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Improving Growth and Quality of Seashore Paspalum By Nano - Micronutrients under Soil Salinity Stress

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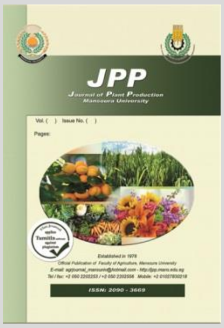

ABSTRACT

In order to evaluate the role of nano-micronutrients (at different rates: 0.0, 0.25, 0.50 and 1.00 g/l) on counteracting the harmful influence of soil salinity (at different levels: 0.0, 8000, 16000 and 24000 ppm) on growth, quality, salt tolerance trait percentage and total chlorophyll content of seashore paspalum, a pot experiment was conducted at Ornamental Nursery, Fac. Agric., Zagazig Univ., Egypt, during the two consecutive winter seasons of 2018/2019 and 2019/2020. The investigations were performed in a split-plot in complete randomized block design with three replications. Plastic pots in 40 cm diameter filled with 8 kg of sand and clay mixture (1:2, *V/V*) were utilized. Results referred to that using soil salinity at high level (24000 ppm) decreased growth characters (plant height, covering density %, herb fresh and dry weights per pot), root system (fresh and dry weights of roots/pot and root length), salt tolerance trait percentage and total chlorophyll content compared to control. While, proline content in leaves was increasing with increasing soil salinity levels to rich the highest values with 24000 and 16000 ppm, respectively. However, the highest values in abovementioned characters of (*Paspalum vaginatum*, Swartz) were noticed by nano-micronutrients at 0.50 and 1.00 g/l rates compared to control (sprayed by tap water) in both seasons. Generally, it could recommend that using 0.50 and 1.00 g/l of nano-micronutrients, showed a uniform effect in alleviating of seashore paspalum growth inhibition and its quality under low salinity stress (8000 ppm) condition with increasing in salt tolerance trait index.

Keywords: *Paspalum vaginatum*, Salinity, Nano-micronutrients, Growth, Quality, Chlorophyll, proline.

INTRODUCTION

Seashore paspalum (*Paspalum vaginatum*, Swartz), an important multidisciplinary turf grasses with major used in the creation of green landscapes for private and public gardens mainly and it is a necessary environmental and aesthetic requirement. Huang *et al.* (1997) and Trenholm *et al.* (1999) reported that seashore paspalum is a succulent warm-season turf type grass that belongs to of Gramineae family. It has noticed superior salt tolerance compared to other turf grasses (Lee, 2000 and Shahba, 2010).

Salinity is one of the primary a biotic agents negatively influencing plant growth and quality all overhead the world (Koca *et al.*, 2007). Al-Karaki *et al.* (2001) pointed out that high rise salt levels in soil minimizes the plant capacity to harmfully impacts metabolic processes, water absorption and effects nutrient absorbance, evenness of stomata behavior, osmotic, hydraulic accessibility, net photosynthetic rate, and intercellular CO_2 concentrations, all of this impacts in negatively influencing the plant density to develop and cultivate. Also, Hasegawa *et al.* (2000) reported that the higher averages of toxic ions like Na^+ and Cl^- damage the equation between ions through detraction the plant capability to occupy in other ions like K^+, Ca^{2+} and Mn^{2+}.

Neoteric research on nano-particles in several plants has illustrated for promoted each of physiological activities, vegetative growth, and productivity signalizing their strength employ in crop improvement (Kole *et al.*, 2013).

Although micronutrients may be added as mineral salts to the nutrition, it is serious to understand how micronutrient amount of forage modulation with phenological evolution to optimize supplying regimes and feed additions. It is well known that as plants develop and grow the crude protein concentration and energy reduces while the dry matter increases (Beever *et al.*, 2000). In addition, the foliar feeding of micronutrients will accrue in alleviating the passive effects of abiotic stresses, with synchronous maximizing productivity. This mechanism is cost-efficient and useful under stressful situation. The plants well-fed with micro nutrients have greater tolerance ability in response to abiotic stresses (Hasanuzzaman *et al.*, 2018).

