Zagazig J. Agric. Res., Vol. 52 No. (4) 2025 725-734

Plant Production Science

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

UTILIZING NANO-MICRONUTRIENTS AS FOLIAR SPRAY IN AMENDING THE HARMFUL IMPACT OF SALINE WATER IRRIGATION STRESS ON SWEET BASIL (*Ocimum basilicum* L.)

Arwa I. Y. Ibrahim, A. S. H. Gendy and M. A. I. Abdelkader

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

Received: 06/07/2025 ; Accepted: 06/08/2025

ABSTRACT: The current study was done in net greenhouse at Roof of Horticulture Department, Agriculture Faculty, Zagazig University, Egypt during 2022/2023 and 2023/2024 seasons. The main factor was saline water irrigation level at (0.0, 1000, 2000 and 3000 ppm), whereas, the sub factor was nano-micronutrient rate at (0.0, 250 and 500 ppm) beside the combination treatments between the two factors. However, the plant height, branches number per plant, fresh and dry weights per plant, salt resistance index and root system of sweet basil responses were determined. Increasing saline water levels gradually decreased growth and salt resistance index as well root length and fresh and dry weight of roots per sweet basil plant to reach the lowest values with 3000 ppm in the two cuts during both seasons. In contrast, all growth and root system parameters were increased as nano-micronutrient rates increased. Furthermore, the utilizing nano-micronutrients at 500 ppm significantly enhance salt resistance index of sweet basil to reach 129.16 and 135.83 % without salinity stress, 115.39 and 126.76 % with 1000 ppm of saline water level and 101.82 and 115.14 % with 2000 ppm of saline water level. In general, it is preferable to utilize micronutrients as nano-particle to decrease a harmful impact of saline water irrigation on the growth and root system of sweet basil plants.

Key words: *Ocimum basilicum*, Saline water, nano-micronutrients, growth, root system.

INTRODUCTION

One economically important herb plant that is produced in Egypt for commercial export is sweet basil (*Ocimum basilicum* L.). Sweet basil is an annual herb that is produced for its very scented leaves, which are either dried and exported or utilized to extract essential oils through steam distillation. Also, the oil is used to flavor mouthwashes, dental treatments, condiments, food and confections (**Madkour *et al*., 2003**). Sweet basil is widely grown around the globe but prevalently noticed in Africa, tropical Asia, South America and Central America (**Paton, 1999**). Ocimum species are rich in phenolic chemicals, which make them a popular therapeutic herb (**Nahak *et al*., 2011**). Sweet basil is also a good donor of vitamins, particularly A and B as well as several minerals such as Mg, Mn and Fe. The **Statistics of the Ministry of Agriculture (2024)** showed that 1,193 feddan of dried *Ocimum basilicum* were grown in Egypt in 2023/2024 (1,158 feddan on newly reclaimed land and 35 feddan on old agricultural land). At an average of 19.747 tons/feddan (19.842 tons/feddan in new reclaimed land and 16.600 tons/feddan in old agricultural land), 23,558 tons were produced (22.977 tons from new reclaimed land and 581 tons from old agricultural land).

Egypt has a limited supply of conventional and non-conventional water resources, and plants should be grown in low-quality water, such as saline water (**Djuma *et al*., 2016**). However, saline environments reduce the plant growth by increasing soil osmotic pressure and negatively affecting plant nutrition (**Huang *et al*., 2019**). Therefore, it is crucial to create management strategies for using low-quality water in agriculture without reducing crop

*** Corresponding author: Tel. :**+ 01007506991
E-mail address: arwaelgaly123@gmail.com

yields significantly (**Singh *et al*., 2021**). Plant height, branch number, and fresh and dry weight of sweet basil plant were all decreased by 10, 31, 46 and 33%, respectively, when irrigated with 5 dS/m saline water as compared to fresh water (**Fekri *et al*., 2024**). Moreover, **Abdelhamed *et al*. (2025)** they observed that as salinity levels increased, there was a substantial decrease in the number of branches per sweet basil plant, plant height, fresh and dry herb weights per plant, and salt resistance index.

