ISSN: 2073-9524
eISSN: 2310-8746

Response of Date Palm Trees (*Phoenix dactylifera* L.) to Treatment with Boron and Silica Sol Nutrient Solution under Saline Growing Conditions

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Article history:

Received: 6 April 2024
Accepted: 15 August 2024
Published: 30 December 2024

Keywords: *Silica, Boron, Khadrawi, Saline, Peroxidase.*

Abstract

The objective of this study is to investigate the impact of different concentrations of boron 0, 100, and 200 mg L^{-1} and silica sol nutritional solutions 0, 3, and 6 mL L^{-1} on Khadrawi date palm trees in the presence of salt conditions. The results demonstrated that the spray treatment with boron at 200 mg L^{-1} and the spray treatment with silica sol nutrient solution at a level of 6 ml L^{-1} exhibited significant superiority. These treatments resulted in the highest values for various parameters including the concentration of mineral elements such as potassium, silicon, and boron, the ratio of potassium to sodium, the membrane stability index, the increase in activity of the peroxidase enzyme in leaves, the increase in the percentage of set, maturity, shoot weight, and total fruit yield. In contrast, the comparison treatment obtained the lowest values for these parameters. The treatments (boron at 200 mg L^{-1} and silica sol 6 mL L^{-1}) decreased significantly, recording the lowest values in the concentration of sodium, chlorine, amino acids, proline, and ionic leakage of potassium ions in the leaves, while the comparison treatment recorded the highest values for the same traits. The interference between the two study factors significantly affected most of the studied traits.

https://dx.doi.org/10.52951/dasj.24160206

Introduction

The date palm is scientifically known as *Phoenix dactylifera* L., is a member of the Arecaceae family and is thought to have originated in southern Iraq and the Arabian Gulf region. According to Zaid and De Wet (2002), it holds significant economic and social value in numerous countries worldwide. Despite the ability of date palm trees to thrive in various environmental situations, their productivity is significantly influenced by numerous environmental stressors, particularly salt stress. Salinity, which refers to the presence of salt in soil or irrigation water, is a significant challenge for agriculture worldwide, particularly in dry and semi-dry regions (Munns and Tester, 2008). Salinity affects approximately 20% of the irrigated lands in the world (Gupta and Huang, 2014).

Iraq leads among Arab and Asian nations in terms of the extensive area impacted by salinity. (Batanouny, 1995). The problem of salinity in Iraq has worsened recently due to the problem of scarcity of rain and water resources, deterioration of their quality, and mismanagement (Yaseen *et al*., 2016). Khadrawi dates are considered one of the international commercial dates, which are famous for their quality, flavor and delicious taste. Khadrawi dates have three strains of the variety, one of which is called Khadrawi Basrah, the second is called Khadrawi Baghdad, and the third is Khadrawi Mandali. (Hzaa and Al_Amiry, 2022) These strains are almost similar except for some simple characteristics. The Khadrawi Basra variety is considered one of the good and desirable varieties and comes after sweets in terms of quantity and quality, its cultivation is widespread in the regions of Basra and the southern governorates, especially Maysan and Dhi Qar. Boron is one of the important elements in plant growth due to its many functions (Bolaños *et al*., 2023).

Its importance appears in that it contributes to the physiological and chemical processes within the plant, as it helps in cell division and the manufacture of proteins, nucleic acids, and plant hormones, especially auxin (IAA). (Shireen *et al*., 2018) It also helps in the growth of meristematic tissues. It facilitates the transfer of sugars from their places of formation to Growth and storage areas due to its formation of a borate-sugar complex, whose transport through cellular membranes is easier than the transport of the sugar molecule alone (Al-Juheishy, 2020). Some research has indicated its role in the movement and transfer of carbon metabolites from the leaves to the active areas of the plant, and this may be due to the union of the borate with the hydroxyl radical. In sugars, alcohols, or organic acids form boric acid esters, which are easier to transfer than polarised sugars alone (Al-Rubaie, 2022).

