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The Impact of Some Foliar Treatments on Chemical Composition and Chlorophyll of Tomato Plant under Saline Condition (Hydroponic Exp.)

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ABSTRACT

A Hydroponic experiment was conducted in a greenhouse at Egypt's National Research Center Dokki to investigate the impact of some foliar treatments on enhancing growth of tomato plants under different salinity levels. Tomato *(Solanum lycopersicum)* seedlings from the Agricultural Research Center station in Dokki variety, Hagen Elssia were used. The tomato seedlings were immersed in Hogland solution for a week, and then the salinity level of the solution was adjusted to the values. 2, 4 and 6 dSm^{-1} using NaCl After one week seven spray treatments were applied (Control, K 500 ppm, Si $8mML^{-}$, Proline 100 ppm, Algae as extraction 2%, Fe 10 ppm + K500 ppm KNO_3 + B 10 ppm, Fe10 ppm + K500 ppm + B10 ppm + Si 8 mML^{-1} and Fe 10 ppm + K500 ppm + B 10 ppm+ proline 100 ppm. The applied spray parameters and their effect on the nutritional characteristics of the tomato plant were evaluated. It was evident through this evaluation that the best treatments were potassium nitrate, followed by the treatment of algae extract, then treatment of Fe+K+B+Prol, then Fe+K+B+Si and the treatment with proline was the least effective treatment on nutrition status.

Keywords: Hydroponic, salinity (Na Cl), silica, KNO_3, prolein, Fe, K, B, Algae.

1. Introduction

Salinity is one of the most important factors limiting agricultural crop productivity, affecting germination, plant vigour, and crop yield (Munns and Tester, 2008). Many irrigated areas are affected by salinization, owing to the usage of brackish water. Water stress, ion toxicity, nutritional problems, oxidative stress, change of metabolic processes, membrane disorganization, reduction of cell division and expansion, genotoxicity are all effects of high salinity on plants. These factors combined have a negative impact on plant growth, development, and survival (Hasegawa *et al.,* 2000, Munns, 2002, Zhu, 2007).

Tomato is a major vegetable crop. Tomatoes are the primary dietary source of lycopene, an antioxidant associated to a variety of health advantages, including a lower risk of heart disease and cancer. Vitamin C, potassium, folate, and vitamin K are all abundant in them FAO, (2011).

The cultivation of tomato crop is very favorable by the growers because of its moderate tolerance to salinity which enable the plant to improve its performance by application of some agricultural practices specially those treatments that provide nutrients to the plants.

Management of mineral nutrient, organic acid and amino acid (whether soil additions or spraying) under salinity stress will aid in the development of salinity resistance methods for plants.

The objective of this study is evaluation of some spraying treatments on tomato plant nutrient content to resist salinity stress on plant and identify the best ones under Hydroponic condition.

2. Materials and Methods

The impact of certain foliar treatments on boosting tomato plant development at varied salinity levels (EC: 2, 4, and 6 dSm^{-1}) using NaCl was investigated in a hydroponic experiment carried out in a greenhouse. Tomato *(Solanum lycopersicum)* seedlings Hybrid Elssia were used. The experimental plots were made up of

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plastic container 1.5 L with cover have two holes one for cup seedlings and the second for tube of aeration. Then each seedlings cup put inside the hole that was made with the container cover immersed in Hoagland's solutions according to Hoagland and Arnon (1950) and insert the air tube from the other hole of the cover. Hoagland solution salinity level has been adjusted to 2, 4 and 6 dSm^{-1} using NaCl.

2.1. After one week seven spray treatments were applied

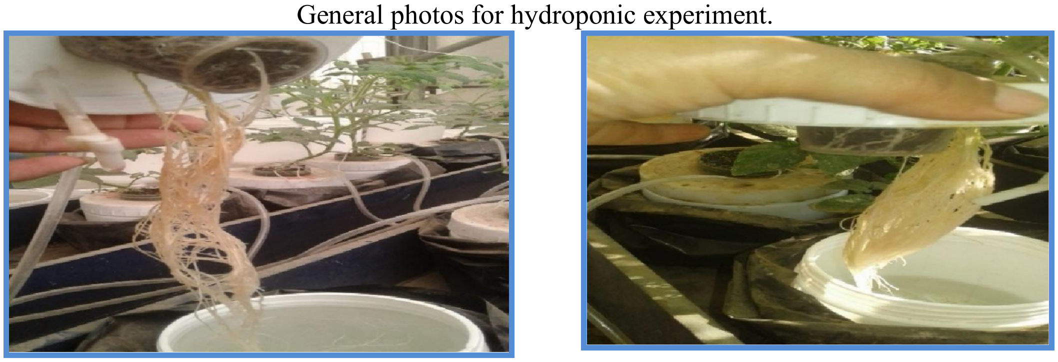
Control (without treatment), K 500 ppm as KNO_3, Si 8 mML^{-1} as calcium silicate, Proline 100 ppm, Algae as extraction 2%, Fe 10 ppm as Fe-EDTA+ K500 ppm as KNO_3 + B 10 ppm as boric acid, Fe10 ppm + K500 ppm + B10 ppm + Si 8 mML^{-1} and Fe 10 ppm + K500 ppm + B 10 ppm+ proline 100 ppm.

Three replications were made for each treatment, and the Hoagland solution was changed weekly with the original content in the experiment and with the same salt concentration for the primary treatments. Spraying by different treatments was done once a week from the start of the experiment for four weeks. The experiment lasted for 7 weeks. Each of macro and micro elements were determined in plant prates (shoot and root).

Dry matter of tomato plants was digested using mixture of sulphuric and perchloric acids (Jackson, 1973). The nutrients were determined in the digest solution.

Total nitrogen was determined according to (Cottenie, 1982) as follows: A dried ground plant sample (0.2 g) was digested using 5 ml concentrated sulphuric acid and 1.1 g of digestion mixture (100 g K_2SO_4, 10 g $CuSO_4.5H_2O$ and 1.0 g selenium) in digestion tube. The digestion was completed until the digest was clear. The ammonia was distilled using 20 ml of NaOH 40%. Twenty ml of 4% boric acid and 4 drops of bromocresol green methyl red mixed indicator solution were used to collect the distilled ammonia which was titrated with 0.05 N sulphuric acid. Total Potassium and Sodium in the plants was determined in digested solution by flame photometer (JENWAY). Total phosphorus in plants was determined in digest solution by the vanadate molybdenum yellow method at wave length of 436 nm as described by (Jackson, 1973) using spectrophotometer (Spectro UV-VIS Double Beam UVD-3500). Micronutrients (Iron, Manganese, Zinc and copper) were determined in digested solution by atomic absorption spectrophotometer (Jackson, 1973). And total chlorophyll by chlorophyll meter (SPAD)- 502 plus.

General photos for hydroponic experiment.



Photos showing how to change the nutrient solution.

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3. Results and Discussion

Hydroponics, often known as soilless agriculture, is a method of growing plants in water without the need of soil by nutrient solutions. Hydroponic experiment used in this study to evaluate several spray treatments on tomato plants' tolerance of different levels of salinity without any other factors.

3.1. Macronutrients

Macronutrients serve a critical function in plant development and growth. They serve a variety of purposes, from structural components to redox-sensitive agents. However, because nutrients are involved in every phase of plant life, plant physiologists, biotechnologists, and eco-physiologists have been working in recent years to examine several other hidden aspects of these minerals and their future prospects. Every macronutrient has its own personality and is hence engaged in a variety of plant metabolic processes.

This experiment was concerned with the effect of spraying treatments on tomato plants' macronutrient (N-P-K).

3.1.1. Nitrogen

The effect of foliar application used on N concentration in tomato plant (shoot and root) under saline condition (hydroponic experiment) was illustrated in table (1).

Table 1: Effect of some foliar application on N content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Foliar treatments	N %							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	4.62^{c-f}	2.61^{ef}	4.36^{g}	2.3^{g}	3.78^{j}	1.97^{i}	4.253^{e}	2.29^{e}
KNO_3	4.75^{b}	2.86^{ab}	4.73^{bc}	2.8^{a-c}	4.26^{gh}	2.4^{g}	4.58^{a} +7.76%	2.68^{a} +17.46%
Si	4.71^{b-d}	2.68^{c-f}	4.63^{b-f}	2.56^{f}	4.03^{i}	2.14^{h}	4.45^{a} +4.91%	2.46^{bc} +7.42%
Proline	4.74^{bc}	2.75^{a-d}	4.67^{b-e}	2.66^{d-f}	3.82^{j}	2.08^{hi}	4.41^{bc} +3.76%	2.49^{b} +9.60%
Algae	4.99^{a}	2.87^{a}	4.75^{b}	2.83^{ab}	4.17^{h}	2.37^{g}	4.64^{a} +9.18%	2.69^{a} +17.46%
Fe+K+B	4.64^{b-f}	2.62^{d-f}	4.53^{f}	2.32^{g}	3.83^{j}	2.11^{h}	4.33^{d} +1.88%	2.35^{de} +2.60%
Fe+K+B+Si	4.68^{b-e}	2.73^{b-e}	4.56^{ef}	2.35^{g}	3.86^{j}	2.09^{hi}	4.37^{cd} +2.82%	2.39^{cd} +4.37%
Fe+K+B+Prol	4.7^{b-d}	2.75^{a-d}	4.59^{d-f}	2.34^{g}	3.89^{j}	2.13^{h}	4.39^{bcd} +3.29%	2.41^{cd} +5.24%
Mean	4.73^{a}	2.73^{a} - 2.75%	4.60^{b} - 2.75%	2.52^{b} -8.00 %	3.95^{c} -16.49%	2.16^{c} -21.17%		
LSD Salinity	0.043	0.049						
LSD treatment	0.070	0.080						
LSD Salinity *treatment	0.122	0.139						

The increase of salinity in the plant growth environment (4, 6 dSm^{-1}) resulted in a decrease in the nitrogen concentration in both the shoot and the root of tomato plant. According to El-Arquan *et al.,* (2002), increasing soil salinity levels reduced nutrient absorption considerably. This suggests that high levels of sodium (Na) and chloride (Cl) ions in the growth medium hinder crucial nutrient absorption and potentially also translocation (Eisa 1997).