Even though micronutrients can be added to the nutrition as mineral salts, it is important to comprehend how the amount of micronutrients in forage changes with phonological evolution in order to optimize feed additions and supply regimes. It is commonly known that as plants mature and grow, their dry matter increases and their crude protein concentration and energy decreases (**Beever *et al*., 2000**). In times of stress, this approach is helpful and economical. Abiotic stress tolerance is higher in plants that are well nourished with micronutrients (**Hasanuzzaman *et al*., 2018**). In addition, **Abdelsadek (2020)** he reported that utilizing 0.50 and 1.00 g/l of nano-micronutrients, shown a consistent effect in reducing the inhibition of seashore paspalum growth and its quality under low salinity stress (8000 ppm) conditions while also enhancing the salt resistance trait index of *Paspalum vaginatum* plants.

The present study was intended to evaluate whether the adverse effects of saline water irrigation on *Ocimum basilicum* growth, salt resistance index and root system could be mitigated by Magro Nano Mix foliar spray as a source of micronutrients.

MATERIALS AND METHODS

In the two winter seasons of 2022–2023 and 2023–2024, a pot experiment was conducted on the roof of the Horticulture Department Building in a net greenhouse at Zagazig University's Faculty of Agriculture in Egypt. The purpose of this study was to examine the impact of various irrigation levels of saline water (0.0, 1000, 2000, and 3000 ppm), rates of nano-micronutrient (0.0, 250, and 500 ppm) and their combinations on the root system, plant growth and salt resistance index (SRI) of the sweet basil plant (*Ocimum basilicum* L). There were six pots in the experimental unit. Five kg of clay soil (containing 46.82 percent clay, 25.73 percent silt, and 27.45% sand) were placed in pots measuring 25 cm in diameter. The soil was irrigated once a week using a conventional nutrient solution that alternated with tap water and varying amounts of saline water. Table 1 shows the electrical conductivity (EC), pH, and cation and anion concentrations of soil used for filling pots and saline water irrigation salts, per **Chapman and Pratt (1978)**.

Plant Cultivation

We purchased sweet basil seedlings from Mustafa Abo-Eisa Nursery in the Sharkia Governorate of Egypt's Belbas District. Seedlings from both seasons were placed in experimental pots as one seedling per pot on November 2. To construct the four levels of artificial seawater, known weights of the natural salt crust of saltwater were dissolved in tap water. To preserve soil moisture levels between 65 and 70 percent of field capacity, plants were irrigated once a week with varying concentrations of salt water and once a week with tap water.

These nano-micronutrients, marketed as Magro NanoMix, were purchased from Modern Agricide Company (MAC). They include the following minerals: Fe (6%), Zn (6%), B (2%), Mn (5%), Cu (1%) and Mo (0.1%), together with 4 percent citric acid. However, at 25, 55, 85, 125, and 155 days following the date of planting, sweet basil plants received five foliar sprays of varying rates of nano-micronutrients. There were twelve different treatments that interacted with the saline water irrigation level and the rates of nano-micronutrients. Every suggested agricultural method for cultivating sweet basil plants was followed when necessary.

Design of Experiment

This experiment was conducted using a split-plot design. The main plots were irrigated with four different concentrations of saline water. The subplots had three different rates of nano-micronutrients. The experiment included combinations of varying concentrations of saline water irrigation and varying rates of nano-micronutrients. There were three duplicates of each therapy. There were six pots in each replication.

Table 1. Electrical conductivity (EC), pH, and the concentration of cations and anions of the salt extract and in the soil used in the pot experiment

Parameter	EC (mmhos/cm)	pH	Cations (meq/l)				Anions (meq/l)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	SO_4^{--}	Cl^{-}
Soil clay	0.84	7.82	13.10	5.45	2.45	18.65	3.00	2.72	4.98
Salt extract at (5:1)	158.4	7.63	11.32	9.84	1612.64	1.98	7.60	79.29	1582.48

Recorded data

The aerial parts of each sweet basil plant were trimmed five centimeters above the soil surface twice a year in both seasons. In both seasons, the two cuts were made on January 31 and April 30. Plant height (cm), number of branches/plant, fresh and dry weights of herbs/plant (g), and root system characteristics (root length and diameter as well as fresh and dry weights of roots per plant) were all measured at the time of harvest. Additionally, the calculation previously indicated by **Wu and Huff (1983)** was used to generate the salt resistance index, or SRI (%), as a true indication for salinity tolerance: SRI (%) = Mean herb fresh weight of the salt-treated plants/mean herb fresh weight of control one × 100.

