Plant growth and yield response of three eggplant hybrids *Solanum melongena* L. to foliar spray with boric acid and potassium fertilizer

Matham A Muhalhal and Jamal A Abbass

Department of Horticulture and Landscape, Faculty of Agriculture, University of Kufa, Iraq
Email: jamal.selman@uokufa.edu.iq; maythamahmad76@gmail.com

Abstract

The study aimed to determine the response of three hybrids of eggplant, THURAYYA, JAWAHER, and BARCELONA to spraying with boric acid (BO3 H3) (17% B) at a concentration of 25 mg L^{-1} or high potassium fertilizer 3 g.L^{-1} as NPK (50) or a combination of both fertilizers under unheated greenhouse conditions. The experiment was carried out using Randomized Complete Block Design with three replicates. The results showed that the Barcelona hybrid was significantly superior in plant height to 63.33 cm, plant content of phosphorus to 0.565% and boron to 34.172 mg Kg^{-1}, fruit weight to 163.80 g $fruit^{-1}$, area productivity to 2.92 ton $hous^{-1}$, fruit content of calcium to 1.294% and anthocyanin to 84.59 mg $100g^{-1}$, compared to the two hybrids Thurayya and Jawaher. Spraying with the fertilizer combination of potassium at a concentration of 3 g.L^{-1} and boron 25 mg.L^{-1} was significantly superior in increasing the studied indicators compared to plants treated with one of the factors or not treated. The results showed that the highest measures for all study indicators recorded a significant increase in the treatment of the Barcelona hybrid interaction and spraying with the fertilizer combination of 3 g.L^{-1} potassium and 25 mg.L^{-1} boron compared to all other interaction treatments between the study factors.

Keywords: genotype, micro-nutrients, solanine, *Solanum*

Introduction

Eggplant (*Solanum melongena* L.) is a vegetable plant of great importance in Iraq and the world, especially in areas with hot and temperate climates, as it contains many vitamins, proteins and minerals and plays a pivotal role in addressing food security and contributing to food diversity [13]. The demand for this crop is increasing in the markets for all its quantities offered in local and international markets in addition to the good economic return for its producers. The cultivated area in the world reached 1,864,556 hectares with a productivity of 54,077,210 million tons. As for Iraq, the area cultivated with eggplant was estimated at 12,388 hectares with a productivity of 183,056 thousand tons [7]. This level of production is considered very low compared to global production.

One of the most important ways to increase production and improve the quality of fruits is to use new hybrids with high production and good quality. The introduction of hybrids is one of the modern technologies in agriculture that works to improve eggplant production in terms of quantity and quality. Exploiting the phenomenon of hybrid strength has played a major role in the production of commercial hybrids, not only to increase the yield but also to improve the quality of production. Many studies on eggplant crops have shown that the derived hybrids show hybrid strength with vegetative growth indicators and high yield in terms of quantity and quality [1].

Fertilization through foliar feeding by spraying on the green group strengthens and supports plant nutrition and is an effective method for increasing plant growth [8]. This includes spraying with nutrients, especially boron, which is essential for active areas of plants such as root tips and helps increase the number of new leaves and buds. It is more

important in meristematic cells than mature tissues. For this reason, boron deficiency symptoms are in young leaves and terminal buds, which are essential for cell division and differentiation. Adding boric acid through foliar spray ensures that these vital nutrients are readily available in meristematic tissues, which enhances plant growth and development [9]. On the other hand, potassium, one of the main elements in plants, has a multi-role in plant physiology, contributing to the activation of enzymes, regulating the function and synthesis of important compounds, and building protein. This increases the absorption of water and nutrients, ensuring ideal conditions for plant growth. Potassium improves the size and quality of the fruits, which increases and improves the production in terms of quantity and type of the plant. In addition, potassium stimulates root growth, which increases the plant's ability to absorb water and nutrients from the soil [11]. Therefore, the study aimed to determine the success of three eggplant hybrids outside their normal seasons under unheated greenhouse conditions. And to test the possibility of improving the eggplant growth and yield indicators by spraying with boric acid and potassium fertilizer.

