlorophyll content (57.07 SPAD) and TSS (13.05%). Direct sowing gives a higher value for fruit weight (3583 g), most yield per plant (3772 g) and most total yield (3772 g). Transplanting produced the highest fruit per plant (1.58 fruit). The 0.5 ml L^{-1} fertilizer treatment had the least time to maturity (92.08 days). The interaction between shading treatment, establishment methods and biozyme fertilizer improve the fruit quality and yield of muskmelon.

Introduction

The melon referred to as "Cantaloupe" is classified as a misnomer that is used widely in the vegetable industry as muskmelon (*Cucumis melo* var. *reticulatus*). True cantaloupe (*C. Melo* var. *cantalupensis*) is grown in Europe and is a small fruit with a hard is known for its unique flavour and taste (Mossler, 2010). Muskmelon is a herbaceous annual plant that thrives in dry, sunny, and hot environments (Fontes, Puiatti, 2005).

Due to the extreme heat of the summer season in Iraq, the usage of shade nets has become popular increasingly. Crops are typically protected from excessive sun radiation by netting (Taiz, Zeiger, 2004; Degri, Samalia, 2014) which improves the thermal environment due to the efficiency of photosynthesis can be diminished when some plants are exposed to high amounts of radiation. Photosynthesis, respiration, transpiration and climatic conductance are all variables that impact muskmelon development and production (Teitel *et al.*, 2008; Silva, Costa, 2013). Providing protection from the elements such as wind and preventing the spread of viral illnesses carried by birds and insects can affect the growth and production of muskmelon (Martinez, 1996). Only a few articles showed the influence of shade to achieve maximum growth and yield. The shaded plant had a significantly higher height and internode length than the non-shaded plants (Rungruksatham, Khurnpoon, 2016; Sankhala *et al.*, 2019). While the shaded plant's stem diameter, chlorophyll content from middle leaves and closest fruit were all considerably smaller than the non-shaded plants. Compared to the shaded plant, the non-shaded plant exhibited considerably larger fruit weight, volume, TSS, and thickness (Rungruksatham, Khurnpoon, 2016). In previous decades, many studies were conducted to show the effect of the muskmelon establishment methods on the development of plants and if there was a reflection on the growth and production of muskmelon and can be either direct sowing or transplanted (Andersen, 2018). The earliest harvested melons command top market prices (Mossler, 2010). Producing seedlings for transplanting seeds are usually sown under-protected conditions which improve germination; poor germination which is a problem in cold soils. In the greenhouse, germination contributes to reducing crop length, early flowering in the field, economies in seed rate, and time saved. Ecological considerations and defence against pests are controlled with direct sowing (Andersen, 2018).

Plant biostimulants, which are natural chemicals other than fertilizers and pesticides that can enhance plant growth, yield, and yield quality when given to the crop in small amounts, are among the most promising solutions to address these increasing issues (Colla, Rouphael, 2015; Du Jardin, 2015).

Thus, the purpose of this work was to study the impact of the shading net, transplanting and foliar application of biozyme on the growth and yield in muskmelon *cv*. 'Gena'.

Materials and Methods

Experiments were conducted using muskmelon plants in a greenhouse at the University of Diyala in Baqubah, Iraq. Between 2 February and 30 May 2020. The soil of the study site is classified as well-drained sandy loam. The chemical properties of the soil were $CaCO_3$ (273.4 g kg^{-1}), $EC_{1:1}$ (6.12 dS m^{-1}), organic matter (1.12 g kg^{-1}), and nitrogen, phosphorous, and potassium as 55, 255, and 9.5 mg kg^{-1}, respectively. Bulk density was 1.45 M mg m^{-3}. Field capacity was 25%. The EC of irrigation water was 0.82 dS m^{-1}.

The experimental design was laid out in a 450 m² area arranged in a split-split plot, in a randomized complete block design, replicated in 3 blocks. The number of experimental units was 24. Each experimental unit included 20 plants and the total number of plants for the experiment was 480.