The 6 dSm^{-1} salinity level caused a decrease in the average nitrogen concentration in the shoot and root system by 16.49% and 21.49%, respectively, compared to the 2 dSm^{-1} salinity level. This may be due to the low rate of water absorption, including the elements it contains, with a high level of salinity. It is also evident from the results of nitrogen concentration that the root is affected by salinity more than the shoot system Also, the effect of salinity on nitrogen concentration was reduced at 4 dSm^{-1} comparing with 6dSm^{-1}.

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All spray treatments had a positive effect on nitrogen concentration in both the shoot and the root system. Spraying with algae extract, followed by potassium nitrate, had the highest levels, with an average increase of 9.18%, and 7.76% respectively compared to control for the shoot system, and 17.46% for the root system of both compared to the control. While spraying with a mixture in Fe + K +B was the least equivalent treatment, with an average increase of 1.88% and 2.6% for shoot and root system respectively compared to control. The results showed that root response in a greater proportion to the treatments compared to shoot.

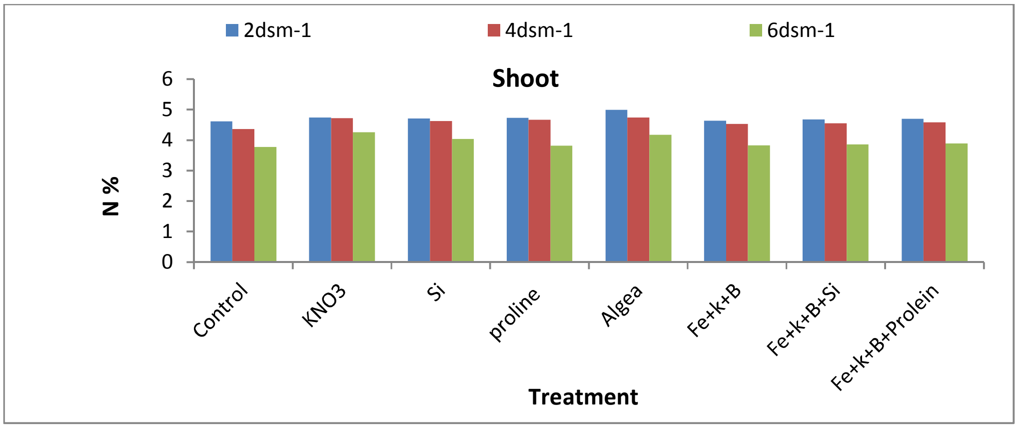

Fig. 1: Effect of some foliar application on N content in shoot of tomato plant under saline condition (hydroponic experiment).

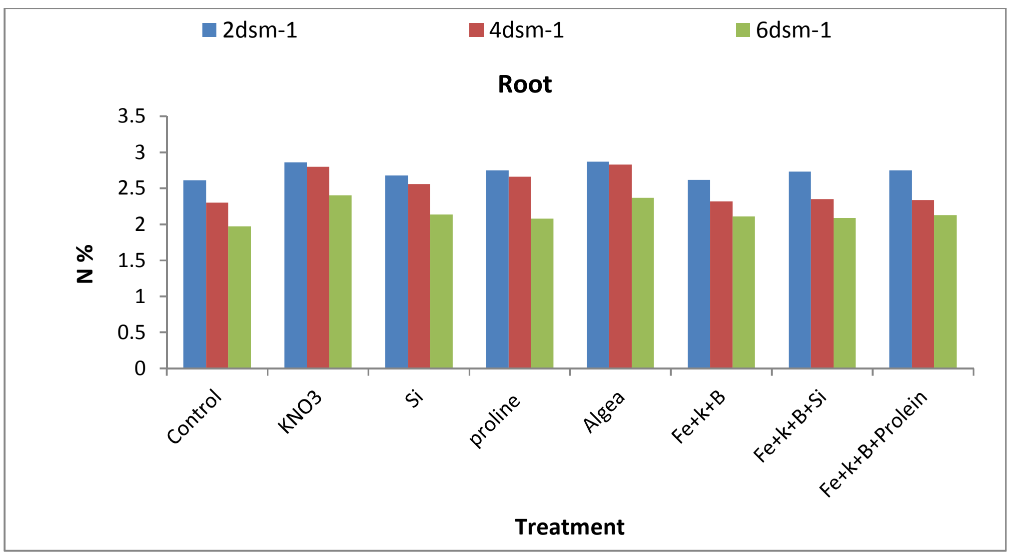

Fig. 2: Effect of some foliar application on N content in root of tomato plant under saline condition (hydroponic experiment).

3.1.2. Phosphorus

Phosphorus (P) is a macro-element that plants require for a variety of metabolic activities, including energy transmission, signal transduction, macromolecule production, photosynthesis, and respiration (Raghothama and Karthikeyan, 2005).

Table 2: Effect of some foliar application on P content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Foliar treatments	P %							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	0.055	0.026^{cd}	0.034	0.023^{d}	0.019	0.011^{e}	0.36^{d}	0.20^{b}
KNO_3	0.062	0.036^{a-c}	0.045	0.033^{a-d}	0.034	0.027^{cd}	0.47^{ab} +30.5%	0.32^{a} +60%
Si	0.056	0.028^{cd}	0.042	0.03^{b-d}	0.03	0.025^{d}	0.43^{a-c} +19.4%	0.28^{a} +40%
Proline	0.059	0.029^{b-d}	0.036	0.029^{b-d}	0.03	0.023^{d}	0.42^{b-d} +16.7%	0.27^{a} +35%
Algae	0.061	0.033^{a-d}	0.054	0.031^{a-d}	0.032	0.026^{cd}	0.49^{a} +36.1%	0.30^{a} +50%
Fe+K+B	0.056	0.032^{a-d}	0.036	0.027^{cd}	0.029	0.024^{d}	0.40^{cd} +11.1%	0.28^{a} +40%
Fe+K+B+Si	0.058	0.039^{ab}	0.036	0.029^{b-d}	0.042	0.025^{d}	0.45^{a-c} +25%	0.31 +55%
Fe+K+B+Prol	0.06	0.041^{a}	0.038	0.031^{a-d}	0.046	0.027^{cd}	0.48^{ab} +33.3%	0.33^{a} +65%
Mean	0.058^{a}	0.033^{a}	- 31% 0.040^{b}	-12.1% 0.029^{b}	-44.8% 0.032^{c}	- 27.3% 0.023^{c}		
LSD Salinity	0.00389	0.00376						
LSD treatment	0.00634	0.00614						
LSD Salinity *treatment	0.01099	0.010634						

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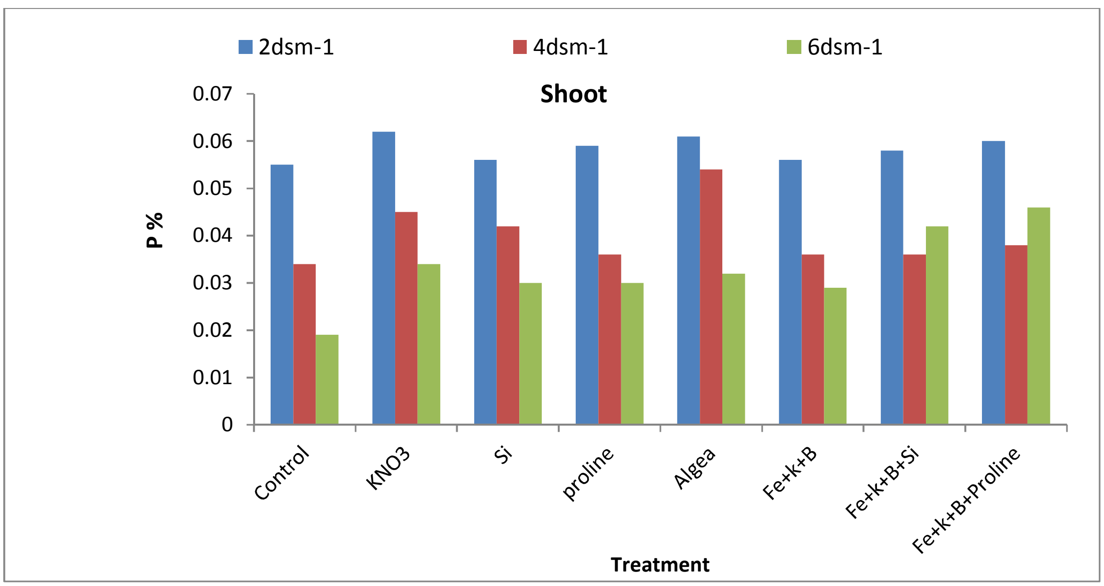

Fig. 3: Effect of some foliar application on P content in shoot of tomato plant under saline condition (hydroponic experiment).