Statistical Analysis

According to **Gomez and Gomez (1984)**, the analysis of variance (ANOVA) approach was used to examine all of the data that was gathered. The means were compared using the Statistix version 9 software (**Analytical software, 2008**). The least significant differences (LSD) were used to compare the differences between means.

RESULTS AND DISCUSSION

Plant Growth

Data of both seasons in Tables 2, 3, 4 and 5 reveal that, using saline water irrigation treatments at high levels (2000 and 3000 ppm) significantly decreased plant height and number of branches per sweet basil plant as well as fresh and dry herb weights per plant in both cuts during both seasons compared to the lowest level as well as control. However, the highest values of sweet basil growth traits were achieved with control (irrigated with tap water). In general, increasing saline water irrigation levels gradually decreased all growth traits of sweet basil plants in the two cuts during the two seasons. The inhibition of photosynthesis, the induction of growth supervisor, the reduction of leaf area (**Kashem *et al*., 2000**), the protein content of the leaf (**Farouk *et al.*, 2012**), and the decreased capacity to supply and utilize assimilates/photosynthates are the reasons why salinity has a detrimental effect on plant development and growth rate. Likewise, **Fatemi and Aboutalebi (2012)**, **Elhindi *et al*. (2017), Shehata and Nosir (2019)** and **Abdelhamed *et al*. (2025)** they reported similar results.

Tables 2, 3, 4, and 5 show that during both cuts in the two successive seasons, as nano-micronutrients increase, plant height, the number of branches per sweet basil plant and the fresh and dried weights per plant were enhanced. Furthermore, in both cuts in two seasons, the highest rate of nano-micronutrients (500 ppm) produced the highest values in *Ocimum basilicum*'s vegetative growth traits when compared to the control and the lowest two under investigation. These results may be attributed to the fact that nano-fertilizers make it easier for plants to consume nutrients, which speeds up photosynthesis and the formation of dry matter while also improving vegetative development (**Hediat, 2012**). **Abdel-kader *et al*. (2014)** on lemongrass and **Ahmed and Abdelkader (2020)** on chilli plants indicated similar results.

Data listed in Tables 2, 3, 4 and 5 reveal that, all combination between saline water irrigation levels (2000 and 3000 ppm) and nano-micronutrients treatments significantly decreased vegetative growth traits of sweet basil plants in both cuts in both seasons. Moreover, the control plants which sprayed at any rate with nano-micronutrients resulted in the highest values of plant height, number of branches and total herb fresh and dry weights/plant of sweet basil compared to the other interaction treatments under study. Also, as mentioned above, nano-micronutrients enhanced vegetative growth parameters of sweet basil grasses, in turn; they together under salinity conditions might maximize their effects leading to taller, more branches and heaviest herb per plant. In addition, Abdelsadek (2020) found that foliar spraying with nano-micronutrients made stimulatory effects on seashore paspalum growth parameters under salinization treatments.

Salt resistance index and root system traits

In contrast to the high saline water irrigation levels under investigation in both seasons, the control plants exhibited the highest values of sweet basil root length and diameter as well as root fresh and dry weights per plant, as indicated by the results presented in Tables 6, 7, and 8. According to scientific consensus, plants that have a 50% salinity resistance index are tolerant of salinity and can be grown in saline soils at these concentrations. Over time, the control treatment which (sprayed with tap water), 1000, and 2000 ppm levels were the most effective treatments in raising the salt resistance index. Generally, over both seasons, rising saline water irrigation levels significantly reduced the salt resistance index and root system characteristics. Furthermore, **Roy and Chakraborty (2014)** stated that the salt-tolerant grasses can withstand increasing salt stress by employing various techniques, such as the vacuolization of toxic Na^+ and Cl^- in ripe or senescing leaves, the secretion of unnecessary salts by salt glands, the accumulation of proline and glycine betaine as osmolytes, and the scavenging of reactive oxygen species by anti-oxidative enzymes. These results are in line with those stated by **Elhindi *et al*. (2017)**, **Shehata and Nosir (2019)** and **Abdelhamed *et al*. (2025)** on sweet basil.