The first factor was shading which included an unshaded control (S_0) and coloured nets that were white (30% shade) (S_1). The second factor was the planting methods (direct sowing and transplanting) as the subplot. Transplanting and direct sowing were done at the same time. The third factor was the level of biozyme at 0 and 0.5 ml L^{-1}. The composition of the biozyme fertilizer as provided by the producing company is reported in (Table 1). The first spraying was after three weeks from the planting then this process was repeated every 10 days until the fruits attained their maturation stage or maturity.

Table 1. Composition of the fertilizer biozyme (as provided by the producing company)

Nutrient	Percent, wt vol.$^{-1}$	Nutrient	Percent, wt vol.$^{-1}$
Plant hormones	78.87	S	0.44
IAA	32.2	B	0.30
GA3	32.2	Fe	0.49
Zeatins	83.2	Mn	0.12
Nutrient minerals	1.86	Zn	0.37
Mg	0.14	other	19.20

Biozyme TF (French company Arista Life Science)

The soil was fertilized with nitrogen (N), phosphorus (P), and potassium (K) at 150 kg ha^{-1}, respectively, using 10-10-10 granular fertilizer was mixed and placed 20 cm deep in the centre of the bed.

Seedlings were transplanted at the 3–5 leaf stage to withstand against adverse effects of wind and frost. Later, when plants had three true leaves, plants were thinned to 1 seeding per hole. For the transplanting method, the seed was sown in plastic trays, 0.50 × 1 m, with 104-cells per tray, containing peat moss as a medium on 21 January 2020 in a greenhouse and seedlings were ready to transplant when they had 3 true leaves on 2 February 2020.

Traits measured

Data were taken from eight randomly selected plants from each plot to determine index chlorophyll in leaves with a chlorophyll meter (SPAD-502 Plus, Konica Minolta, Japan), early maturity (days), number of fruits per plant, fruit weight (g), total yield (t greenhouse^{-1} (504 m^2) and total soluble solids (TSS) of muskmelon juice were determined with a handheld refractometer (PR-32, Co. Ltd., Tokyo, Japan) with automatic temperature compensation.

Data analysis

The statistics analysis was done using the SAS program; the LSD test was set up to determine the significant differences between means and the confidence level was (0.05).

Results

Table 2 shows that all measured traits in this study was significantly influenced by the single factor of shading (S), methods of planting (G), or foliar spray with biozyme (F). The S1 gave the highest value for leaf chlorophyll content (57.07 SPAD) and TSS (13.05%) which was significantly different from S0 for early maturity, number of fruits per plant, fruit weight, plant yield and total yield there was found a non-significant difference among levels of (S) treatment. The G0 gave a higher value for fruit weight (3583 g), most yield per plant (3772 g) and most total yield (3772 g).

Table 2. Effect of shading methods, establishment methods and biozyme fertilizer on production, and quality of muskmelon

Factors	SPAD index	Early maturity, days	No. of fruits per plant	Fruit weight, g	Plant yield, g	Total yield, t house^{-1}	TSS, %
S0	55.88	89.58	1.33	2406	2782	2.78	11.08
S1	57.07	91.25	1.33	2303	2742	2.74	13.05
LSD	1.227	3.586	0.621	449.4	619.6	0.619	0.271
G0	55.59	88.75	1.08	3583	3772	3.77	12.18
G1	56.37	92.08	1.58	1125	1752	1.75	11.94
LSD	2.92	4.627	0.327	332.3	247.6	0.247	0.595
F0	55.87	88.75	1.25	2385	2645	2.64	11.69
F1	56.09	92.08	1.42	2325	2879	2.88	12.43
LSD	1.285	2.354	0.544	407	596.5	0.597	0.934

S_0 – non-shading, S_1 – 30% shading, G_0 – direct sowing, G_1 – transplanting, F_0 – without foliar spraying and F_1 – foliar spraying

The G1 gave the highest value for fruit per plant (1.58 fruit), significantly different from G0. The F1 had less time to maturity (92.08 days) which was significantly different from F0. However, the leaf chlorophyll content, number of fruits per plant, fruit weight, plant yield, total yield, and TSS there were found a non-significant difference among levels of (F) treatment.