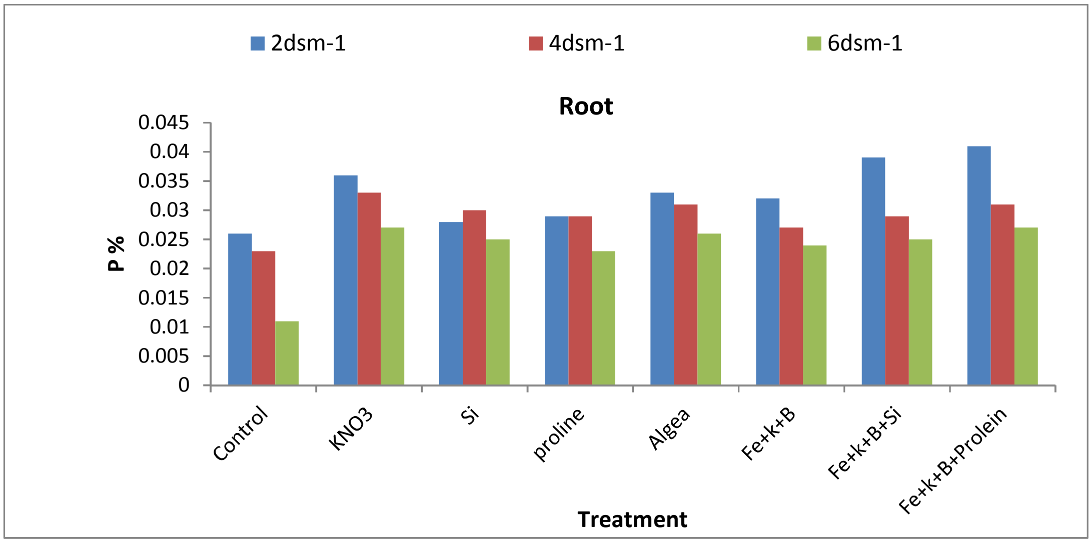

Fig. 4: Effect of some foliar application on P content in root of tomato plant under saline condition (hydroponic experiment).

In a hydroponic experiment, the effect of salt levels and varied foliar applications on P content in the tomato plant's shoot and root system is shown in Table (2).

The results showed a decrease in the average concentration of phosphorus for tomato plants, with an increase in the level of salinity in the growth solution. The effect on the shoot system was greater compared to the root system, as the decrease was 31% and 44.8 for the concentration of salts 4d Sm^{-1} and 6 dSm^{-1} respectively for plant shoot system while the decrease in the phosphorus level was 12.1% and 27.3% for plant root system in salt-affected soil, Cho-Ruk and Morrison (2004) discovered that as salt concentrations rise, P adsorption decreases**.** Using the mean values all spraying treatments had a favorable impact on the environment concentration of P component for both shoot and root of tomato. Spraying with algae extract, and potassium nitrate, had the highest levels of phosphorous concentration with an increase of 36.1% and 30.5% of the shoot system, respectively, while the Fe + K + B + Prol treatment, and potassium nitrate, cleaned the highest levels of root with increases of 65% and 60%, respectively. Spraying with a mixture of Fe + K + B was the least effective treatment, with an increase of 11.1% and 40% for the shoot and root system, respectively.

3.1.3. Potassium

Along with nitrogen (N) and phosphorus (P), potassium (K) is the third of the three major nutrients required by plants (P). In plant tissue, potassium is linked to the flow of water, minerals, and carbohydrates. It influences protein, starch, and adenosine triphosphate (ATP) synthesis by activating enzymes inside the plant. The rate of photosynthesis may be controlled by the creation of ATP. Potassium absorption by plants is influenced by a number of parameters, including moisture, aeration, salinity, oxygen content, and temperature. Potassium in plants is mobile, moving from lower to high leaves.

Table (3) illustrates the impact of salinity levels and different foliar treatments on K concentration in shoot and root system of tomato plant in hydroponic experiment like nitrogen and phosphorous, the concentration of potassium decreases with the increase in the level of salinity, and the level of salinity 6dSm-1 shows the lowest values of potassium absorbed by tomato plants. The percentage decrease in plant concentration was 21.9% and 47.2% for the shoot system, while the percentage decrease in the root was 23.9% and 26.9% for salinity levels 4 $dSm^{-1}$and 6 dSm^{-1} compared to salinity concentration 2 dSm^{-1}. Salinity decreased net K absorption rates and, to a lesser extent, K translocation from root to shoot, resulting in greater K shoot concentrations and lower K root concentrations (Al-Karaki, 2000).

The overall mean of potassium concentration values in the plant showed an increase for all spraying treatments used compared to the control. All spraying agents containing potassium showed the most effective treatments (KNO_3, Fe + K + B, Fe+K+B+Si, Fe+K+B+prol) Also, the treatment

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with algae extract had a positive effect on the average potassium concentration values, with an increase of 10.03% compared to the control. The mixture (Fe + K + B + Si) and KNO_3 had the highest effect on the average potassium concentration values of tomato plants, with an increase of 11.5% and 11.21%, respectively, compared to the control. While the spray treatment with Si had the least effect, with an increase of 5.01%.

Table 3: Effect of some foliar application on K content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Foliar Treatments	K %							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	4.62^{e}	2.56^{c}	3.31^{k}	1.89^{i}	2.24^{o}	1.69^{j}	3.39^{e}	2.05^{d}
KNO_3	4.75^{d}	2.7^{ab}	3.91^{g}	2.25^{d}	2.65^{l}	2.26^{d}	3.77^{b} +11.21%	2.40^{a} +17.07
Si	4.41^{f}	2.64^{bc}	3.75^{i}	2.15^{e}	2.51^{mn}	1.99^{fg}	3.56^{d} +5.81%	2.26^{b} +10.24%
Proline	4.74^{d}	2.65^{b}	3.57^{j}	2.12^{e}	2.44^{n}	1.91^{g-i}	3.58^{d} +5.60%	2.23^{bc} +8.78%
Algae	4.79^{cd}	2.74^{a}	3.86^{gh}	1.98^{f-h}	2.55^{m}	1.9^{hi}	3.73^{bc} +10.03%	2.21^{c} +7.80%
Fe+K+B	4.84^{bc}	2.71^{ab}	3.74^{i}	1.95^{f-i}	2.55^{m}	1.98^{f-h}	3.71^{c} +9.44%	2.21^{c} +7.80
Fe+K+B+Si	4.97^{a}	2.69^{ab}	3.8^{hi}	1.99^{fg}	2.56^{m}	2.0^{f}	3.78^{b} +11.50%	2.23^{bc} +8.78%
Fe+K+B+Prol	4.9^{ab}	2.76^{a}	3.77^{i}	1.98^{f-h}	4.59^{e}	1.95^{f-i}	3.75$^{a c}$ +10.62%	2.23^{bc} +8.78%
Mean	4.75^{a}	2.68^{a}	-21.9% 3.71^{b}	- 23.9% 2.04^{b}	-47.2% 2.76^{c}	-26.9% 1.96^{c}		
LSD Salinity	0.030	0.028						
LSD treatment	0.050	0.046						
LSD Salinity *treatment	0.086	0.080						

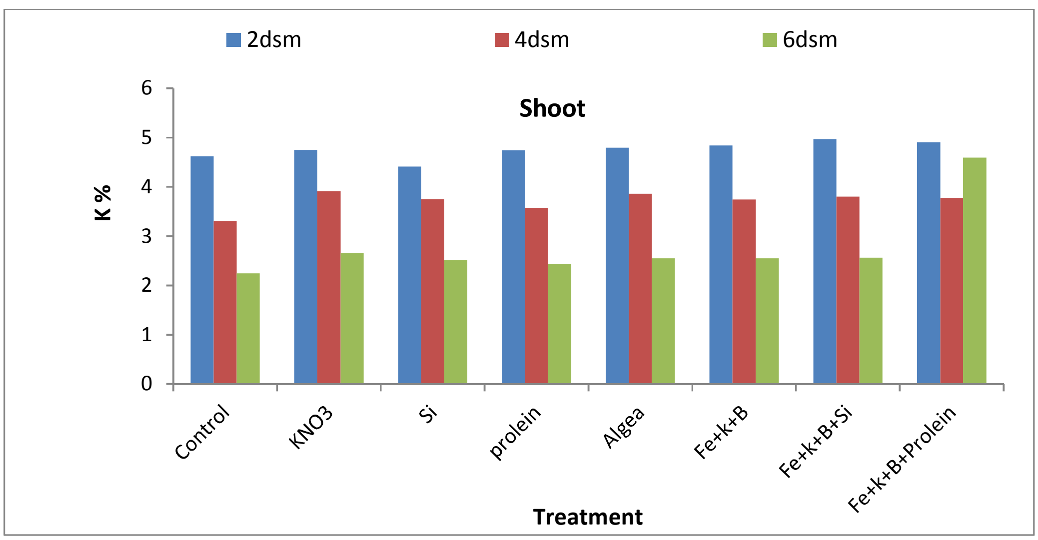

Fig. 5: Effect of some foliar application on K content in shoot of tomato plant under saline condition (hydroponic experiment).