Tables 6, 7 and 8 show that when the rates of nano-micronutrients grew in both cuts over both seasons, the percentage of the salt resistance index, the length, diameter, and fresh and dried weights of the roots of sweet basil all increased progressively. When compared to the control treatment (sprayed with tap water) and the lowest one (250 ppm) under investigation, the use of 500 ppm nano-micronutrients as foliar spray significantly improved the salt resistance index and root system characteristics. The importance of micronutrients is demonstrated by their ability to stimulate photosynthesis and, consequently, their beneficial influences on root development (**Hänsch and Mendel, 2009**). Furthermore, it should be noted that the notable improvement in the sweet basil salt resistance index by using nano-micronutrients is directly related to the beneficial effect on the plant's vegetative growth, which led to an increase in the metabolites produced for root growth and, ultimately, an increase in the resistance to saline water irrigation.

As a result of the interaction treatments between saline water stress and nano-micronutrients, the data presented in Tables 6, 7, and 8 indicate that the salt resistance index, root length, root diameter, and fresh and dry weights of *Ocimum basilicum* recorded a trend that was more or less similar to vegetation growth. Also, the best interaction treatment, when compared to the other interactions between saline water levels and nano-micronutrient rates under research in both seasons, was 0.0 ppm of saline water irrigation and 500 ppm of nano-micronutrients. In this regard, the detrimental effects of soil salinity stress were often lessened when nano-micronutrients were used at the maximum rate. In addition, **Noreen *et al*. (2018)** they found that micronutrient administration improved crop tolerance to abiotic stressors and net photosynthetic rate. Also, **Tolay (2021)** stated that Zn application could enhance the salinity tolerance of basil.

CONCLUSION

According to the results, it is better to spray nano-micronutrients at 500 ppm to *Ocimum basilicum* plants under salty water irrigation settings in order to improve the growth of the sweet basil, the salt resistance index and the root system in Sharkia Governorate conditions.

Table 2. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on plant height (cm) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	First season							
	First cut				Second cut			
Control	51.33	56.67	62.33	**56.78**	42.67	46.67	51.00	**46.78**
1000	49.00	52.33	61.00	**54.11**	38.33	42.67	47.78	**42.89**
2000	44.00	51.33	57.67	**51.00**	40.33	44.00	47.33	**43.89**
3000	32.67	43.00	49.00	**41.56**	37.33	38.67	40.33	**38.78**
Mean (N)	**44.25**	**50.83**	**57.50**		**39.67**	**43.00**	**46.58**	
L.S.D. at 5%	**(S)= 2.13**	**(N)= 1.12**	**(SN)= 2.80**		**(S)= 1.68**	**(N)= 0.93**	**(SN)= 2.26**	
	Second season							
	First cut				Second cut			
Control	50.00	55.33	78.00	**61.11**	33.00	45.33	48.67	**42.33**
1000	50.67	53.33	71.33	**58.44**	36.00	42.67	45.67	**41.44**
2000	48.00	56.00	68.33	**57.44**	38.67	43.33	52.67	**44.89**
3000	44.00	50.33	55.00	**49.78**	33.33	36.00	41.33	**36.89**
Mean (N)	**48.17**	**53.75**	**68.17**		**35.25**	**41.83**	**47.08**	
L.S.D. at 5%	**(S)= 3.37**	**(N)= 1.84**	**(SN)= 4.50**		**(S)= 0.60**	**(N)= 0.95**	**(SN)= 1.66**	