It is believed that boron activates several enzymatic reactions and contributes to regulating osmotic potential by increasing the plant’s efficiency in absorbing potassium. It also plays a role in the formation of pectin and quinine, as 50% of boron is found in the cell wall, and a lack of boron leads to an accumulation of simple carbohydrates. It does not convert to cellulose or lignin, which is necessary for the formation of the cell wall (Abu Dahi and Al-Younis, 1988), in addition to its important and vital role in the growth and germination of pollen grains and the completion of pollination and fertilization processes. It has also been noted that it has other metabolic stimulatory roles such as nitrogen metabolism, the formation of nucleic acids, and regulation and activity.

Al-Mayahi (2019) found that palm trees of the Sayer and Al-Halawi varieties were pollinated with pollen resulting from spraying their trees with boron in the form of boric acid at a concentration of 1500 mg. L^{-1} gave a significant increase in the chemical characteristics of the fruits represented by total dissolved solids and dry matter for the Khalal and Rutab stages, and the highest rate of set and maturity compared to the comparison treatment for the Halawi and Sayer cultivars, respectively. Sobeih (2021) found that spraying Al-Sayer date palm trees with boron at a concentration of 300 mg L^{-1} gave a significant superiority in recording the highest values in the concentration of chlorophyll and total carbohydrates in the leaves, the highest average weight and lowest water content of fruits compared to the control treatment. The topic of plant hormones and photosynthesis is discussed in the book Hansch and Mendel (2009).

The silica sol solution is a nutrient solution for plants that is applied to the leaves. It contains silicon oxide, potassium oxide, a combination of seaweed, amino acids, fulvic acid, and humic acid. The use of the silica sol solution enhances the plant's capacity to uptake water and nutrients from the soil, hence augmenting the quality of crops in terms of their size, weight, and color. Additionally, it fortifies the plant's resilience to various stressors. The plant mitigates drought by minimizing transpiration from the leaves (Al-Abadi, 2019).

The potential mechanism of silicon under conditions of salt stress includes increasing the water content in the plant (Romero-Aranda *et al.,* 2006), improving the effectiveness of the photosynthesis process and the synthesis of cell organelles, reducing the toxicity of sodium ions by reducing their permeability in the plant and increasing the permeability of potassium ions (Tahir *et al*., 2006), increasing the ratio of potassium to sodium (Hasegawa *et al*., 2000), increasing the effectiveness of enzymes and increasing the concentrations of soluble substances in the bark as a result of reducing the absorption of sodium ions by the plant (Liang, 1999). Al-Abadi (2019) explained in his study on treating seedlings of three varieties of grapes, *Vitis vinifera* L., by spraying with silica sol solutions at concentrations of 0, 0.4, 0.8, 1, and 1.4 mL L^{-1}, concentration exceeds 1 $ml.L^{-1}$ gives the highest significant increase in the percentage of nitrogen, phosphorus and potassium elements in the leaves. The study conducted by Faisal (2019) showed that when spraying date palm seedlings of the Barhi variety growing in a saline environment with silicon, a significant increase in the concentration of potassium and an increase in the ratio of potassium to sodium and the concentration of silicon in the leaves at a concentration of 600 mg L^{-1} compared to the comparison treatment.

Given the worsening problem of soil and water salinity in Iraq in recent years and Basrah Governorate in particular, and the lack of studies on the effect of silica sol and boron solutions on date palm seedlings, to know the effect of boron and silicon sol solution in alleviating the negative effects of salinity on date palm trees of the Khadrawi variety, this study was conducted.

Materials and Methods

This research was carried out in one of the private orchards in the Shatt al-Arab district, Al-Jazeera region, Basra Governorate. It was carried out during the agricultural season in the third month of 2022 and ended in the first month of 2023.

Aim of studying the effect of spraying treatments with boron and the silica sol nutrient solution on the date palm trees of the Khadrawi dates variety growing in salty soil. Twenty-seven trees, all of similar growth and aged 10 years, were meticulously selected for service operations that were started using the same method as the palm groves in the area, the date palm trees on 3/25 were manually inoculated with Al-Ghanami green pollen. After a period of 10 days, 6 inflorescences were chosen for each palm tree while the remaining ones were eliminated.