Therefore, the main propose of this study was to evaluate the role of nano-micronutrients on counteracting the deleterious influence of soil salinity on vegetative growth, root system, salt tolerance trait index as well as total chlorophyll and proline contents of seashore paspalum turf grasses.

MATERIALS AND METHODS

Two pot experiments in open field were conducted during the two winter consecutive seasons of 2018/2019 and 2019/2020 at Ornamental Nursery, Fac. Agric., Zagazig Univ., Egypt. This work was carried out to evaluate the influence of soil salinity levels (0.0, 8000, 16000 and 24000 ppm), nano-micronutrients [control (sprayed with tap water), 0.25, 0.50 and 1.00 g/l] as foliar applications and their interaction treatments on growth, root system, salt tolerance trait index, total chlorophyll content and proline content of seashore paspalum plants.

Circle pieces from pre-prepared rolls of seashore paspalum at a radius of 35 cm (its fresh weight ranged

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between 250-280 g) were planted on 10th October during both seasons in the center of 40 cm diameter pots (1 piece/pot) filled about 8 kg of a mixture of sand: clay (1:2 v/v). The physical and chemical properties of the mixture soil are shown in Table 1, according to Chapman and Pratt (1978).

Table 1. Physical and chemical properties of the experimental soil mixture (average of two seasons)

							Physical analysis					Soil texture	
Clay (%)						Silt (%)				sand (%)		Sandy	
21.07						9.83				69.10			
		Chemical analysis											
Time	pH	E.C.	Soluble cations (m.mol/l)					Soluble anions (m.mol/l)			Available (ppm)		
		(dsm^{-1})	Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
Before planting	7.80	0.59	1.90	0.95	0.32	1.11	1.32	3.14	1.13	0.86	121	42	54

After seashore paspalum pieces were planted, softly compressed by hand to be more approach with the mixture soil, then it was covered with a tender layer (1 cm) of the same soil. Pots were irrigated every day with tap water (about 500 ml) for two weeks to wet only the zone in which pieces are established.

Response of seashore paspalum plants to different levels of soil salinity was evaluated under pots culture conditions. Four levels of artificial soil salinity were used by dissolving the natural salt crust of sea water in distilled water then added to the soil based on its weight (8g salt/1 kg soil to obtain 8000 ppm, etc.). The chemical analysis of salt is shown in Table 2.

Table 2. Chemical analysis of salt (water-salt extract at 5:1)

E.C. (mmhos/cm)	Soluble cations (m.mol/l)				Soluble anions (m.mol/l)			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{--}	SO_4^{--}	Cl^{-}
168.8	9.28	8.54	2988.0	2.80	5.96	0.0	76.86	2935.00

Nano-micronutrients which commercially known as Magro NanoMix, which consists of the following minerals: Fe (6%), Zn (6%), B (2%), Mn (5%), Cu (1%) and Mo (0.1%) as well as it consists of citric acid (4%) was obtained from Modern Agricide Company (MAC). However, seashore paspalum plants were foliar sprayed with different rates of nano-micronutrients five times at 25, 55, 85, 125 and 155 days after planting date. The interaction treatments between soil salinity level and nano-micronutrients rates were consisted of 16 treatments. All recommended agricultural practices of growing seashore paspalum plants were done when ever needed. In addition, the basal doses of nitrogen (N) at (140 mg/kg soil), phosphorous (P_2O_5) at (60 mg/kg soil) and potassium (K_2O) at (40 mg/kg soil) were applied in each pot through ammonium sulphate, single superphosphate and potassium sulphate, respectively, at 25, 55, 85, 125 and 155 days of planting date.