Table 3. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on number of branches per plant of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	First season							
	First cut				Second cut			
Control	8.33	9.67	11.00	**9.67**	14.33	15.67	18.67	**16.22**
1000	7.00	10.00	12.00	**9.67**	16.67	17.00	19.67	**17.78**
2000	5.67	7.67	10.33	**7.89**	10.33	13.67	17.67	**13.89**
3000	4.67	6.67	8.00	**6.44**	10.00	13.67	17.33	**13.67**
Mean (N)	**6.42**	**8.50**	**10.33**		**12.83**	**15.00**	**18.33**	
L.S.D. at 5%	**(S)= 0.71**	**(N)= 0.62**	**(SN)= 1.23**		**(S)= 2.47**	**(N)=1.10**	**(SN)= 3.05**	
	Second season							
	First cut				Second cut			
Control	6.00	8.33	11.00	**8.44**	11.00	15.67	19.00	**15.22**
1000	9.00	10.67	11.33	**10.33**	16.00	19.00	21.00	**18.67**
2000	6.00	7.67	9.67	**7.78**	11.33	14.67	16.67	**14.22**
3000	5.67	7.33	8.67	**7.22**	11.67	14.67	18.67	**15.00**
Mean (N)	**6.67**	**8.50**	**10.17**		**12.50**	**16.00**	**18.83**	
L.S.D. at 5%	**(S)= 0.71**	**(N)= 0.31**	**(SN)= 0.87**		**(S)= 1.13**	**(N)= 0.83**	**(SN)= 1.76**	

Table 4. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on fresh weight of herb per plant (g) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	First season							
	First cut				**Second cut**			
Control	27.77	34.57	38.67	**33.67**	41.73	44.97	51.10	**45.93**
1000	26.73	33.43	34.33	**31.50**	43.53	42.80	45.87	**44.07**
2000	24.53	30.43	28.50	**27.82**	36.60	39.90	42.27	**39.59**
3000	16.10	24.70	28.93	**23.24**	34.57	38.70	41.13	**38.13**
Mean (N)	**23.78**	**30.78**	**32.61**		**39.11**	**41.59**	**45.09**	
L.S.D. at 5%	**(S)= 1.63**	**(N)= 1.31**	**(SN)= 2.69**		**(S)= 1.97**	**(N)= 0.50**	**(SN)= 2.13**	
	Second season							
	First cut				**Second cut**			
Control	34.03	38.50	52.40	**41.64**	37.97	42.73	45.40	**42.03**
1000	25.20	40.67	47.47	**37.78**	35.70	36.33	43.80	**38.61**
2000	25.00	30.43	41.30	**32.44**	33.43	37.10	41.60	**37.38**
3000	21.63	25.33	31.33	**26.10**	30.53	31.77	40.53	**34.28**
Mean (N)	**26.47**	**33.73**	**43.13**		**34.41**	**36.98**	**42.83**	
L.S.D. at 5%	**(S)= 0.99**	**(N)= 1.04**	**(SN)= 1.96**		**(S)= 0.82**	**(N)= 0.45**	**(SN)= 1.10**	

Table 5. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on dry weight of herb per plant (g) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	First season							
	First cut				**Second cut**			
Control	5.33	6.37	7.27	**6.32**	6.87	7.77	11.30	**8.64**
1000	4.90	6.10	6.80	**5.93**	9.10	8.43	10.13	**9.22**
2000	4.47	5.77	4.70	**4.98**	6.87	7.40	7.80	**7.36**
3000	2.67	4.40	5.30	**4.12**	6.00	6.07	7.30	**6.46**
Mean (N)	**4.34**	**5.66**	**6.02**		**7.21**	**7.42**	**9.13**	
L.S.D. at 5%	**(S)= 0.29**	**(N)= 0.20**	**(SN)= 0.43**		**(S)= 0.41**	**(N)= 0.36**	**(SN)= 0.72**	
	Second season							
	First cut				**Second cut**			
Control	5.70	6.57	11.37	**7.88**	7.57	8.67	10.37	**8.87**
1000	5.23	7.13	8.23	**6.87**	6.27	6.97	8.00	**7.08**
2000	4.13	5.17	6.33	**5.21**	5.07	5.73	6.67	**5.82**
3000	3.80	4.30	5.17	**4.42**	4.67	5.23	5.97	**5.29**
Mean (N)	**4.72**	**5.79**	**7.78**		**5.89**	**6.65**	**7.75**	
L.S.D. at 5%	**(S)= 0.41**	**(N)= 0.43**	**(SN)= 0.82**		**(S)= 0.40**	**(N)= 0.20**	**(SN)= 0.52**	