Solutions of the materials used in the experiment were prepared, where boric acid H_3BO_3 containing 17% boron was used by dissolving 588.23 mg in a liter of water to prepare 100 mg L^{-1}, and dissolve 1176.46 mg of boric acid to prepare a concentration of 200 mg L^{-1} (Al-Mayahi, 2019), and prepare a silica sol solution at concentrations of 0, 3, and 6 mL L^{-1} is a foliar nutrient solution prepared by the Iranian company Keman Zamin Chemical Industries and consists of 22% silicon oxide (Sio_2), 11% soluble potassium oxide (K_2O), 2% seaweed extract, and amino acids. Acid at a rate of 2%, Fulvic Acid at a rate of 0.5%, and Humic Acid at a rate of 0.5% **(**Al-

Abadi, 2019). The first spraying with boron was carried out on 3/24, and the second spraying was done a week after the first spray. The trees were sprayed with silica sol nutrient solution on 2/15 and 3/15. And 15/4, the trees were sprayed in the early morning until they were completely wet at a rate of 20 liters per tree, and the Tween 20 was added at a rate of 0.01% to all treatments, in addition to the control treatment, which sprayed with distilled water.

Foliar measurements were taken at the end of June, and they were analyzed by taking samples of the third frond, starting from the growing tip. As for the characteristics of the fruits, the percentage of the set was taken a month after the pollination process. As for the percentage of maturity and dry matter, it was taken in the wet stage when the fruits entered the final maturity stage. Measurements of bunch weight and total yield were taken in the date stage. Prior to the research, a procedure was carried out, examination of the orchard soil, Table 1.

Table 1. Characteristics of orchard soil at a depth of 0-60 (cm)

Characteristics	Valuable
Electrical conductivity (E. C) d / m	13.11
Soil degree of interaction (pH)	7.84
Available nitrogen (mg Kg^{-1})	315.86
Available Phosphorus (mg kg^{-1})	29.82
Available Potassium (mg Kg^{-1})	176.67
Available Silicon (mg Kg^{-1})	9.03
Available Boron	5.71
Organic matter %	0.51
Soil separations	
Sand	11.70
Clay	45.80
Silt	42.50
Soil texture	Alluvial clay

Chemical and physiological properties studied in the fronds

Samples were collected from the leaves located in the third row from the top of the frond (Al-Ani, 1998). The leaves underwent a washing process with distilled water, followed by acidified water (HCI) 0.1 N, and then another rinse with distilled water to eliminate any traces of dust and pesticide residues. Subsequently, the samples were dried, transferred to perforated paper bags, and subjected to an electric oven set at 70º until a constant weight was achieved.

The dried samples were then ground, and 0.2 g was measured for each element. Finally, the samples were digested based on the specific method for preparing each mineral element:

1- Potassium and sodium levels were determined following the methodology described by Page *et al*., (1982) utilizing a flame photometer. The results were reported in (mg g^{-1}).
2- Estimating the potassium to sodium ratio: The ratio was determined by dividing the potassium measurements by the sodium measurements.

3- Estimation of the chloride element: It was estimated according to the method (Kalra, 1997) and the results were expressed in (mg g^{-1}) dry matter.
4- Estimation of the silicon element: The silicon element was estimated in the laboratory of the Palm Research Center according to the method of Wei-Min *et al*. (2005), and the results were expressed in (mg g^{-1}) dry matter.
5- Estimation of the boron element: It was estimated according to the colorimetric method using Curcumin and a spectrophotometer device type (CE292) CECL at a wavelength of 540 nm and as described in Page *et al*. (1982).
6- Estimation of free amino acids: They were estimated according to what was stated in Moore and Stein (1954).
7- Determination of proline (µg g^{-1}): Estimated according to the method of Bates *et al*. (1973).
8- Ionic leakage of potassium ions (%): The method described by Jasim (1988) was followed.
9- The Membrane Stability Index (MS) was determined using the methodology described by Lutts *et al.* (1996). It is expressed as a percentage.
10- Estimating peroxidase enzyme activity: The activity of the peroxidase enzyme was evaluated using the method developed by Whitaker and Bernhard (1972).