Experimental Design

These treatments were arranged in a split-plot in randomized complete blocks design with three replicates. Soil salinity levels were randomly arranged in the main plots and nano-micronutrients rates were distributed randomly in the sub plots.

Data Recorded

The first cut was handy done after 60 days from planting (on 15th December) utilizing fully sharp stainless steel cutter departure stubbles with 3 cm long. Other four cuts were monthly undertaken thereafter (at 15th January, 15th February, 15th March and 15th April).

Vegetative growth:

Before each cut in the two seasons, plant height (cm) was noticed, also covering density percentage (number of tillers/area) as recorded by Mahdi (1953) as well as total herb fresh and dry weights g /pot of the resulted clippings after mowing were determined after each cut. However, the growth characters of seashore paspalum grass were shown as an average of five cuts during the first and second seasons.

Root system:

At the end of the experiment in the two seasons, root fresh and dry weights (g) and root length cm were recorded.

Salt tolerance trait index (STTI):

It is a genuine index for soil salinity tolerance was studied from the equation mentioned previously by Wu and Huff (1983):

SSTI (%) = Mean root length of the salt treated plants/mean root length of control one × 100.

Pigments content:

In seashore paspalum fresh leaf before the last cut (on 15th April), total chlorophyll content (SPAD unit) were measured by using SPAD- 502 meter as described by Markwell *et al.* (1995).

Statistical Analysis

The statistical layout of this experiment was a split-plot experiment in completely randomized block design (CRBD). Data were analyzed by using LSD at 5% level according to Gomez and Gomez (1984). The obtained data means were compared using computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Vegetative growth characters:

Effect of soil salinity

Data of both seasons in Tables 3 and 4 reveal that, using soil salinity treatments at high levels (16000 and 24000 ppm) significantly decreased plant height and covering density percentage as well as fresh and dry herb weights of seashore paspalum compared to control and the lowest level (8000 ppm) in both seasons. Furthermore, the highest values of vegetative growth characters were obtained with the lowest salinity level compared to control (sprayed with tap water). The deleterious effectiveness of soil salinity on plant development and growth rate are due to the repression of photosynthesis, the induction of growth supervisor, and lowering of leaf area (Kashem *et al*., 2000), protein content in leaf (Farouk *et al*., 2012), and reduced capability to supply and utilize assimilates/photosynthates (Kashem *et al*., 2000). However, Pessarakli and Touchane (2006) demonstrated that seashore paspalum shoot and root lengths were activated at the low levels of NaCl salinity (5000 and 10000 ppm), but basically reduced at the higher levels (especially at 30000 ppm). As the exposure time to salt stress was proceeded, shoot and root fresh and dry weights were more influenced than shoot and root length. Pompeiano *et al.* (2016) suggested that biomass fresh and dry weights of seashore paspalum, a recently progressive cultivated cultivar were not influenced by NaCl salinity up to 600 mM.

Effect of nano-micronutrients

It is evident from the obtained data in Tables 3 and 4 that, plant height, covering density percentage and total herb fresh and dry weights/pot of seashore paspalum were increased as Nano- micronutrients increased in the two consecutive seasons. In addition, the highest rate of Nano-micronutrients (1.00 g/l) gave the highest values in vegetative growth parameters of *Paspalum vaginatum* compared to control and the lowest two one under study in both seasons. These findings could be referred to Nano-fertilizers enhance easiness of use of nutrient to the plants which increase rate of photosynthesis and production of dry material as well result get superior in the vegetative growth (Hediat, 2012). Also, Abdel-kader *et al.* (2014) found that herb fresh and dry weights/plant of lemongrass plants were significantly increased by the micronutrients mixture as foliar application compared to control. Moreover, Ahmed and Abdelkader (2020) showed that the chilli vegetative growth significantly increased by nano-micronutrients at 0.5 g/l rate compared to control. These results are in line with those found by Gomaa *et al.* (2020) on maize.