Table 6. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on salt resistance index (%) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	Salt resistance index (%)							
	First season				Second season			
Control	100.00	114.44	129.16	**114.53**	100.00	112.82	135.83	**116.22**
1000	101.10	109.69	115.39	**108.73**	84.58	106.95	126.76	**106.10**
2000	87.96	101.20	101.82	**96.99**	81.16	93.80	115.14	**96.70**
3000	72.90	91.22	100.81	**88.31**	72.45	79.30	99.81	**83.86**
Mean (N)	**90.49**	**104.14**	**111.80**		**84.55**	**98.22**	**119.39**	
L.S.D. at 5%	**(S)= 2.54**	**(N)= 2.14**	**(SN)= 4.31**		**(S)= 2.21**	**(N)= 1.56**	**(SN)= 3.36**	

Table 7. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on root length (cm) and diameter (cm) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	Root length (cm)							
	First season				Second season			
Control	23.00	33.00	51.00	**35.67**	35.33	38.67	44.33	**39.44**
1000	35.00	44.67	46.67	**42.11**	31.00	35.00	46.67	**37.56**
2000	23.00	32.67	37.67	**31.11**	17.67	28.33	32.33	**26.11**
3000	17.00	21.33	33.00	**23.78**	16.67	20.67	31.00	**22.78**
Mean (N)	**24.50**	**32.92**	**42.08**		**25.17**	**30.67**	**38.58**	
L.S.D. at 5%	**(S)= 1.29**	**(N)= 0.93**	**(SN)= 1.99**		**(S)= 1.50**	**(N)= 1.07**	**(SN)= 2.30**	
	Root diameter (cm)							
	First season				Second season			
Control	0.85	0.91	1.10	**0.95**	0.88	1.01	1.18	**1.02**
1000	0.77	0.84	0.99	**0.87**	0.69	0.89	0.98	**0.85**
2000	0.69	0.80	0.99	**0.83**	0.65	0.74	1.08	**0.82**
3000	0.67	0.84	1.11	**0.87**	0.69	0.75	1.13	**0.86**
Mean (N)	**0.75**	**0.85**	**1.05**		**0.73**	**0.85**	**1.09**	
L.S.D. at 5%	**(S)= 0.05**	**(N)= 0.04**	**(SN)= 0.08**		**(S)= 0.09**	**(N)= 0.03**	**(SN)= 0.10**	

Table 8. Impact of saline water irrigation concentration (S), Nano-micronutrients concentration (N) and their combinations (S×N) on root fresh and dry weights per plant (g) of sweet basil during 2023/2024 and 2024/2025 seasons

Saline water concentration (ppm)	Nano-micronutrients concentration (ppm)							
	0.0	250	500	Mean (S)	0.0	250	500	Mean (S)
	Root fresh weight per plant (g)							
	First season				Second season			
Control	15.40	25.70	30.27	**23.79**	22.20	25.70	31.30	**26.40**
1000	25.70	29.70	35.00	**30.13**	24.93	38.47	42.93	**35.44**
2000	17.10	22.67	30.37	**23.38**	21.77	32.93	35.40	**30.03**
3000	9.73	15.50	24.30	**16.51**	7.90	13.77	21.10	**14.26**
Mean (N)	**16.98**	**23.39**	**29.98**		**19.20**	**27.72**	**32.68**	
L.S.D. at 5%	(S)= 1.12	(N)= 0.79	(SN)= 1.71		(S)= 1.72	(N)= 1.00	(SN)= 2.36	
	Root dry weight per plant (g)							
	First season				Second season			
Control	5.07	7.00	8.87	**6.98**	5.97	7.40	9.80	**7.72**
1000	7.07	9.10	10.07	**8.74**	7.40	9.80	12.10	**9.77**
2000	5.10	5.47	7.47	**6.01**	7.10	9.23	10.10	**8.81**
3000	2.93	4.53	5.57	**4.34**	2.57	4.27	6.40	**4.41**
Mean (N)	**5.04**	**6.53**	**7.99**		**5.76**	**7.68**	**9.60**	
L.S.D. at 5%	(S)= 0.20	(N)= 0.20	(SN)= 0.38		(S)= 0.37	(N)= 0.19	(SN)= 0.47	

REFERENCES

Abdelhamed, A. M., A. S. H. Gendy and M. A. I. Abdelkader (2025). Variation in growth and salt resistance index of sweet basil (*Ocimum basilicum* L.) under foliar application of *Spirulina* extract and saline water irrigation stress. Zagazig Journal of Agricultural Research, 52(2): 285-293.