Fruit measurements

1- Fruit set rate (%)

The fruit set percentage one month after pollination was calculated by following the method of Ream and Furr (1970), which involved determining the number of fruit set and the number of empty scars for ten shamrakh randomly selected from each cluster, the percentage of fruit set was calculated from the following equation:

$$\text{Fruit setting percentage (\%)} = \frac{\text{Number of fruits set}}{\text{The number of fruitless fruits + the number of empty scars}} * 100$$

2 - Maturity rate (%)

Calculated maturity rate by following the method of Abbas and Abbas (1992), the fruit maturity percentage was calculated two weeks after the fruits entered the final maturity stage (Rutab) by randomly taking five shoots from each stalk for each replicate and all treatments. The number of fruits in the Rutab stage and the total number of fruits was calculated, and then the fruit maturity percentage was calculated from the following equation:

$$\text{Fruit maturity percentage (\%)} = \frac{\text{Number of ripe fruits}}{\text{Total number of fruits}} * 100$$

3- Dry matter (%)

The dry matter in fruits was estimated according to Abbas and Abbas (1992), by the following equation:

$$\text{Dry matter (\%)} = \frac{\text{Dry sample weight}}{\text{Fresh sample weight}} * 100$$

4- Average weight of fruit bunches (kg)

The average shoot weight the fruit bunches of each palm tree in the date stage according to Abbas and Abbas (1992) was calculated by cutting the shoots of each palm tree, weighing them with a field scale, and then dividing the total weight of the shoots by their number.

5- Total yield of palm tree (Kg)

After cutting the fruit bunches of each palm tree, it was weighed using a field scale to represent the weight of the total yield of each palm tree (kg $tree^{-1}$).

Statistical Analysis

The study utilized a Randomized Complete Block Design (RCBD) and consisted of nine treatments with three replications. The data was analyzed with GenStat version 7, and the means were compared using the Least Significant Difference Test (LSD) at a significance level of 0.05 (Al-Rawi and Khalafallah, 2000).

Results and Discussion

Table 2 shows the effect of treatment with boron and the silica sol nutrient solution on date palm trees, the Khadrawi variety. It is clear from the table that there was a significant increase in the content of nutrients in the leaves when treated with boron and for both concentrations, as the treatment with boron was superior to the concentration of 200 mg L^{-1} recorded the highest values of mineral elements in the leaves. reaching 3.00 and 0.168 mg g^{-1} for potassium (K) and silicon (Si) and 36.05 mg kg^{-1} for the boron (B) element and 5.27 for the potassium to sodium ratio (K/Na), compared to the comparison treatment, which recorded the lowest values of (2.03, 0.101) mg g^{-1} and 30.41 mg kg^{-1} and 2.56 for potassium, silicon, boron, and the potassium to sodium ratio, respectively.

Treatment 200 mg L^{-1} recorded a significant decrease in the leaves' content of sodium (Na) and chlorine (Cl), with the lowest values amounting to 0.623, 14.76 mg g^{-1}, compared to the comparison treatment, which recorded the highest values, amounting to 0.827, 17.54 mg g^{-1}. The silica sol nutrient solution had a concentration of 6 mL L^{-1}, recorded the highest concentration of the mineral elements K, Si and B, and the ratio of (K/Na), in the leaves reached 2.90 and 0.150 mg g^{-1}, 34.66 mg kg^{-1}, and 5.07 compared to the comparison treatment, which recorded the lowest values amounting to (1.90, 0.094) mg g^{-1}, 32.04 mg kg^{-1} and 2.18, respectively. The identical therapy resulted in a notable reduction in the levels of sodium (Na) and chlorine (Cl), found in the leaves, amounting to 0.605, 14.12 mg g^{-1}, while the comparison treatment recorded the highest values of 0.890, and 18.62 mg g^{-1}, respectively. The interference between the two study agents was significant, as the interference treatment boron (B) at a concentration of 200 mL L^{-1}. The nutrient solution has a concentration of 6 mL L^{-1}. Recorded the highest values for the concentration of potassium, silicon and boron and the ratio of potassium to sodium compared to the control treatment between the two factors, which recorded the lowest values for the traits studied above.

The interference treatment between the two factors above decreased significantly in the concentration of sodium and chlorine in the leaves, as the lowest values were recorded in the highest values for sodium and chlorine concentrations were recorded in the comparison treatment for the interaction between the two factors.