Table 3. Effect of soil salinity level (S), nano-micronutrients rate (N) and their interactions (S×N) on plant height and covering density (%) of seashore (*Paspalum vaginatum*) during 2018/2019 and 2019/2020 seasons

Soil salinity level (ppm)	Nano-micronutrients rate (g/l) 0.0	0.25	0.50	1.00	Mean (S)
Plant height (cm)					
		2018/2019 season			
Control	34.33	25.55	40.03	36.78	36.42
8000	36.22	37.22	39.34	40.89	38.42
16000	30.78	32.67	33.11	34.22	32.69
24000	27.33	28.56	31.00	31.45	29.58
Mean (N)	32.17	33.25	35.86	35.83	
L.S.D. at 5 %	(S)= 1.21		(N)= 1.39	(S×N)= 2.69	
		2019/2020 season			
Control	35.78	36.33	36.56	37.11	36.44
8000	38.89	40.22	41.00	42.11	40.55
16000	31.33	32.67	35.00	35.22	33.56
24000	26.22	27.11	28.55	28.78	27.67
Mean (N)	33.06	34.08	35.28	35.81	
L.S.D. at 5 %	(S)= 0.45		(N)= 0.39	(S×N)= 0.81	
Covering density (%)					
		2018/2019 season			
Control	180.34	184.58	187.10	192.89	186.23
8000	182.44	191.66	197.31	203.45	193.72
16000	158.07	161.63	169.10	172.33	165.28
24000	125.57	127.30	130.70	131.60	128.79
Mean (N)	161.60	166.29	171.05	175.07	
L.S.D. at 5 %	(S)= 0.85		(N)= 1.04	(S×N)= 1.98	
		2019/2020 season			
Control	173.35	176.38	181.93	188.83	180.12
8000	176.45	180.55	189.49	196.74	185.81
16000	144.96	150.16	158.17	165.96	154.81
24000	118.77	122.47	128.05	132.57	125.47
Mean (N)	153.38	157.39	164.41	171.03	
L.S.D. at 5 %	(S)= 1.29		(N)= 1.23	(S×N)= 2.48	

Table 4. Effect of soil salinity level (S), nano-micronutrients rate (N) and their interactions (S×N) on herb fresh and dry weights/pot (g) of seashore (*Paspalum vaginatum*) during 2018/2019 and 2019/2020 seasons

Soil salinity level (ppm)	Nano-micronutrients rate (g/l) 0.0	0.25	0.50	1.00	Mean (S)
Herb fresh weight /pot (g)					
		2018/2019 season			
Control	84.08	86.61	90.14	91.29	88.03
8000	85.87	90.27	92.71	95.37	91.05
16000	64.78	69.39	72.65	72.81	69.91
24000	48.57	49.97	51.74	56.93	51.80
Mean (N)	70.83	74.06	76.81	79.10	
L.S.D. at 5 %	(S)= 0.49		(N)= 0.63	(S×N)= 1.20	
		2019/2020 season			
Control	75.11	78.96	81.27	83.33	79.67
8000	78.57	82.53	85.43	87.51	83.51
16000	61.62	65.18	70.87	70.35	67.00
24000	50.86	52.11	55.65	58.82	54.36
Mean (N)	66.54	69.69	73.31	75.00	
L.S.D. at 5 %	(S)= 0.75		(N)= 0.78	(S×N)= 1.54	
Herb dry weight /pot (g)					
		2018/2019 season			
Control	31.24	32.52	36.49	38.62	34.72
8000	33.05	36.66	39.07	44.67	38.36
16000	22.57	25.16	29.39	28.77	26.47
24000	19.42	20.55	23.35	25.02	22.09
Mean (N)	26.57	28.72	32.08	34.27	
L.S.D. at 5 %	(S)= 0.29		(N)= 0.47	(S×N)= 0.86	
		2019/2020 season			
Control	36.20	37.69	39.22	41.43	38.64
8000	36.99	41.81	44.28	48.75	42.96
16000	24.05	25.50	29.19	30.40	27.28
24000	17.81	18.81	21.65	23.19	20.37
Mean (N)	28.76	30.95	33.59	35.94	
L.S.D. at 5 %	(S)= 0.64		(N)= 0.54	(S×N)= 1.14	