Abdel-kader, H.H., S. M. A. El-Gamal, A. M. Hamza. H. Y. Massoud and F. K. Youssef (2014). Effect of irrigation intervals and foliar fertilization on lemongrass (*Cymbopogon citratus* (DC.) Stapf) plant: A-Effects on yield and essential oil production and constituents. J. Plant Production, Mansoura Univ., 5 (9): 1505-1522.

Abdelsadek, O. A. (2020). Improving growth and quality of seashore paspalum by nano-micronutrients under soil salinity stress. Journal of Plant Production, 11(10): 991-996.

Ahmed M. A. and M. A. I. Abdelkader (2020). Enhancing growth, yield components and chemical constituents of chilli (*Capsicum annuum* L.) plants by using different NPK fertilization levels and nano-micronutrients rates. Asian Journal of Soil Science and Plant Nutrition, 6 (2): 17-29.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Chapman H. and P. Pratt (1978). Methods of Analysis for Soils, Plants and Waters. Div. Agric., Sci. Univ. Calif. USA, 16-38.

Djuma, H., A. Bruggeman, M. Eliades and M.A. Lange (2016). Non-conventional water resources research in semiarid countries of the Middle East. Desalin Water Treat, 57: 2290–2303.

Elhindi, K. M., A. Sharaf El-Din and A. M. Elgorban (2017). The impact of arbuscular mycorrhizal fungi in mitigating salt-induced adverse effects in sweet basil (*Ocimum* *basilicum* L.). Saudi Journal of Biological Sciences, 24: 170–179.

Farouk, S., Youssef, S. A. and A. A. Ali (2012). Induction of systemic resistance in tomato against *Alternaria solani* by biostimulants and vitamins. Alex. J. Agric. Res., 57 (1): 117-129.

Fatemi, R. and A. Aboutalebi (2012). Evaluation the interaction of salinity and salicylic acid on Sweet basil (*Ocimum basilicum*) properties. Annals of Biological Research, 3 (11):5106-5109.

Fekri, M. O., H. H. Gomah and M. A. Eissa (2024). Growth improvement of sweet basil (*Ocimum basilicum* L.) irrigated with saline water using biochar and *Spirulina* algae extract. Assiut Journal of Agricultural Sciences, 55(2): 260-275.

Gomez, N. K. and A. A. Gomez (1984). Statical Procedures for Agricultural Research. 2nd Ed., John wiley and sons, New York. USA, 680.

Hänsch, R. and R. Mendel (2009). Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B and Cl). Curr. Opin. Plant Biol., 12 (3):259–266.

Huang, M., Z. Zhang, Y. Zhai, P. Lu and C. Zhu (2019). Effect of straw biochar on soil properties and wheat production under saline water irrigation. Agronomy, 9(8): 457.

Kashem, M. A., N. Sultana, T. Ikeda, H. Hori, T. Loboda and T. Mitsui (2000). Alteration of starch-sucrose transition in germinating wheat seed under sodium chloride salinity. J. Plant Biol., 43:121-127.

Madkour, H., T. T. Mahgoub and R. A. Drar (2003). The effect of some macro and micronutrients on yield and oil yield of sweet basil grown in sandy soils. Journal of Soil Sciences and Agricultural Engineering, 28(1): 617-628.

Nahak, G., R. K. Sahu and R. C.Misra (2011). Phytochemical investigation and in vitro antioxidant evaluation of some Ocimum species. Journal of Pharmacy Research, 4 (7): 2340-2343.

Noreen, S., Z. Fatima, S. Ahmad, H. Athar and M. Ashraf (2018). Foliar application of micronutrients in mitigating abiotic stress in crop plants. Plant Nutrients and Abiotic Stress Tolerance, 6 (2): 95-117.