Table 3 shows the interaction between two factors (S*G, S*F or G*F), there was a significant difference among treatments for all measured traits. The S1*G1 has observed the highest value of leaf chlorophyll content (57.45 SPAD) which was significantly differenced from others. The S0*G0 was given the highest value of fruits weight (3740 g) and less time to maturity (87.5 days) which was significantly different from others. The S0*G1 gave the highest value of fruit per plant (1.67 fruit). The S1*G0 gave the highest value of yield plant (3803 g), higher total yield (3.8 t house^{-1}), and highest TSS (13.63%) which was significantly differenced from others. The S1*F1 gave the highest leaf chlorophyll content (57.08 SPAD) and TSS (13.18%), significantly different from others. For the other measured traits, there were found non-significant between S*F interaction. The G0*F0 gave less time to maturity (87.5 days) and heavier fruit (3663 g). The highest value of fruit per plant and TSS was observed in G1*F1 (1.67 fruit and 12.47%). The highest value of yield per plant and total yield was observed in G1*F0 which was significantly different from others.

For the three-factor interactions (S*G*F), there was a significant difference among treatments for all measured traits (Table 4). The treatment S1*G1*F0 was observed the highest value of leaf chlorophyll content (57.57 SPAD), which was significantly differenced from others. The treatment S0*G0*F0 gave less time to maturity (86.67 days), which was significantly different from others. The highest fruit weight was observed in the treatment S0*G0*F0 (3787 g). The highest yield, total yield, and TSS was observed in the treatment S1*G0*F1 (3973 g, 3.97 t house^{-1}, and 13.8%, respectively). However, the treatment S1*G1*F0 was given the lowest value (1478 g and 1.47 t house^{-1}, respectively). The lowest value of TSS was observed in the treatment S0*G1*F0.

Table 3. Effect of the interaction shading × establishment methods, shading × biozyme fertilizer and establishment methods × biozyme fertilizer on production, and quality of muskmelon

Factors	SPAD index	Early maturity, days	No. of fruits per plant	Fruit weight, g	Plant yield, g	Total yield, t house^{-1}	TSS, %
S0G0	54.48	87.5	1	3740	3740	3.74	10.73
S0G1	55.28	91.67	1.67	1072	1823	1.82	11.42
S1G0	56.7	90	1.17	3428	3803	3.8	13.63
S1G1	57.45	92.5	1.5	1178	1680	1.64	12.47
LSD	2.884	4.649	0.494	392.9	493.8	0.494	0.588
S0F0	54.67	88.33	1.33	2372	2733	2.73	10.47
S0F1	55.1	90.83	1.33	2441	2830	2.83	11.68
S1F0	57.07	89.17	1.17	2397	2556	2.55	12.92
S1F1	57.08	93.33	1.5	2209	2928	2.93	13.18
LSD	1.395	3.038	0.619	458.4	660.5	0.661	0.938
G0F0	55.33	87.5	1	3663	3663	3.66	11.97
G0F1	56.4	90	1.5	1106	1626	1.62	11.42
G1F0	55.85	90	1.17	3505	3880	3.88	12.4
G1F1	56.33	94.17	1.67	1145	1877	1.88	12.47
LSD	2.877	4.613	0.579	464.8	611.9	0.612	1.005

S_0 – non-shading, S_1 – 30% shading, G_0 – direct sowing, G_1 – transplanting, F_0 – without foliar spraying and F_1 – foliar spraying

Table 4. Effect of the interaction shading × establishment methods × biozyme fertilizer and establishment methods × biozyme fertilizer on production, and quality of muskmelon