Effect of interaction between soil salinity and nano-micronutrients

Data recorded in Tables 3 and 4 indicate that, all interaction between soil salinity levels (16000 and 24000 ppm) and nano-micronutrients treatments significantly decreased seashore paspalum vegetative growth characters in both seasons. The lowest level of soil salinity (8000 ppm) which sprayed with nano-micronutrients at any rate resulted in the highest values of plant height, covering density percentage and total herb fresh and dry weights/pot of seashore paspalum compared to the other interaction treatments under study in both seasons, in most cases. The increases in plant height and covering density percentage were about 19.11 and 17.69 % as well as 12.81 and 13.49 % for the interaction between soil salinity at 8000 ppm + 1.00 g/l nano-micronutrients over control treatment (un-salinized plants + sprayed plants with tap water) in the 1st and 2nd seasons, respectively. Moreover, as mentioned above, nano-micronutrients increased vegetative growth parameters of seashore paspalum grasses, in turn; they together under soil salinity conditions might maximize their effects leading to taller, more covering and heaviest herb per pot. In addition, El-Fouly *et al.* (2011) indicated that foliar spraying with micronutrient made stimulatory influences on wheat growth parameters under salinization treatments.

Root system characters and salt tolerance trait index: Effect of soil salinity

From data presented in Tables 5 and 6 demonstrated that, the highest values of seashore paspalum root fresh and dry weights and root length were achieved with the low level of soil salinity compared to control and the high levels of salinity under study in both seasons. It is scientifically accepted that the Index of salinity tolerance of 50% indicates that the plants are tolerant to salinity and are suitable for cultivation in saline soils for these concentrations.

Whenever, the best treatments in increase salt tolerance trait index were the control (sprayed with tap water) and 8000 ppm salinity level. In general, increasing soil salinity levels gradually decreased root system characters and salt tolerance trait index during 2018/2019 and 2019/2020 seasons. Roy and Chakraborty (2014) indicated that salt tolerant grasses are qualified of remaining at increasing salt stress by using different technically that contain vacuolization of toxic Na^+ and Cl^- in ripe or senescing leaves, secretion of superfluous salts by salt glands, accumulating glycine betaine and proline as osmolytes, and scavenging of reactive oxygen species by anti-oxidative enzymes. These results are in line with those stated by Arghavani *et al*. (2012) on Kentucky Bluegrass as well as Dergham *et al*. (2017) and Mohammed *et al*. (2019) on seashore paspalum.

Table 5. Effect of soil salinity level (S), nano-micronutrients rate (N) and their interactions (S×N) on root fresh and dry weights/pot (g) of seashore (*Paspalum vaginatum*) during 2018/2019 and 2019/2020 seasons