Increase the concentration of potassium, silicon, and boron in the leaves, and the ratio of potassium to sodium, and the decrease in the concentration of sodium and chlorine when treated with boron (Table 2), may be due to the role of activating a number of enzymatic reactions and contributing to the regulation of osmotic potential by raising the plant's efficiency in absorbing potassium and other nutrients (Sardans and Peñuelas, 2021).

Table 2. Effect of treatment with boron and silica sol nutrient solution on the mineral element content of the leaves of the Khadrawi cultivar

Boron concentration (mg L^{-1})	Silica concentration (mL L^{-1})	K (mg g^{-1})	Na (mg g^{-1})	K/Na	Cl (mg g^{-1})	Si (mg g^{-1})	B (mg kg^{-1})
0	0	1.30	0.970	1.34	20.09	0.081	27.18
	3	2.38	0.795	2.99	17.13	0.093	31.79
	6	2.41	0.718	3.36	15.42	0.131	32.28
100	0	2.10	0.881	2.38	18.98	0.094	33.76
	3	2.56	0.701	3.65	15.89	0.155	34.39
	6	2.78	0.619	4.50	14.22	0.116	34.79
200	0	2.31	0.819	2.82	16.80	0.107	35.20
	3	3.17	0.572	5.64	14.76	0.193	36.04
	6	3.52	0.479	7.37	12.73	0.205	36.92
LSD at 0.05		0.43	0.086	1.12	1.13	0.013	1.60
Average effect of boron	0	2.03	0.827	2.56	17.54	0.101	30.41
	100	2.48	0.733	3.51	16.36	0.136	34.31
	200	3.00	0.623	5.27	14.76	0.168	36.05
LSD at 0.05		0.24	0.049	0.64	0.65	0.008	0.92
Average effect of silica solution	0	1.90	0.890	2.18	18.62	0.094	32.04
	3	2.70	0.689	4.09	15.92	0.147	34.07
	6	2.90	0.605	5.07	14.12	0.150	34.66
LSD at 0.05		0.24	0.049	0.64	0.65	0.008	0.92

It is also possible that the increased concentration of nutrients in the leaves when treated with silica sol solution is due to they contain the element silicon which may be attributed to its role in increasing the availability of nutrient and the mitigation of harmful elements' toxic impact. This is because silicon aids in boosting nutrient absorption by plants, as evidenced by Epstein (1994) in the stimulation of root growth under salt stress conditions (Liang, 1999). Alternatively, the positive impact of silicon on the effectiveness of carrier protein ATPase-H+ in root plasma membranes, crucial for potassium ion transportation (Liang *et al.*, 2007).

Table 3 It is evident that there has been a notable reduction in the levels of free amino acids, proline, and potassium ion leakage in the leaves, particularly after exposure to a 200 mg L^{-1} concentration of boron. where the lowest values were recorded at 58.71 mg 100 g^{-1}, 20.35 µg g^{-1}, 6.67, compared to the comparison treatment, which recorded the highest values of 62.70 mg 100 g^{-1}, 23.98 µg g^{-1} , 8.80% for free amino acids, proline, and ionic leakage for potassium ions, respectively. The same treatment was significantly superior in the content of the leaves in the membrane stability index and the activity of the peroxidase enzyme in the leaves, recording the highest values of 67.18%, 38.91 units g^{-1} compared to the comparison treatment, which recorded the lowest values, amounting to 56.32%, 28.17 units g^{-1}.

Treatment with silica sol nutrient solutions at a concentration of 6 ml L^{-1}, was also recorded significantly decrease the leaf content of free amino acids, proline, and ionic leakage of potassium ions, amounting to 58.83 mg 100 g^{-1}, 18.98 micrograms g-1, 6.79%, while the control treatment recorded the highest values amounting to 62.69 mg100 g^{-1}, 25.54 µg g^{-1}, 9.09%, respectively. While the same treatment resulted in a notable rise in content of the leaves in the membrane stability index and the activity of the peroxidase enzyme in the leaves amounted to 68.04%, 37.95 units g^{-1} compared to the comparison treatment, which recorded the lowest values, amounting to 53.27%, 28.14 units g^{-1} for membrane stability index and peroxidase activity, respectively.