Factors	SPAD index	Early maturity, days	Number of fruits per plant	Fruit weight, g	Plant yield, g	Total yield, t house^{-1}	TSS, %
S0G0F0	54.10	86.67	1.00	3693	3693	3.69	10.5
S0G0F1	54.87	88.33	1.00	3787	3787	3.78	10.6
S0G1F0	55.23	90.00	1.67	1050	1773	1.77	10.4
S0G1F1	55.33	93.33	1.67	1095	1873	1.87	12.4
S1G0F0	56.57	88.33	1.00	3633	3833	3.83	13.4
S1G0F1	56.83	91.67	1.33	3223	3973	3.97	13.8
S1G1F0	57.57	90.00	1.33	1162	1478	1.47	12.4
S1G1F1	57.33	95.00	1.67	1195	1882	1.88	12.5
LSD	3.034	5.167	0.834	640	890	0.891	1.366

S_0 – non-shading, S_1 – 30% shading, G_0 – direct sowing, G_1 – transplanting, F_0 – without foliar spraying and F_1 – foliar spraying

Discussion

It is important to note that the nature of the growth of the root system is of great importance in determining its efficiency in absorbing water and nutrients from the soil and the available depth of the soil for these roots. Using the seeds in cultivation directly in the soil allows the formation of a deep root system that has greater efficiency in providing the plant with the requirements of growth and production. High solar radiation in the Middle East causes heat stress that increases the rate of respiration of plants and thus loses a percentage of water and sugars manufactured in the plant, which negatively affects the inhibition of growth rate. In this study, the weight of fruits increased when seeds were directly sowed in the soil. This may be due to the formation of a deep root system that is highly efficient in absorbing water and nutrients from the soil, thus stimulating an increase in the metabolism process within the plant and then depressing more of it in the developing fruits. The muskmelon is usually directly planted by using the seeds since the roots will partially be damaged during transportation from containers to soil and which will affect the development of the roots naturally (Andersen, 2018).

The positive effect of shading on chlorophyll, TSS, and the positive combination effect on the yield indicators, maybe due to the impact of shading that reduced the excess solar radiation than the plant needs to reduce excess heat (Taiz, Zeiger, 2004; Pacharane, 2016; Abu-Zahra, Ateyyat, 2016; Diliprao, 2018; Utkhede *et al.*, 2019). Therefore, reducing solar radiation makes the ideal temperature for growth. Other results indicated that the 30% shading improved most of the vegetative characteristics and the yield of muskmelon plants compared to the plants exposed to full solar radiation. A significantly negative effect in the early maturity of the fruits, when compared to untreated plants, resulted from the continuity of the vegetative growth of the plants for the longest time (Francisco *et al.,* 2011). Other previous studies have indicated the importance of foliar spraying in improving the growth and yield of vegetable plants. In limited experimental investigations, considering the impact of biostimulants under open-field and greenhouse settings, a rise in early and total marketable fruit yields has been observed for various crops. (Halpern *et al.,* 2015; Ali *et al.,* 2016; Rouphael *et al.,* 2017).

Conclusion

1. Planting of the muskmelon in plastic house by the transplant method had a significant effect on the number of the fruits, at the expense of decreased; weight of the fruit to levels that exceeded their positive impact on the number of fruits. Moreover, this effect caused decreasing in the plant's yield.
2. Shading of the plants had a significant effect on the index of chlorophyll (spad-502) and TSS in the fruits and significantly superior by their treatments combination such as increasing the yield and improving the quality of the fruit.
3. Plants treated with biozyme had a negative effect that delayed fruits maturity compared with the untreated plants.

Recommendation

Using the seeds directly in the planting of the muskmelon is recommended since it improves their growth and productivity, as well the shading which reduces solar radiation and thermal stress on plants in the spring season.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this paper.

Author contributions

AO 25%, HA 25%, KH 25%, GH 25% – study conception and design;
HA 50%, AO 50% – acquisition of data;
AO 50%, AH 25%, KH 25% – analysis and interpretation of data;
AO 25%, HA 25%, KH 25%, GH 25% – critical revision and approve the final manuscript.

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