Materials and methods

The field experiment was conducted for the spring growing season 2024 at the Agricultural Research Station of the College of Agriculture / University of Kufa to study the response of three hybrids of eggplant plants under unheated greenhouse conditions by spraying with boric acid and high potassium fertilizer. Soil analysis tests were conducted before planting with ten random samples of field soil prepared for planting taken at a depth ranging from 0-30 cm after mixing and drying Table (1).

Field preparation and planting methods:

The field was divided into three equal sectors, each sector containing 12 experimental units, thus the number of experimental units was 36 (12 experimental units × replicates). The area of the experimental unit was 25.5 m (5.3 length × 5.1 width). A distance of 1 m was left between the experimental units to prevent mixing between treatments. Each experimental unit contained seven plants, and the distance between one plant and another

was 50 cm. The seeds were planted in plastic dishes in the nursery on 9/13/2023. When the seedlings reached 4-5 true leaves and a height of 10-15 cm, they were transferred to the plastic house prepared for cultivation. The field was watered immediately after

Table1. Some physical and chemical properties of field soil before planting

No.	Analysis	Unit	Value
1	Ph	-------	7.6
2	EC	dSm m^{-1}	1.24
3	Nitrogen N	Ppm	22.875
4	Phosphorus P	Ppm	16.481
5	Potassium Ion K+	Ppm	41.21
6	Sodium Ion +N	Ppm	1.32
7	Calcium Ion +Ca	Ppm	160.00
8	Magnesium Ion +Mg	Ppm	60.00
9	Sulfate Ion SO4	Ppm	25.652
10	Chloride Ion –CI	Ppm	495.60
11	Bicarbonate Ion HCO3	Ppm	26.108
12	Carbonate Ion CO3	Ppm	NIL
13	Organic Matter	%	1.25

14	Soil texture	Clay	17%	Sand-loam
		Silt	15%	
		Sand	68%	

planting by drip irrigation, and watering was repeated whenever the plant needed it, with all the required operations carried out (6).

Experiment general procedure

The treatments were distributed in a factorial experiment using Randomized Compiled Block Design (R.C.B.D) using three sectors with three replicates. The first factor included three hybrids of eggplant: Thuraya, Jawaher and Barcelona. The second factor included spraying with high potassium fertilizer 3 gm. L^{-1} in the form of NPK fertilizer (50,0,0) produced by Grow MoRE or the American company or with boron in the form of boric acid (H3Bo3) (17% B) or a combination of both fertilizers in addition to the control treatment (spraying with distilled water only). The application was carried out at a rate of three sprays, the first after 15, 30, and 45 days from transplanting in the field.

Experiment measurements

Study indicators

At the end of the experiment, data were collected for the study indicators, which included measuring the plant height for 3 plants from each experimental unit taken randomly. The plant height was measured from the soil surface level to the highest apical of the plant. The total number of leaves (leaf. $plant^{-1}$) was also determined, and the percentage of phosphorus in the leaves% was estimated using ascorbic acid and ammonium molybdate and calculated at a wavelength of 620 nm using a Spectrophotometer [2]. The leaf content of boron (mg. kg^{-1}) was estimated according to carmine dye method and with the aid of Spectrophotometer at a wavelength of 585 nm [4]. The study parameters also included estimating the productivity per unit area (ton. plastic $house^{-1}$) and the calcium content of the fruits by Atomic absorption spectrometry. The anthocyanin content in the fruits (mg. kg^{-1}) was estimated by the method described by Ranganna (1977) using a Spectrophotometer at a wavelength of 535 nm.

The averages were compared according to the Least Significant Differences Test (LSD) at a probability level of 0.05 (3).