The Interference between the two study factors was significant, such that the interaction between boron treatments was reduced at 200 ml.L^{-1} and silica sol solution with 6 ml L^{-1}. Recorded the lowest leaf content of free amino acids and proline and the least leakage of potassium ions, compared to the comparison treatment of the interaction, which recorded the highest leaf content of free amino acids and proline and the most leakage of potassium ions. The same interaction treatment between the two factors recorded the highest index of membrane stability and the highest activity of the peroxidase enzyme, compared to the comparison treatment of the intervention, which recorded the lowest index of membrane stability and the lowest activity of the peroxidase enzyme in the leaves.

The increase in the membrane stability index, the activity of the peroxidase enzyme, the decrease in free amino acids, and the decrease in proline concentration when treated with proline (Table 3) It is possible that the presence of boron plays a role in promoting the synthesis of proteins, in addition to its physiological control over processes such as protein metabolism, pectin formation, regeneration of ATP energy molecules, and maintenance of cellular interactions (Pandey, 2014).

Boron can also help regular water in the plant, in addition to the entry of boron into the structure of the cell wall, enzymatic reactions and cell divisions of plant meristematic tissues, and its entry into the formation and manufacture of carbohydrates and proteins (Shireen *et al*., 2018).

The application of silicon resulted in a decrease in the concentration of amino acids and proline in the leaves, as indicated in Table 3. May be due to the role of silicon in alleviating stress conditions and thus reducing the effectiveness of the protease enzyme, which in turn is reflected in reducing protein breakdown, and this leads to a decrease in acid concentrations. Free amino acids in the leaves, including proline, (Gao, *et al*., 2022) It is possible that the enhancement of peroxidase enzyme effectiveness and membrane stability is a result of the physiological roles played by these compounds in boosting the plant's resilience to environmental stress. This is achieved through heightened enzymatic activity, improved photosynthesis efficiency, and increased peroxidase effectiveness during stressful conditions (Sellami *et al*., 2022).

Table 3. Effect of boron and silica sol nutrient solution treatment on various physiological characteristics in the leaves of the Khadrawi cultivar

Boron concentration (mg L^{-1})	Silica concentration (mL L^{-1})	Concentration of free amino acids (mg 100 g^{-1})	Proline concentration microgram (µg g^{-1})	Film stability index (%)	Ionic leakage potassium ions %	Peroxidase activity (unit gm^{-1})
0	0	64.74	29.94	48.80	9.98	25.85
	3	62.75	22.42	56.98	8.77	28.11
	6	60.62	19.59	63.19	7.66	30.54
100	0	62.75	23.71	55.16	9.25	28.42
	3	59.59	20.86	65.87	8.17	31.90
	6	58.89	19.04	66.98	7.24	35.45
200	0	60.58	22.99	55.86	8.05	30.17
	3	58.56	19.76	71.75	6.51	38.71
	6	57.00	18.32	73.95	5.47	47.87
LSD at 0.05		1.40	1.58	6.30	0.87	2.50
Average effect of boron	0	60.70	23.98	56.32	8.80	28.17
	100	60.41	21.20	62.67	8.22	31.92
	200	58.71	20.35	67.18	6.67	38.91
LSD at 0.05		0.80	0.91	3.63	0.50	1.44
Average effect of Silica solution	0	62.69	25.54	53.27	9.09	28.14
	3	60.30	21.01	64.86	7.81	32.90
	6	58.83	18.98	68.04	6.79	37.95
LSD at 0.05		0.80	0.91	3.63	0.50	1.44

Table 4 indicates that there was a significant superiority in fruit characteristics, set percentage, maturity percentage, dry matter, fruit bunches weight, and total tree yield when treated with boron at both concentrations compared to the control treatment, so that the boron treatment at a concentration of 200 mL L^{-1}, was recorded the highest values were (86.70, 63.31, 64.15%), (7.52, 45.16 kg) compared to the comparison treatment, which recorded the lowest values of (063.53, 52.12, 56.57%), (5.03, 30.04 kg) for the percentage of knots, maturity, dry matter, and fruit bunches weight and total tree yield.