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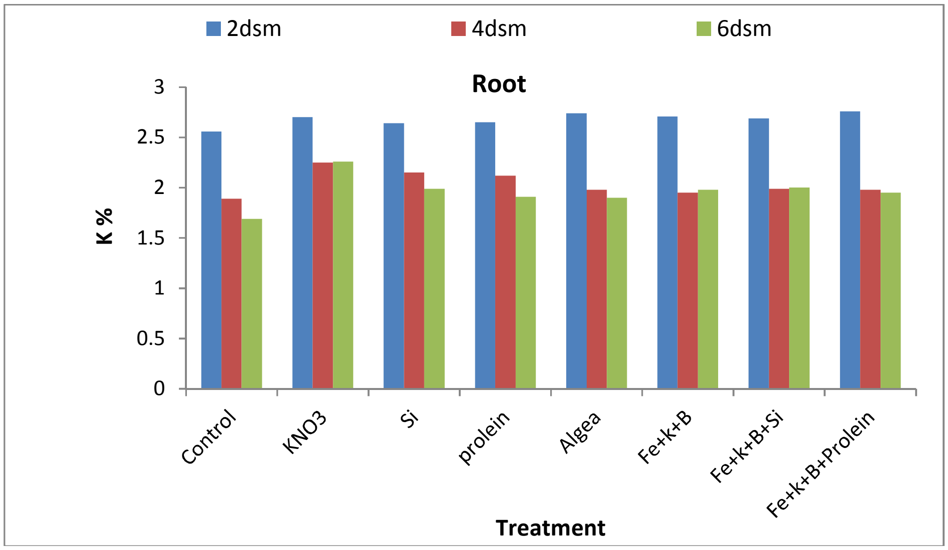

Fig. 6: Effect of some foliar application on K content in root of tomato plant under saline condition (hydroponic experiment).

3.1.4. Sodium

Plants do not require sodium, although it may be utilized in tiny amounts, similar to micronutrients, to help in chlorophyll metabolism and synthesis. In some plants, it can be used as a partial replacement for potassium and aids in the opening and closing of stomata's, which helps regulate internal water balance. Because sodium can be present in high, but not dangerous, concentrations in the growth media, it can compete for absorption by plant roots with helpful fertilizer components. Sodium competes for plant absorption with potassium, calcium, magnesium, and ammonium.

Table 4: Effect of some foliar application on Na content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Foliar treatments	Na %							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	0.65^{l}	0.72^{g}	1.98^{g}	1.84^{e}	2.98^{a}	2.86^{a}	1.87^{a}	1.81^{a}
KNO_3	0.54^{n}	0.44^{k}	1.55^{k}	1.55^{f}	2.3^{ef}	2.05^{c}	1.46^{e} -21.9%	1.35^{e} -25.4%
Si	0.58^{l-n}	0.69^{gh}	1.8^{i}	1.81^{e}	2.63^{b}	2.33^{b}	1.67^{bc} -10.7	1.61^{b} -11.0%
Proline	0.61^{l-n}	0.64^{g-i}	1.9^{gh}	1.83^{e}	2.6^{bc}	1.94^{d}	1.70^{b} -9.1%	1.47^{cd} -18.8%
Algae	0.55^{mn}	0.62^{h-j}	1.69^{j}	1.52^{f}	2.26^{f}	1.94^{d}	1.5^{e} -19.8%	1.36^{e} -24.9%
Fe+K+B	0.63^{lm}	0.55^{j}	1.88^{hi}	1.79^{e}	2.54^{c}	1.94^{d}	1.68^{b} -10.2%	1.43^{d} -21.0%
Fe+K+B+Si	0.61^{l-n}	0.6^{ij}	1.67^{j}	1.78^{e}	2.43^{d}	2.09^{c}	1.57^{d} -16.0%	1.49^{c} -17.7%
Fe+K+B+Prol	0.6^{l-n}	0.64^{g-i}	1.9^{gh}	1.77^{e}	2.38^{de}	2.02^{cd}	1.63^{c} -12.8%	1.48^{c} -18.2%
Mean	0.596^{c}	0.61^{c}	1.79^{b} +200%	17.3^{b} +185.2%	2.51^{a} +318.3%	2.15^{a} +252.4%		
LSD Salinity	0.030	0.028						
LSD treatment	0.048	0.047						
LSD Salinity *treatment	0.083	0.080						

Data in table (4) and illustrated in Fig (7, 8) show the influence of salt levels and varied foliar treatments on Na concentration in the tomato plant's shoot and root system in hydroponic experiment.

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It was found that the level of sodium concentration in plants increased with increasing salinity, as there was an increase of 200% and 318% in the shoot of salinity levels 4 and 6 dSm^{-1} respectively. While the increase in the root was 185% and 252% for salinity levels 4 and 6 dSm^{-1} respectively. The results also show that the increase in sodium is greater in the shoot system, compared to the root.

All the treatments used showed a decrease in the level of sodium in tomato plants compared to the untreated control .The potassium nitrate, followed by algae extract, was the best treatment in reducing the sodium level by a ratio equivalent to 25.4% and 21.9% as a general average for vegetative and root system, respectively for potassium nitrate (Hussain *et al.,* 2013), Potassium application decreased leaf [Na] and significantly increased [K]; while the average percentage of decrease was 24.9% and 19.8% for each of the vegetative and the root system, respectively, for spray treatment with algae extract. The spraying with silica was the least effective treatment in reducing the sodium level of tomato plant. The water content of the shoot portion was shown to be the least impacted by salt when compared to the root portion.

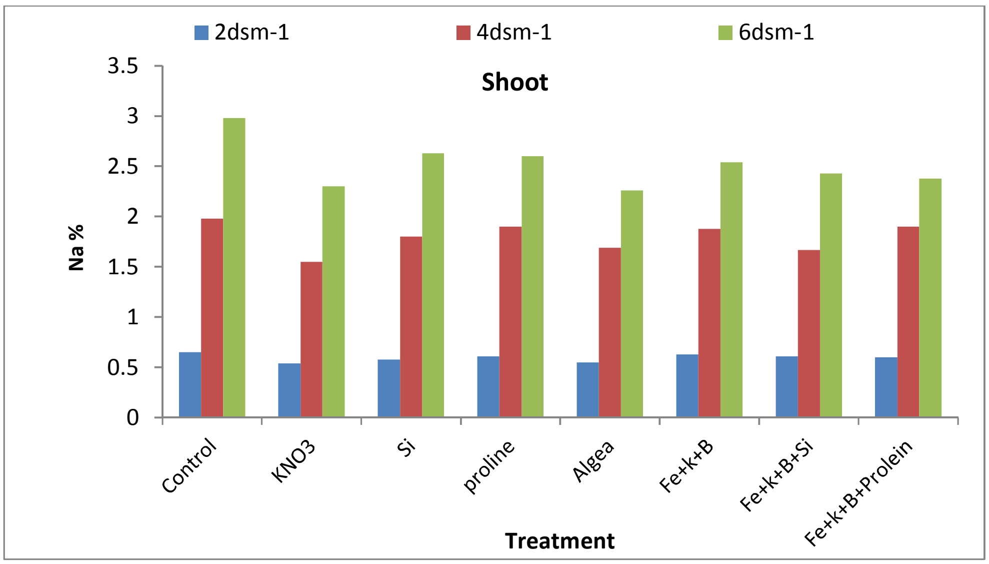

Fig. 7: Effect of some foliar application on Na content in shoot of tomato plant under saline condition (hydroponic experiment).

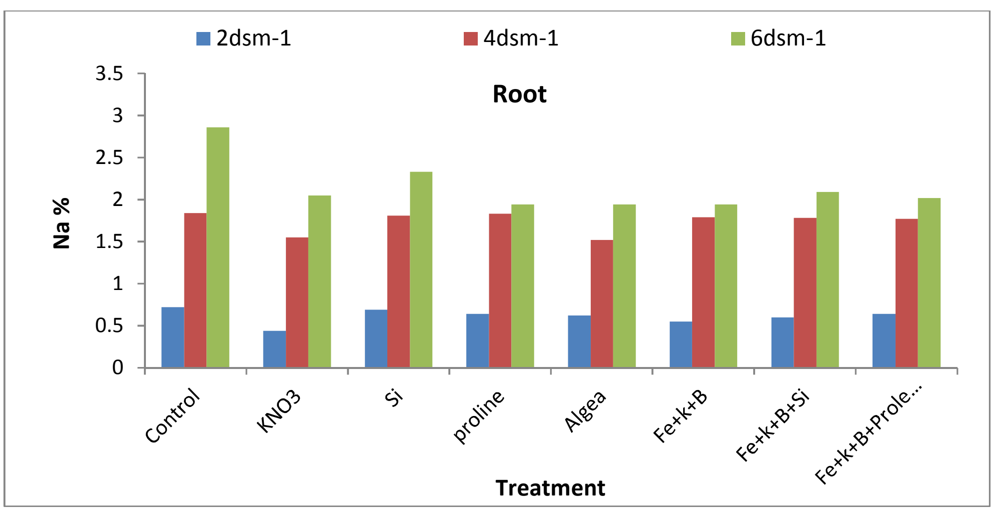

Fig. 8: Effect of some foliar application on Na content in root of tomato plant under saline condition (hydroponic experiment).

3.1.5. Potassium: sodium ratio:

Table (5) shows the impact of varying salinity levels and foliar treatments on K/Na ratio in shoot and root system of tomato plant in hydroponic experiment. The results showed a gradual decrease in the value of K: Na with an increase in the level of salinity. According to Patel *et al.* (2010), increasing NaCl concentration lowered growth and nutrient absorption, whereas increasing Na raised N, P, K, Ca, and K/ Na. The average value of K/ Na was 8.08, 2.08 and 1.01 of the shoot system; while it was 4.47, 1.18 and 0.93 for root system under saline condition of 2,4and 6 dSm^{-1} respectively. The results also showed an increase in the value of K/ Na in the green system compared to the root system under different levels of salinity.