Paton, A., M.R. Harley and M. M. Harley (1999). *Ocimum*: an overview of classification and relationships". Published by license under the Harwood Academic Publishers imprint, part of the Gordon and Breach Publishing Group. Amsterdam: OPA (Overseas Publishers Association) N.V.38.

Roy, S. and U. Chakraborty (2014). Salt tolerance mechanisms in salt tolerant grasses (STGs) and their prospects in cereal crop improvement. Botanical Studies, 55 (1):1-9.

Shehata, A. M. and W. S. E. Nosir (2019). Response of sweet basil plants (*Ocimum basilicum*, L.) grown under salinity stress to spraying seaweed extract. The Future Journal of Biology, 2 (1):16-28.

Singh, G., M.S. Mavi, O.P. Choudhary, N. Gupta and Y. Singh (2021). Rice straw biochar application to soil irrigated with saline water in a cotton-wheat system improves crop performance and soil functionality in north-west India. Journal of Environmental Management, 295: 113-127.

Statistics of the Ministry of Agriculture (2024). Statistics of vegetable, field, medicinal and aromatic crops production in Egypt, Pages, 1-154.

Tolay, I. (2021). The impact of different zinc (Zn) levels on growth and nutrient uptake of basil (*Ocimum basilicum* L.) grown under salinity stress. Plosone, 16 (2): 1-12.

Wu, L. and D. R. Huff (1983). Characteristics of creeping bentgrass clones (*Agrostis stolonifera*, L.) from a salinity-tolerant population after surviving drought stress. HortScience, 18(6): 883-885.

استخدام العناصر الصغرى النانوية رشا على الأوراق في تقليل التأثير الضار لإجهاد الري بالمياه المالحة على الريحان الحلو

أروى إبراهيم يونس إبراهيم - أحمد شاكر حسين جندي- محمد أحمد إبراهيم عبد القادر

قسم البساتين – كلية الزراعة – جامعة الزقازيق – مصر

أجريت الدراسة الحالية في صوبة شبكية على سطح قسم البساتين، كلية الزراعة، جامعة الزقازيق، مصر خلال موسمي 2023/2022 و2024/2023. كان العامل الرئيسي هو مستوى الري بالمياه المالحة (صفر، 1000، 2000 و3000 جزء في المليون)، بينما كان العامل الثاني هو معدل العناصر الصغرى النانوية (صفر، 250 و500 جزء في المليون) إلى جانب معاملات التداخل بين عاملي الدراسة. تم قياس ارتفاع النبات وعدد الأفرع لكل نبات والوزن الطازج والجاف لكل نبات وتقدير مؤشر مقاومة الملوحة واستجابات المجموع الجذرى للريحان الحلو. أدت زيادة مستويات الري بالمياه المالحة تدريجيًا إلى انخفاض النمو ومؤشر مقاومة الملوحة وكذلك طول الجذر والوزن الطازج والجاف للجذور لكل نبات وصولاً إلى أدنى القيم عند تركيز ملوحة 3000 جزء في المليون في الحشتين خلال كلا الموسمين. على النقيض، زادت جميع صفات النمو والمجموع الجذري مع زيادة معدلات العناصر الصغرى النانوية. أدى الرش بالعناصر الصغرى النانوية بمعدل 500 جزء في المليون إلى تحسين مؤشر مقاومة الريحان الحلو للملوحة معنوياً، ليصل إلى 129.16 و135.83% دون التعرض للإجهاد الملحي، و115.39 و126.76% عند مستوى 1000 جزء في المليون من الماء المالح، و101.82 و115.14% عند مستوى 2000 جزء في المليون من الماء المالح. عموماً، يُفضل استخدام العناصر الصغرى في صورة نانوية لتقليل التأثير الضار للري بالمياه المالحة على النمو والمجموع الجذري لنباتات الريحان الحلو..

المحكمــــون:

1- أ.د. وليد صبري السيد إبراهيم نصير أستاذ نباتات الزينة والطبية والعطرية قسم البساتين كلية الزراعة جامعة الزقازيق.

2- أ.د. يــاسـر عبد الفتــاح غطــاس أستاذ نباتات الزينة والطبية والعطرية قسم البساتين كلية الزراعة بمشتهر جامعة بنها.