The silica sol solution was also significantly superior in all fruit characteristics compared to the comparison, so the silica sol solution at 6 mL L^{-1} concentration recorded the highest values of (80.42, 59.78, 62.86%), (6.93, 41.58 kg), while the comparison treatment recorded the lowest values of (73.42, 55.29, 58.71%), (5.63, 33.80 kg) for the percentage of fruit set, maturity and dry matter. Bunch weight and the trees total yield, respectively.

The interaction between the two factors was significant, such that the interaction treatment between boron at 200 mg L^{-1} and 6 mL L^{-1} of silica sol solution, had the highest percentage of set, maturity, dry matter, bunch weight, and total tree yield, while the control treatment of the interaction recorded the lowest values for these fruit traits.

Table 4. Effect of treatment with boron and silica sol nutrient solution on some fruit traits of the Khadrawi date palm

Boron concentration (mg L^{-1})	**Silica concentration** (mL L^{-1})	**Contract rate (%)**	**Maturity rate (%)**	**Dry matter (%)**	**Weight of the stem is (kg)**	**Total yield of the tree (kg)**
0	0	53.64	48.83	54.91	3.88	23.32
	3	67.46	52.97	56.65	5.27	31.62
	6	69.49	54.58	58.15	5.86	35.18
100	0	81.47	56.80	59.44	6.10	36.60
	3	82.80	57.74	62.65	6.52	39.16
	6	83.54	58.78	64.29	6.67	40.02
200	0	85.15	60.24	61.79	6.91	41.48
	3	86.73	63.73	64.56	7.40	44.44
	6	88.23	65.98	66.12	8.26	49.56
LSD at 0.05		1.27	1.29	2.39	0.56	3.38
Average effect of boron	0	63.53	52.12	56.57	5.03	30.04
	100	82.60	57.77	62.12	6.43	38.59
	200	86.70	63.31	64.15	7.52	45.16
LSD at 0.05		0.73	0.75	1.38	0.32	1.95
Average effect of Silica solution	0	73.42	55.29	58.71	5.63	33.80
	3	78.99	58.14	61.28	6.39	38.40
	6	80.42	59.78	62.86	6.93	41.58
LSD at 0.05		0.73	0.75	1.38	0.32	1.95

The increase in the percentage of set, maturity, and dry matter in the fruits, the weight of the shoot, and the total yield of the tree (Table 4), may be due to the role of boron in its important and vital role in the growth and germination of pollen and the completion of the pollination and fertilization processes. (Ganie *et al*., 2013).

It has also been noted that it has other metabolic stimulating roles, such as nitrogen metabolism and synthesis. Nucleic acids and in the regulation and activity of plant hormones and the process of photosynthesis (Hansch and Mendel, 2009). Boron works to increase the sugar content of fruits, as it increases the movement of carbohydrates through the association of the borate radical with the hydroxyl groups in the sugars to facilitate their movement and transfer in the plant, which leads to an increase in the fruits' content of soluble solids and total and reducing sugars, and thus an increase in the dry matter in the fruits (Al-Sahaf, 1989; Marschner, 2011), which is reflected positively in an increase in shoot weight and total yield.

Salt functions by neutralizing the harmful impact of free radicals through its role as a co-factor that speeds up proton oxidation, forming compounds that react with hydrogen peroxide, resulting in its breakdown into water and oxygen. Additionally, salt plays a crucial part in enhancing the stability of cell membranes and chlorophyll pigment. Consequently, its efficacy is heightened in combating the detrimental effects of stress, serving as a biochemical mechanism to resist environmental stresses (Hossain *et al*., 2013).

Conclusions

Can conclude from this study that treatment with boron and silica sol nutrient solution has positive effects in alleviating the negative effects of salinity, especially silica nutrient solution because it contains a high percentage of silicon, which plays an essential role in trees' resistance to the effects of salinity by stimulating root activity for tree growth and increasing transport proteins. Boron presented a hopeful approach to alleviate the negative effects of salt stress and improve plant growth through addressing osmotic and ionic stresses and altering root cell wall components, which play a fundamental role in increasing the tolerance of the Khadrawi date palm trees to unsuitable environmental stress conditions, which has a positive impact on the fruit growth characteristics.

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgments

The authors would like to thank everyone at the Central Laboratory at the College of Agriculture, University of Basrah and the biotechnology laboratory at the palm research center and to all who assisted with the technical aspects of this work.

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