Table 5: Effect of some foliar application on K/ Na content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

foliar treatments	K/Na							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	7.01	3.56	1.67	1.03	0.75	0.59	3.14	1.73
KNO_3	8.79	6.14	2.52	1.45	1.15	1.10	4.15	2.90
Si	7.47	3.83	2.08	1.19	0.95	0.85	3.50	1.96
Prolline	8.71	4.14	1.88	1.16	0.94	0.98	3.84	2.09
Algae	8.71	4.42	2.28	1.30	1.13	0.98	4.04	2.23
Fe+K+B	7.68	4.93	1.99	1.09	1.00	0.99	3.56	2.34
Fe+K+B+Si	8.15	4.48	2.27	1.12	1.05	0.96	3.82	2.19
Fe+K+B+Prol	8.17	4.31	1.98	1.12	1.09	0.97	3.75	2.13
Mean	8.80	4.47	2.08	1.18	1.01	0.93		

All the applied spray treatments showed an increase in the average K / Na value. The average treatment with potassium nitrate was the best treatment with an increase of 32.16% compared to the control. Hussain *et al.* (2013) show that uptake of K reduced Na uptake resulting in significant increase in K: Na ratio of leaf tissues, while the treatment with silica was the least effective treatment with an increase of 11.46%.

3.2. Micronutrients

3.2.1. Iron

Iron (Fe) is a micronutrient, which means it is required in less amounts by plants than main or secondary macronutrients. Iron is essential for plant health and growth, so don't let the categorization throw you off. Iron is the most important of the micronutrients, and its availability is influenced by the pH of the growth media. Except for molybdenum, all micronutrients become less accessible when the pH of the growth media rises, but become more accessible as the pH falls. The capacity of crops to absorb micronutrients determines the appropriate pH range for them.

The effects of salt levels and various foliar applications on Fe concentration in shoot and root system of tomato plant in hydroponic experiment are shown in Table (6). The increase of salinity in the growth media of the tomato plant caused a gradual decrease in the iron concentration, as it gave ratios of 100, 69.83, and34.27 % for salinity levels 2, 4 and 6 dSm^{-1} in the green part, while it was 100, 82.0 and 49.50% for the root system. Mer *et al.* (2000) discovered that the uptake of all macronutrients (N, P, K, Mg, and Ca) and micronutrients (Fe, Mn, Zn, and Cu) in different plant organs is inversely correlated with salinity**.**

The decrease in the root system is less than it compared to the green system. All spray treatments containing iron resulted in an increase in iron concentration, whether in the foliage or the root system. Spraying micronutrients before or after salinity treatments, according to EL-Fouly *et al.* (2010), might reverse the deleterious effects of salinity on dry weight and nutrient absorption. Micronutrient foliar sprays have been recommended as a way to increase plant tolerance to salt water.

The spray treatment Fe+K+B, Fe+K+B+Si, and Fe+K+B+Prol were the highest concentration in the green System as they increased the averages equal to 48.44%,51.23 and 53.48%, respectively compared to the control. The potassium nitrate treatment was the highest effect spray of the non-iron containing treatments, as it produced an increase in the averages equivalent to 42 .04% compared to the control.

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With regard to the tomato root system, potassium nitrate spraying was the most effective treatment Where it brought about an increase in the general average by 29.72%%, compared to the control as it is with the green system, the iron-containing treatments gave the highest positive effects.

Table 6: Effect of some foliar application on Fe content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Treatments foliar	Fe (ppm)							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	51.4^{f}	61.31^{c-e}	31.2^{l}	54.2^{ef}	11.04^{t}	31.23^{ij}	31.21^{h}	48.91^{d}
KNO_3	69.28^{a}	89.19^{a}	43.11^{i}	62.79^{cd}	20.62^{p}	38.39^{hi}	44.33^{d}	63.45^{a}
Si	60.1^{d}	73.5^{b}	35.12^{j}	56de	19.12^{q}	25.42^{j}	38.11^{f}	51.64^{d}
Prolein	61^{c}	80.65^{b}	43.06^{i}	61^{c-e}	15.17^{r}	35.9^{hi}	39.74^{e}	59.18^{bc}
Alge	61.08^{bc}	73.7^{b}	33.83^{k}	63.75^{c}	12.61^{s}	33.9^{hi}	35.84^{g}	57.11^{c}
Fe+K+B	60.9^{c}	73.8^{b}	50^{h}	64.9^{c}	28.1^{o}	40.23^{gh}	46.33^{c}	59.64^{a-c}
Fe+K+B+Si	61^{c}	74.9^{b}	50.8^{g}	65.4^{c}	29.8^{n}	45.9^{g}	47.2^{b}	62.06^{ab}
Fe+K+B+Prol	61.27^{b}	75.3^{b}	52.3^{e}	66.2^{c}	30.13^{m}	47.24f^{g}	47.9^{a}	62.91^{ab}
Mean	60.75^{a}	75.29^{a}	42.42^{b}	61.78^{b}	20.82^{c}	37.27^{c}		
LSD Salinity	0.074	0.257						
LSD treatment	0.121	0.419						
LSD Salinity *treatment	0.209	0.726						

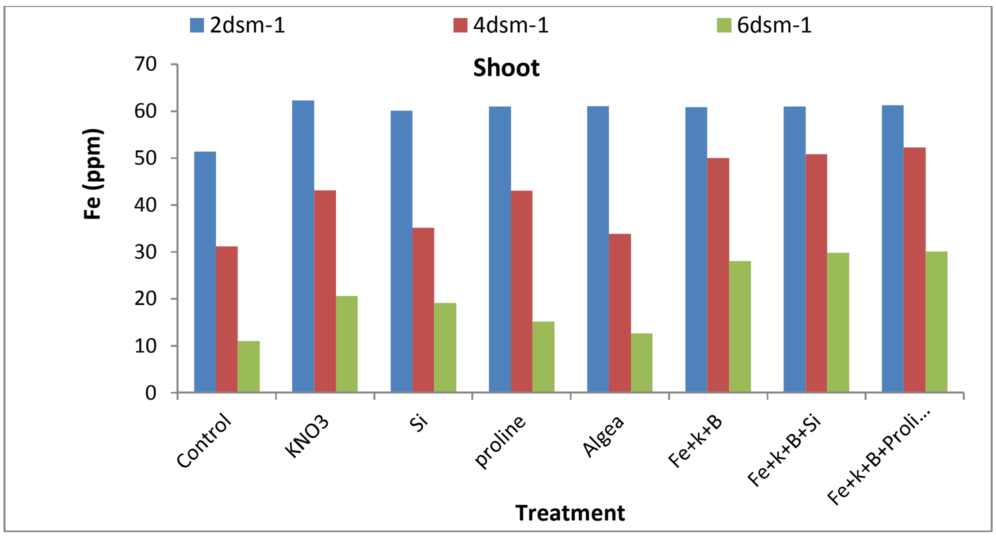

Fig. 9: Effect of some foliar application on Fe content in shoot of tomato plant under saline condition (hydroponic experiment).

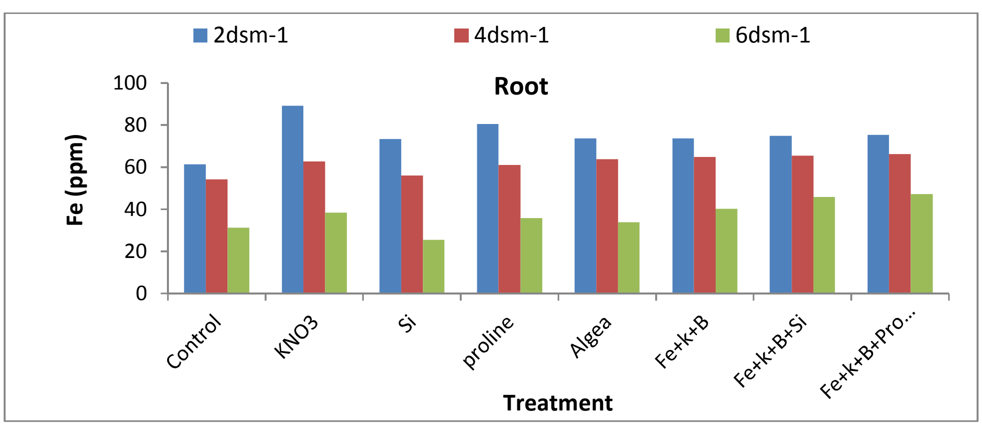

Fig. 10: Effect of some foliar application on Fe content in root of tomato plant under saline condition (hydroponic experiment).

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3.2.2. Manganese

All spray treatments caused a significant increase in the concentration of manganese in tomato plants. The treatments Fe+K+B+Prol and KNO_3 were the highest effective treatments with an increase in the averages equal to 21.44 and 19.91%, respectively. While the Si treatment and, Proline was the least effective spray treatments as they equaled the effect with an increase of 12.25%.