Soil salinity level (ppm)	Nano-micronutrients rate (g/l) 0.0	0.25	0.50	1.00	Mean (S)
Root fresh weight /pot (g)					
		2018/2019 season			
Control	9.00	9.15	10.73	11.37	10.06
8000	10.37	11.03	12.17	12.89	11.62
16000	6.46	6.79	8.54	8.88	7.67
24000	4.62	5.35	6.17	6.47	5.65
Mean (N)	7.61	8.08	9.40	9.90	
L.S.D. at 5 %	(S)= 0.43	(N)= 0.32	(S×N)= 0.70		
		2019/2020 season			
Control	9.37	10.06	10.70	11.78	10.48
8000	9.66	10.40	11.80	12.17	11.01
16000	6.45	7.03	7.91	9.01	7.60
24000	5.15	6.08	6.60	7.22	6.26
Mean (N)	7.66	8.39	9.25	10.04	
L.S.D. at 5 %	(S)= 0.24	(N)= 0.34	(S×N)= 0.64		
Root dry weight /pot (g)					
		2018/2019 season			
Control	4.09	4.34	4.94	5.13	4.62
8000	3.87	4.83	6.08	6.88	5.42
16000	2.97	3.29	4.11	4.45	3.71
24000	1.85	2.09	2.57	2.83	2.34
Mean (N)	3.19	3.64	4.42	4.82	
L.S.D. at 5 %	(S)= 0.13	(N)= 0.18	(S×N)= 0.33		
		2019/2020 season			
Control	4.14	4.19	4.78	5.51	4.66
8000	4.02	4.72	5.79	6.30	5.21
16000	2.21	2.78	3.97	4.00	3.24
24000	1.67	2.09	2.68	3.02	2.37
Mean (N)	3.01	3.44	4.30	4.71	
L.S.D. at 5 %	(S)= 0.36	(N)= 0.21	(S×N)= 0.51		

Table 6. Effect of soil salinity level (S), nano-micronutrients rate (N) and their interactions (S×N) on root length (cm) and salt tolerance index (%) of seashore (*Paspalum vaginatum*) during 2018/2019 and 2019/2020 seasons

Soil salinity level (ppm)	Nano-micronutrients rate (g/l) 0.0	0.25	0.50	1.00	Mean (S)
Root length (cm)					
		2018/2019 season			
Control	18.44	20.13	23.19	23.74	21.37
8000	18.74	19.15	22.34	24.01	21.06
16000	10.74	12.60	13.74	14.38	12.87
24000	8.22	10.52	11.80	12.31	10.71
Mean (N)	14.04	15.60	17.77	18.61	
L.S.D. at 5 %	(S)= 0.31	(N)= 0.55	(S×N)= 1.00		
		2019/2020 season			
Control	16.60	20.33	20.74	22.33	20.00
8000	17.35	19.60	22.12	23.47	20.63
16000	10.73	13.69	14.49	16.17	13.77
24000	9.64	12.31	12.67	13.94	12.14
Mean (N)	13.58	16.48	17.51	18.98	
L.S.D. at 5 %	(S)= 0.53	(N)= 0.44	(S×N)= 0.93		
Salt tolerance trait index (%)					
		2018/2019 season			
Control	100.00	100.00	100.00	100.00	100.00
8000	101.67	95.14	96.36	101.18	98.59
16000	58.29	62.61	59.30	60.61	60.20
24000	44.59	52.23	50.92	51.85	49.90
Mean (N)	76.14	77.49	76.65	78.41	
L.S.D. at 5 %	(S)= 1.59	(N)= 2.18	(S×N)= 4.08		
		2019/2020 season			
Control	100.00	100.00	100.00	100.00	100.00
8000	104.55	96.46	106.71	105.09	103.20
16000	64.67	67.35	69.94	72.41	68.59
24000	58.09	60.58	61.07	62.45	60.55
Mean (N)	81.83	81.10	84.43	84.99	
L.S.D. at 5 %	(S)= 2.81	(N)= 2.92	(S×N)= 5.77		

Effect of nano-micronutrients

It is quite clear from data in Tables 5 and 6 that, root fresh and dry weights, root length and salt tolerance index percentage of seashore paspalum were gradually with increasing of Nano- micronutrients levels in both seasons. Using 1 g/l nano-micronutrients as foliar spray five time per season significantly increased root system characters and salt tolerance index compared to control (sprayed with tap water) and the lowest ones (0.25 and 0.50 g/l) under study. These results knot true in both seasons. The prominence of the micronutrients turns up from its impact of activating the process of photosynthesis and thus its positive effect on the root growth (Hänsch and Mendel, 2009). Moreover, it could be mentioned that, the notability in seashore paspalum salt tolerance index by nano-micronutrients usage is directly owing to the ameliorative influence on vegetative growth seashore grasses, which resulted in raises in metabolites syntheses to root growth and this in turn increase soil salinity resistance. These results are united in opinion with the returns of Pavithra *et al.* (2017) on rice.