Results and discussion

The results of Table (2) showed significant differences in hybrids in plant height, leaf phosphorus percentage and leaf boron content. In general, Barcelona hybrid was significantly superior by giving the highest average plant height 63.33 and leaf phosphorus content 0.565% and boron 34.172 compared to Thuraya and Jawaher hybrids respectively. On the other hand, in the fertilization treatment, spraying with a fertilizer combination with high potassium fertilizer at a concentration of 3 $g.L^{-1}$ and boric acid at a concentration of 25 $mg.L^{-1}$ was superior with a significant increase in the highest average plant height 62.61 and leaf phosphorus content 0.549% and boron 31.867 compared to single fertilization or unfertilized control. The results of the same table showed that the Barcelona hybrid interaction treatment and the fertilizer combination of 3 $gm.L^{-1}$ potassium and 25 $mg.L^{-1}$ boric acid were superior, which differed significantly in giving the highest average plant height of 64.83, and leaf content of phosphorus 0.587% and boron 36.593

compared to all single and interaction treatments, as the lowest average of the mentioned indicators was recorded in the Jawaher hybrid interaction treatment in the absence of fertilization

The results (Table 3) showed that the fruit weight differed among the eggplant hybrids under study, where it was noted that the highest average fruit weight was recorded in the Barcelona hybrid plants with an average of 163.80 compared to Thuraya and Jawaher, which recorded 152.20 and 136.50, respectively. In the fertilization treatments, the potassium fertilizer combination of 3 g. L^{-1} and boric acid at 25 mg. L^{-1} was superior in increasing the fruit weight by an average of 157.70 compared to the distilled water treatment, which recorded the lowest rate of 149.90. As for the interaction, it was found that the Barcelona interaction treatment, fertilizing with potassium at 3 g. L^{-1} and boric acid at 25 mg. L^{-1}, recorded a significant increase in the average fruit weight to 167.50 compared to lower values in the other treatments.

The yield weight (productivity per unit area) also differed according to the effect of the plant variety, as Barcelona recorded the highest average yield for the plastic house 2.92 tons/plastic house compared to the two hybrids Thuraya and Jawaher with productivity of 2.37 and 1.81 tons/plastic house respectively. Similarly, the spray treatment with the fertilizer combination of 3 g. L^{-1} with high potassium fertilizer and 25 mg. L^{-1} and

Table2. Effect of hybrid type and fertilization with potassium and/or boron on vegetative growth indicators of eggplant

Treatments	**Plant height**				**Leaf content of phosphorus%**				**Leaf content of boron%**			
	Eggplant hybrids (B)				Eggplant hybrids (B)				Eggplant hybrids (B)			
Fertilizer (A)	Br	J	Th	Average	Br	J	Th	Average	Br	J	Th	Average
0	62.17	58.33	60.67	60.39	0.528	0.465	0.524	0.505	32.08	25.69	28.42	28.73
K	62.83	58.33	61.33	61.17	0.568	0.496	0.534	0.533	33.14	26.66	29.51	29.77
B	63.50	60.50	61.67	61.89	0.678	0.505	0.540	0.541	34.87	27.95	30.58	31.13
K/B	64.83	61.50	61.55	62.61	0.587	0.513	0.550	0.550	36.59	27.98	31.08	31.86
Average	63.33	59.92	61.29		0.565	0.495	0.537		34.17	27.07	29.88	
LSD 0.05		A=0.49 B=0.56 A/B=0.97				A=0.014 B=0.016 A/B=N.S				A=0.488 B=0.563 AB=0.976		

boric acid recorded a significantly higher productivity for the plastic house than the rest of the individual treatments. Also, the highest productivity rate of 3.16 tons/plastic house was recorded in the interaction treatment Barcelona and the fertilizer combination of potassium 3 g. L^{-1} and boric acid 25 mg. L^{-1} with a significant difference from most other interaction treatments and control, especially with the Jawaher hybrid.