Table 7: Effect of some foliar application on Mn content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Treatments foliar	Mn (ppm)							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	145.5^{d}	320.5^{e}	95.5^{n}	195.5^{l}	85.5^{n}	190.5^{m}	108.83^{f}	235.5^{h}
KNO_3	160.5^{a}	320.5^{e}	120.5^{f}	260.5^{f}	110.5^{i}	175.5^{n}	130.5^{b}	258.83^{a}
Si	150.5^{b}	325.5^{c}	110.5^{i}	220.5^{i}	105.5^{l}	200.5^{k}	122.16^{e}	248.83^{c}
Proline	155.5^{b}	321.5^{d}	105.5^{l}	225.5^{h}	105.5^{l}	210.5^{j}	122.16^{e}	252.5^{b}
Algae	155.5^{b}	320.5^{e}	115.5^{g}	235.5^{g}	114.5^{h}	160.5^{p}	128.5^{c}	238.83^{g}
Fe+K+B	160.5^{a}	335.5^{b}	115.5^{g}	235.5^{g}	108.5^{k}	165.5^{o}	128.16^{d}	245.5^{d}
Fe+K+B+Si	155.5^{b}	325.5^{c}	120.5^{f}	235.5^{g}	109.5^{j}	165.5^{o}	128.5^{c}	242.16^{e}
Fe+K+B+Prol	155.5^{b}	335.5^{b}	125.5^{e}	225.5^{h}	115.5^{g}	163.5^{p}	132.16^{a}	241.5^{f}
Mean	154.87^{a}	328.12^{a}	113.62^{b}	229.25^{b}	106.87^{c}	179^{c}		
LSD Salinity	0.114	0.126						
LSD treatment	0.187	0.206						
LSD Salinity *treatment	0.323	0.356						

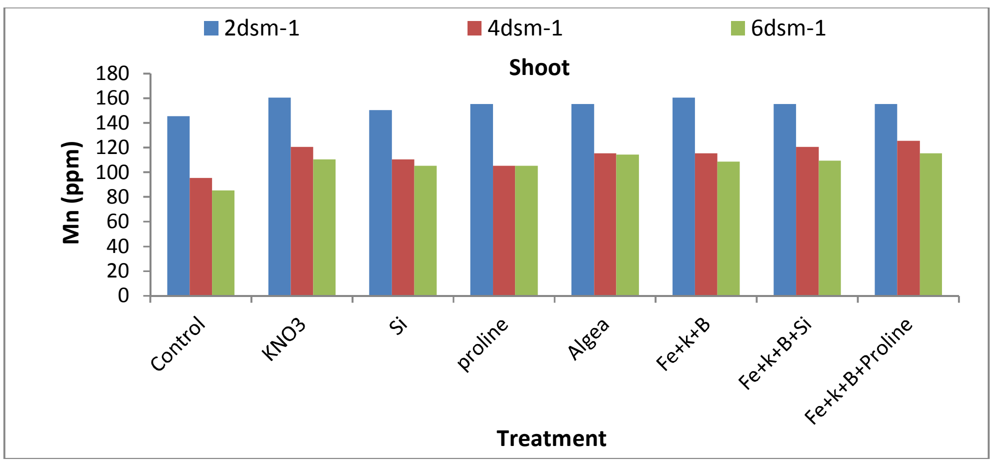

Fig. 11: Effect of some foliar application on Mn content in shoot of tomato plant under saline condition (hydroponic experiment).

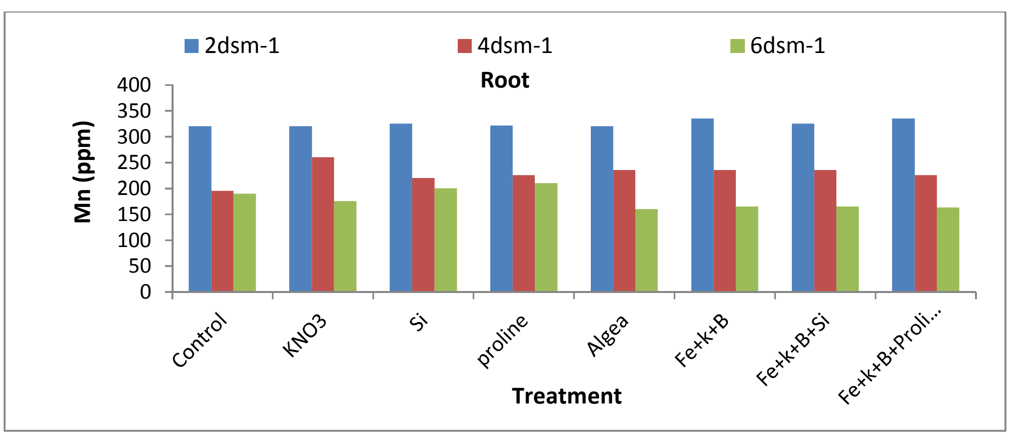

Fig. 12: Effect of some foliar application on Mn content in root of tomato plant under saline condition (hydroponic experiment).

3.2.3. Zinc

Zinc aids the plant's ability to survive low temperatures by assisting in the creation of chlorophyll and certain carbohydrates, as well as the conversion of starches to sugars. Auxins aid in growth control and stem elongation, and zinc is required for their production.

In a hydroponic experiment, the effect of salt levels and varied foliar applications on Zn content in the tomato plant's shoot and root system is shown in Table (8). Like Iron (Fe) and Manganese (Mn) the concentration of Zn decreases with the increase in the level of salinity, and the level of salinity 6dSm^{-1} shows the lowest values of Zn absorbed by tomato plants. The percentage decrease in plant concentration was 11.65% and 26.67% for the shoot system, while the percentage decrease in the root was 13.82% and 26.86% for salinity levels 4 dSm^{-1}and 6 dSm^{-1} compared to salinity concentration 2 dSm^{-1}. Gunes *et al.,* (1999) show that salinity decreased Zn concentrations and Zn uptake of the Pepper plants. Data also show that Zn concentration was higher in root compared with those in shoot this confirmed with the finding of (Tunçturk *et al.,* 2008).

All spray treatments caused a significant increase in the concentration of zinc in tomato plants. The treatments KNO_3 and Fe+K+B+Prol were the highest effective treatments with an increase in the averages equal to 23.57% and 21.81%, respectively. According to Elhindi *et al.,* (2016), Supplied with KNO_3 treatment exhibited considerably improved resistance to salt. The positive effects of all external KNO_3 applications on membrane permeability, photosynthetic activities, relative water content, and nutrient balance and concentration under salinity stress conditions might explain this... The Si treatment and, Proline was the least effective spray treatments on Zn concentration as they effect with an increase of 8.21%and 9.25% respectively.

Table 8: Effect of some foliar application on Zn content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Treatments foliar	Zn (ppm)							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	69.3^{d}	72.3^{k}	57.2^{ef}	58.3^{s}	50.4^{f}	56.5^{u}	58.96^{d}	62.36^{h}
KNO_3	72.3^{cd}	88.5^{a}	73.3^{b-d}	77.4^{f}	61.2^{e}	65.3^{n}	68.93^{ab}	77.06^{a}
Si	77.4^{a-c}	76.5^{g}	68.3^{d}	69.7^{l}	50.5^{f}	56.54^{u}	65.4^{bc}	67.48^{g}
Proline	73.7^{b-d}	81.5^{e}	60.5^{e}	65.8^{m}	51.3^{f}	57.1^{t}	61.83^{cd}	68.13^{f}
Algae	82.1^{a}	85.47^{d}	70.8^{cd}	74.5^{i}	58.47^{e}	59.47^{r}	70.45^{a}	73.14^{e}
Fe+K+B	79.6^{ab}	85.4^{d}	71^{cd}	73.6^{j}	59.1^{e}	61.6^{q}	69.9^{a}	73.53^{d}
Fe+K+B+Si	80^{ab}	86.2^{c}	71.47^{cd}	75.2^{h}	60.6^{e}	63.7^{p}	70.79^{a}	75.03^{c}
Fe+K+B+Prol	82^{a}	87^{b}	72^{cd}	76.5^{g}	60.5^{e}	64.4^{o}	71.5^{a}	75.96^{b}
Mean	77.05^{a}	82.82^{a}	68.07^{b}	71.37^{b}	56.50^{c}	60.57^{c}		
LSD Salinity	2.465	0.101						
LSD treatment	4.025	0.179						
LSD Salinity *treatment	6.972	0.310						

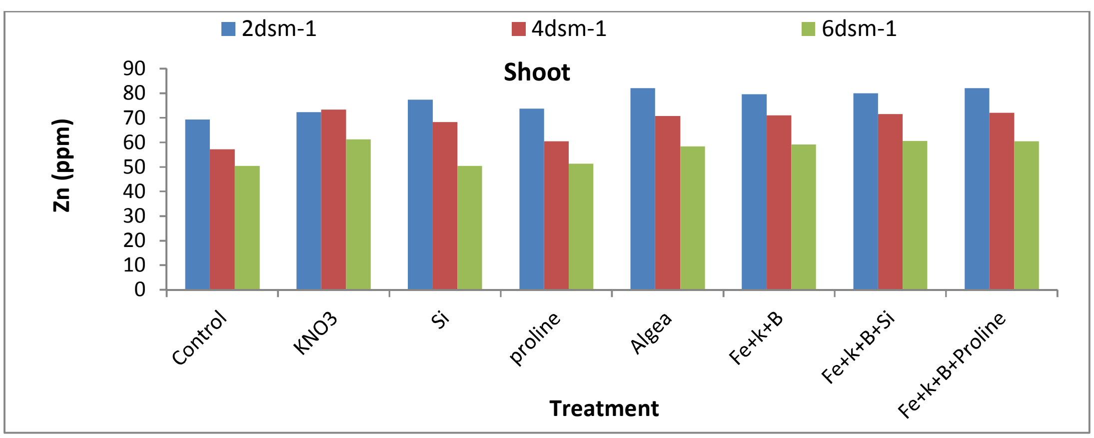

Fig. 13: Effect of some foliar application on Zn content in shoot of tomato plant under saline condition (hydroponic experiment).