Effect of interaction between soil salinity and nano-micronutrients

The data illustrated in Tables 5 and 6 indicate that, the root fresh and dry weights, root length and salt tolerance index of *Paspalum vaginatum* recorded more/or less similar trend as mentioned in vegetative growth as a result of interaction treatments between soil salinity stress and nano-micronutrients. The best interaction treatment was 8000 ppm of soil salinity and 1 g/l of nano-micronutrients in comparison with the other interactions between salinity levels and nano-micronutrients rates under study in both seasons. Generally, using nano-micronutrients at the highest rate reduced the harmful influence of soil salinity stress in this respect. Furthermore, Noreen *et al.* (2018) reported that application of micronutrients increased net photosynthetic rate and crop tolerance capacity to abiotic stresses.

Total chlorophyll and proline contents:

Effect of soil salinity

As shown in Table 7 that, the highest values of total chlorophyll content (SPAD unit) in seashore paspalum leaves was obtained from the low level of soil salinity compared to control and the high levels of soil salinity under study. In contrast, proline content (mg/g as dry weight) was gradually increased as soil salinity decreased in both seasons, in most cases. Furthermore, the highest values in proline content were noticed with 24000 ppm of soil salinity level. These findings are in harmony with those found by Uddin *et al*. (2011) on *Paspalum vaginatum*, *Zoysia japonica* and *Zoysia matrella*.

Effect of nano-micronutrients

Data in Table 7 show that, nano-micronutrients rate treatments significantly increased seashore paspalum total chlorophyll content and proline accumulation in leaves compared to untreated plants in both seasons. Nano-micronutrients at 1 g/l significantly increased abovementioned characters compared to control and the other ones under study. Also, due to the effect of nano-micronutrients, which penetrate rapidly into the plant tissues through plant stomata and play vital roles in physiological and biological processes of seashore paspalum grasses which were reflected on the higher amount of chlorophyll and proline in leaves of plant. The obtained results were parallel with those stated by Refaat *et al*. (1996) on lemongrass plant.

Table 7. Effect of soil salinity level (S), nano-micronutrients rate (N) and their interactions (S×N) on total chlorophyll content (SPAD) and proline content in leaves (mg/g as dry weight) of seashore (*Paspalum vaginatum*) during 2018/2019 and 2019/2020 seasons

Soil salinity level (ppm)	**Nano-micronutrients rate (g/l) 0.0**	**0.25**	**0.50**	**1.00**	**Mean (S)**
Total chlorophyll content (SPAD)					
		2018/2019 season			
Control	42.55	45.34	47.44	48.89	46.06
8000	43.56	45.55	47.22	50.78	46.78
16000	40.11	40.22	41.11	43.44	41.22
24000	38.22	39.11	39.22	40.00	39.14
Mean (N)	41.11	43.75	42.56	45.78	
L.S.D. at 5 %	(S)= 0.93		(N)= 0.51	(S×N)= 1.28	
		2019/2020 season			
Control	43.22	43.45	46.78	47.22	45.17
8000	42.22	46.11	49.44	52.33	47.53
16000	41.34	42.89	44.67	44.44	43.33
24000	38.11	34.22	37.56	39.56	38.11
Mean (N)	41.22	42.42	44.61	45.89	
L.S.D. at 5 %	(S)= 0.47		(N)= 0.66	(S×N)= 1.15	
Proline content in leaves (mg/g as dry weight)					
		2018/2019 season			
Control	3.22	3.35	3.61	3.85	3.51
8000	2.88	2.88	3.74	3.47	3.24
16000	4.24	5.52	7.15	6.91	5.95
24000	6.99	7.88	8.65	8.90	8.11
Mean (N)	4.33	4.91	5.79	5.78	
L.S.D. at 5 %	(S)= 0.48		(N)= 0.36	(S×N)= 0.71	
		2019/2020 season			
Control	2.58	2.70	3.39	3.44	3.03
8000	2.74	3.47	3.50	3.74	3.36
16000	4.67	4.60	6.40	7.61	5.82
24000	5.85	8.73	8.78	9.39	8.19
Mean (N)	3.96	4.88	5.52	6.04	
L.S.D. at 5 %	(S)= 0.28		(N)= 0.21	(S×N)= 0.46	