The results showed the difference between eggplant hybrids in some fruit qualities, as the Barcelona hybrid was significantly superior in increasing the fruit content of calcium to 1.294 compared to Thuraya and Jawaher, which recorded 1.065 and 0.733, respectively. Also, the fertilizer combination with high potassium fertilizer 3 $g.L^{-1}$ and boric acid at 25 $mg.L^{-1}$ recorded an increase in the fruit calcium content of 1.134, with a significant difference from the control, which recorded 0.926. In general, the highest calcium content in the fruit was recorded in the Barcelona hybrid interaction treatment and spraying with the fertilizer combination of potassium 3 $g.L^{-1}$ and boric acid 25 $mg.L^{-1}$, with a significant difference from most of the individual and interaction treatments (Table 3). It was also found that the anthocyanin content of the fruits was the highest in the Barcelona hybrid, recording 84.59 compared to the Thuraya and Jawaher hybrids, which recorded 74.02 and 62.62, respectively. Also, spraying with the fertilizer combination of high potassium fertilizer 3 $g.L^{-1}$ and boric acid 25 $mg.L^{-1}$ recorded a significant increase in the anthocyanin content of the fruits 77.77 compared to the comparison, which recorded 70.11. The highest pigment content of the fruits was recorded in the dual interaction treatment of the Barcelona hybrid, and spraying with the fertilizer combination of high potassium fertilizer 3 $g.L^{-1}$ and boric acid 25 $mg.L^{-1}$ recorded 87.28, with a significant difference from the Jawaher hybrid treatment and the control treatment, which recorded the lowest average of 57.63.

The results generally showed that the Barcelona hybrid was superior in all the studied indicators in terms of plant growth and quantitative and qualitative yields. The superiority of the Barcelona hybrid is often attributed to genetic characteristics and the hybrid's suitability to environmental conditions compared to other varieties [12]. As for the weight of the fruits, the moral superiority is also due in one way or another to the genetic nature of the hybrid, which is characterized by increased fruit weight and thus increased productivity per unit area [1]. The growth and yield indicators were also affected by the type of fertilization and the concentration of the fertilization treatment. It was noted that the study parameters increased in the boron fertilization treatments. Undoubtedly, boron plays an important role in pollen germination, as it enters into the fertilization process and regulates the activity of plant hormones, including gibberellin, which plays a role in inducing the growth and development of flowers [8]. This, in turn, leads to an increase in the percentage of flower set, which was positively reflected in increasing the productivity per unit area. The results also indicated a clear increase in growth and yield indicators in eggplant plants due to the effect of potassium fertilization. Potassium fertilizer has a clear role in reducing the rate of respiration and increasing the rate of photosynthesis by increasing the surface area and thus increasing the

Table3. Effect of hybrid type and fertilization with potassium and/or boron on eggplant yield indicators and quality

Treatments	Fruit weight (g)				Productivity ton greenhouse^{-1}				Fruit content of calcium %				Fruit content of Anthocyanin mg 100g^{-1} FW			
	Eggplant hybrids (B)				Eggplant hybrids (B)				Eggplant hybrids (B)				Eggplant hybrids (B)			
Fertilizer (A)	Br	J	Th	Average	Br	J	Th	Average	Br	J	Th	Average	Br	J	Th	Average
0	163.20	142.0	144.4	149.9	2.72	1.67	2.13	2.17	1.233	0.593	0.953	0.926	57.63	82.49	70.21	70.11
K	161.50	124.20	144.9	143.6	2.85	1.72	2.27	2.28	1.260	0.690	1.043	0.977	60.46	83.81	72.05	72.11
B	162.90	137.60	155.6	152.10	2.94	1.84	2.46	2.41	1.293	0.783	1.120	1.065	64.94	84.78	75.24	74.99
K/B	167.50	141.80	163.8	157.70	3.16	2.01	2.61	2.59	1.390	0.866	1.146	1.134	67.46	87.28	78.58	77.77
Average	163.80	136.50	152.2		2.92	1.81	2.37		1.294	0.733	1.065		62.62	84.59	74.02	
LSD 0.05	A=5.98, B=6.91, A/B=N.S				A=0.036, B=0.041, AB=0.071				A=0.017, B=0.020, AB=0.034				A=0.70, B=0.81, AB=1.42			

carbohydrates produced in the plant [13].

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