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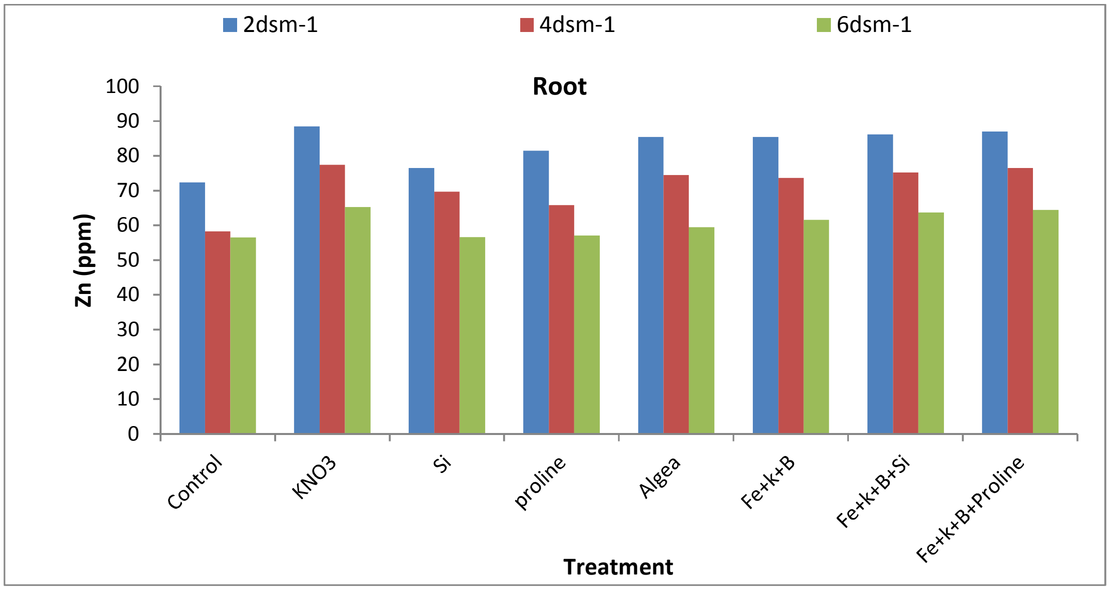

Fig. 14: Effect of some foliar application on Zn content in root of tomato plant under saline condition (hydroponic experiment).

3.2.4. Copper (Cu)

Copper is required in numerous enzyme systems and stimulates several enzymes involved in lignin production in plants. It is also necessary for photosynthesis, vital for plant respiration, and aids in glucose and protein metabolism in plants.

In a hydroponic experiment, the effect of salt levels and varied foliar applications on Cu concentration in the tomato plant's shoot and root system is shown in table (9). Considering the level of salinity 2 dSm^{-1} is the control, there is a gradual decrease in the values of copper concentration with the increase of salinity, where the decline rates were 25 92% and 47.02% for the shoot, while it was 16.84 and 49.89% for the root for salinity ratios 4 dSm^{-1} and 6 dSm^{-1} respectively. Mer *et al.* (2000) reported that Cu, uptake in different organs of plant negatively relate affected with salinity. The results also showed that the concentration of copper in the root was higher than that of the green part, and this confirmed with what (Tunçturk *et al.,* 2008) found.

Table 9: Effect of some foliar application on Cu content in tomato plant (shoot and root) under saline condition (hydroponic experiment).

Treatments foliar	Cu (ppm)							
	Salinity levels							
	2 dSm^{-1}		4 dSm^{-1}		6 dSm^{-1}		Mean	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	9.39^{i}	14.01^{f}	6.32^{r}	8.8^{n}	3.43^{t}	4.84^{u}	6.38^{g}	9.21^{h}
KNO$_3$	14.69^{a}	15.03^{a}	11.99^{f}	13.14^{g}	8.0^{m}	9.04^{m}	11.56^{a}	12.40^{a}
Si	10.61^{g}	14.14^{e}	8.83^{k}	12.21^{k}	6.29r	7.54^{p}	8.58^{e}	11.29^{e}
Proline	10.61^{g}	14.44^{c}	8.52^{l}	11.56^{l}	5.62^{s}	6.7^{t}	8.25^{f}	10.9^{g}
Algae	12.65^{d}	14^{f}	9.64^{h}	12.74h	7.43^{n}	8.17^{o}	9.90^{c}	11.64^{b}
Fe+K+B	12.55^{e}	14.24^{d}	8.86^{k}	12.21^{k}	6.76^{q}	6.92^{s}	9.39^{d}	11.12^{f}
Fe+K+B+Si	13.46^{c}	14.5^{c}	9.34^{i}	12.41^{j}	7.05^{p}	7.13^{r}	9.95^{c}	11.34^{d}
Fe+K+B+Prol	13.88^{b}	14.64^{b}	9.02^{j}	12.54^{i}	7.28^{o}	7.29^{q}	10.06^{b}	11.49^{c}
Mean	12.23	14.37^{a}	9.06^{b}	11.95^{b}	6.48^{c}	7.20^{c}		
LSD Salinity	0.031	0.026						
LSD treatment	0.050	0.042						
LSD Salinity *treatment	0.0873	0.073						

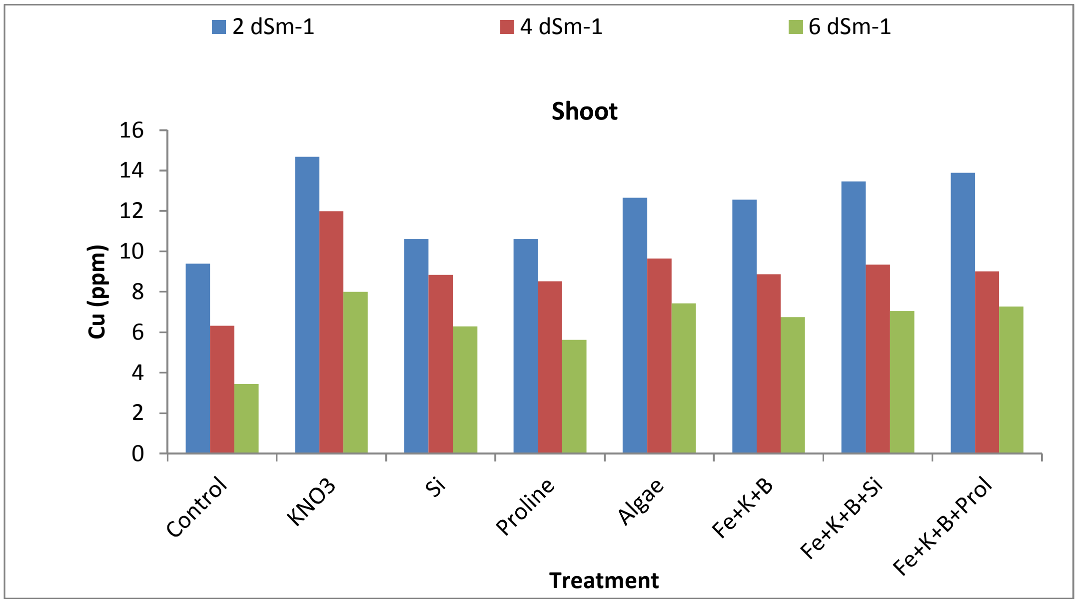

Fig. 15: Effect of some foliar application on Cu content in shoot of tomato plant under saline condition (hydroponic experiment).

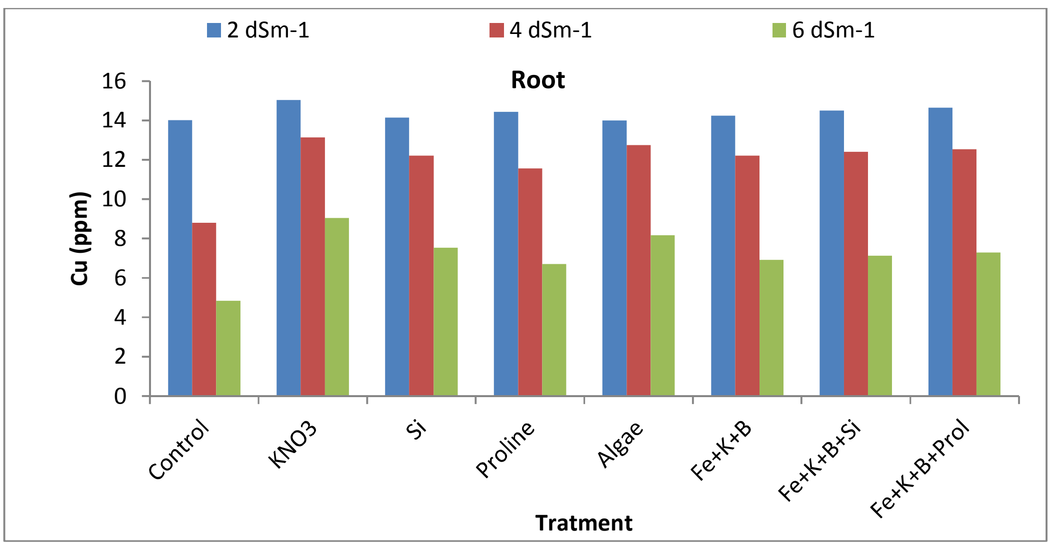

Fig. 16: Effect of some foliar application on Cu content in root of tomato plant under saline condition (hydroponic experiment).

As Zn All spray treatments caused a significant increase in the concentration of cooper in tomato plants. The treatments KNO_3 and Fe+K+B+Prol were the highest effective treatments with an increase in the averages equal to 34.64% and 24.75%, respectively. Supplied with KNO_3 treatment demonstrated considerably improved resistance to salt, according to Elhindi *et al.* (2016). The positive effects of all external KNO_3 administration on membrane permeability, photosynthetic activities, and relative permeability can explain this... The Proline treatment and, Si was the least effective spray treatments on Cu concentration as they effect with an increase of 18.44%and 22.58% respectively.

3.3. Chlorophyll

Chlorophyll is a group of similar green pigments found in cyanobacteria's exosomes and algae's and plants' chloroplasts. The Greek words χλωρός, khloros and φύλλον, phyllon are used to give it its name. Chlorophyll is required for photosynthesis, which allows plants to absorb light energy. The role of chlorophyll in a plant is to absorb light, which is generally sunlight. Light energy is delivered to two different types of energy-storing molecules. Photosynthesis is the process by which a plant converts carbon dioxide (a gas received from the air) and water into glucose, a sugar.

Table (10) shows the influence of varying salinity levels and foliar applications on Chlorophyll content in a tomato plant's shoot system in a hydroponic experiment. The increase of salinity in the growth media of the tomato plant caused a gradual significant decrease in the Chlorophyll concentration, as it gave ratios of 100, 97.27, and 89.73 % for salinity levels 2, 4 and 6 dSm^{-1} in the green part. After salt treatment, Aicha *et al.* (2020) found a significant fall in chlorophyll content index and shoot and root dry weight.

Table 10: Effect of some foliar application on chlorophyll content in tomato leaves under saline condition (hydroponic experiment).

Treatments foliar	Salinity levels			
	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	Mean
	Chlorophyll SPAD	Chlorophyll SPAD	Chlorophyll SPAD	Chlorophyll SPAD
Control	49.19^{d}	46.24^{n}	40.5^{v}	45.31^{h}
KNO_3	51.23^{a}	49.69^{c}	45.46^{q}	48.79^{a}
Si	47.13^{k}	46.83^{l}	43.44^{t}	45.8^{f}
Proline	48.32^{h}	46.43^{m}	41.71^{u}	45.48^{g}
Algae	49.15^{d}	48.69^{f}	44.49^{s}	47.44^{d}
Fe+K+B	48.65^{f}	47.63^{j}	45.65^{p}	47.31^{e}
Fe+K+B+Si	48.91^{e}	48.56^{g}	45.7^{o}	47.72^{c}
Fe+K+B+Prol	50.09^{b}	47.86^{i}	45.4^{r}	47.78^{b}
Mean salinity	49.08^{a}	47.74^{b}	44.04^{c}	
LSD Salinity	0.0153			
LSD treatment	0.0249			
LSD Salinity*treatment	0.0432			

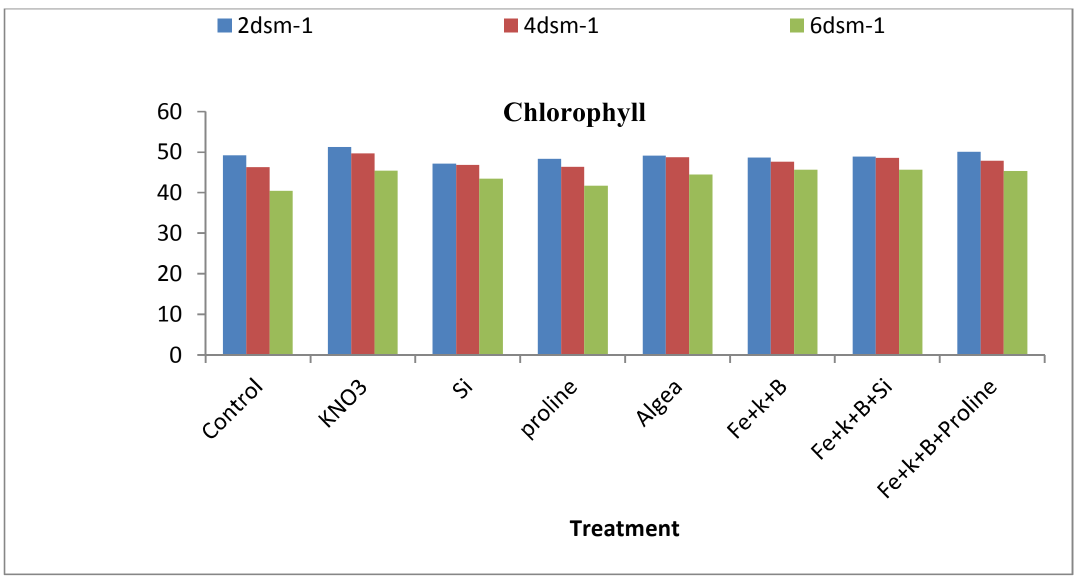

Fig. 17: Effect of some foliar application on chlorophyll content in tomato leaves under saline condition (hydroponic experiment).

All the applied spray treatments showed a significant increase in the average chlorophyll value. The average treatment with potassium nitrate was the best treatment with an increase of 7.68% compared to the control. According to Elhindi (2016), salt stress had a negative impact on growth rate, relative leaf water content, plant protein and chlorophyll content, gas exchange attributes such as net CO2 assimilation rate, transpiration rate, stomatal conductance and substomatal CO_2 concentration, essential oil content, and leaf K^{+}, Mg^{2+}, P, Ca^{2+}, N, and Na^{+} /K^{+} ratio, While it increased electrolyte leakage, plant content of proline and Na^{+}, the researchers found that the foliar application of KNO_3 under saline and control circumstances had a favorable effect on all of the examined parameters.

Supplied with KNO_3 therapy, the animals were much more tolerant to salt. The favorable effects of all external KNO_3 applications on membrane permeability, photosynthetic activities, relative water content, and nutrients balance and concentration under salinity stress conditions might explain this.

The effect of KNO_3 treatment followed by Fe+K+B+Prol foliar treatments with an increase of 5.45%compared to the control, while the treatment with proline was the least effective foliar treatment with an increase of 0.38% compared to the control.

3.4. Evaluation of spray treatment

The (hydroponic experiment) aims to choose the best spraying treatments used to affect the plant under conditions of salinity for application in the field through the estimated botanical characteristics. A numerical method was used to evaluate the sparing treatment and since the number of treatment was 8, the best treatment was given the value 8, each of the treatments graded from the value of 8 until reaching the least influential treatment, which was given the value 1 (Table 11).

Table 11: Evaluation of spray treatments for hydroponic experiment.

Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	∑
Control	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
KNO_3	7	7	6	7	7	8	8	8	8	8	5	8	7	8	4	8	8	8	8	138
Si	6	5	4	3	3	7	4	2	2	2	3	2	2	6	3	2	3	4	3	65
Proline	5	6	3	2	2	4	2	5	5	3	4	4	2	7	2	3	2	2	2	65
Algae	8	7	8	5	5	3	7	7	7	6	2	3	5	2	6	4	5	7	5	109
Fe+K+B	2	2	2	3	4	2	3	6	3	7	6	5	4	5	5	5	4	3	4	75
Fe+K+B+Si	3	3	5	6	8	4	6	3	6	5	7	6	5	4	7	6	6	5	6	101
Fe+K+B+Prol	4	4	7	8	6	4	5	4	4	4	8	7	8	3	8	7	7	6	7	111

Where, the numbers refer to the following:

1	N in shoot	**11**	Fe in shoot
2	N in root	**12**	Fe in root
3	P in shoot	**13**	Mn in shoot
4	P in root	**14**	Mn in root
5	K in shoot	**15**	Zn in shoot
6	K in root	**16**	Zn in root
7	Na in shoot	**17**	Cu in shoot
8	Na in root	**18**	Cu in root
9	K/Na in shoot	**19**	Chlorophyll
10	K/Na in shoot		

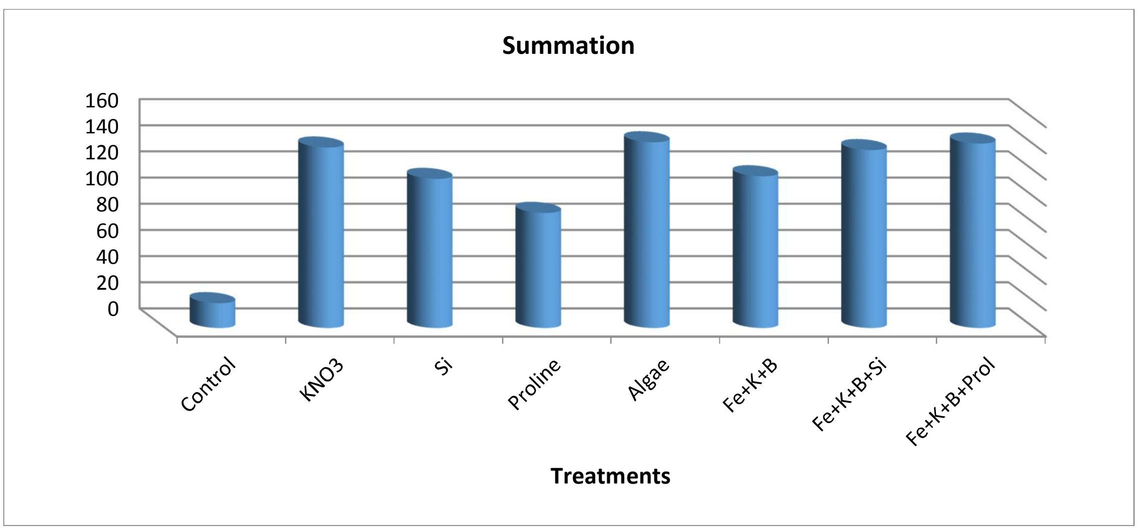

Fig. 18: Evaluation of spray treatments for hydroponic experiment.

It was evident through this evaluation that the best treatments were potassium nitrate, which was given a numerical value of 138, followed by the treatment of Fe+K+B+Prol with a value of 111, then treatment of algae extract with a value of 109, then Fe+K+B+Si with a value of 101 and the treatment with proline and silica were the least effective treatments on plant characteristics with a value of 65.

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