Effect of interaction between soil salinity and nano-micronutrients

Data tabulated in Table 7 reveal that, the interaction between salinity and nano-micronutrients mostly decreased total chlorophyll content comparing to control (without salinization and sprayed by water). In the other words, proline content was increased under most of interaction treatments under study compared to control in the two seasons. Also, using 1 g/l of nano-micronutrients increased total chlorophyll and proline contents of seashore paspalum in comparison to the salinized plants under the same levels alone in both seasons. Generally, the highest values in total chlorophyll content were achieved by the interaction treatment between 1 g nano-micronutrients /l and 8000 ppm salinity level in both seasons. However, micronutrients are considered one of the important growth substances affecting plant development processes under stress conditions (Reffat and Balbaa, 2001). Also, micronutrients are well known an important nutrient which has positive influences on plant growth and significantly mitigates the injuries caused by a biotic stresses (Noreen *et al*., 2018). These results are in harmony with those reported by Pourjafar *et al*. (2016) and Elsakhawy *et al*. (2018).

CONCLUSION

It could be concluded that seashore paspalum grasses grown into a sandy soil produced relatively more growth with higher quality under salinity stress up to 16000 ppm level as estimated by salt tolerance traits index. Also, soil salinity at 8000 ppm level with foliar spraying of nano-micronutrients at 1 g/l rate and their interaction caused an increase in the growth, root system and total chlorophyll content.

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تحسين نمو وجودة نجيل جزر البحر باستخدام العناصر الصغرى متناهية الصغر تحت ظروف إجهاد ملوحة التربة

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أجريت تجربة أصص بمشتل الزينة ، كلية الزراعة، جامعة الزقازيق، مصر، خلال موسمي الشتاء المتتاليين لأعوام 2019/2018 و 2020/2019 لتقييم دور العناصر الصغرى متناهية الصغر (بمعدلات مختلفة: صفر و0,25 و 0,50 و 1,00 جم/لتر) على مقاومة التأثير الضار لملوحة التربة (عند مستويات مختلفة: صفر و 8000 و16000 و24000 جزء/المليون) على النمو، والجودة، ودليل تحمل الملوحة ومحتوى الكلوروفيل الكلي لنبات نجيل جزر البحر. صممت التجربة كقطع منشقة مرة واحدة في تصميم القطاعات العشوائية الكاملة في ثلاثة مكررات. تم استخدام أصص بلاستيكية بقطر 40 سم ملئت بحوالي 8 كيلوجرام من خليط الرمل والطين (2:1 حجم/حجم). أشارت النتائج المتحصل عليها إلى أن استخدام ملوحة التربة بمستوى عالٍ (24000 جزء في المليون) أدى إلى انخفاض صفات النمو (ارتفاع النبات، النسبة المئوية لكثافة التغطية، الوزن الطازج والجاف للعشب لكل أصيص)، المجموع الجذري (الأوزان الطازجة والجافة للجذور/أصيص وطول الجذر)، نسبة تحمل الملوحة ومحتوى الكلوروفيل الكلي مقارنة بالكنترول. بينما، ازداد المحتوى من البرولين في الأوراق بزيادة مستويات ملوحة التربة إلى أعلى القيم عند مستوي ملوحة 24000 و16000 جزء/المليون، على التوالي. ومع ذلك، لوحظت أعلى القيم في الصفات المذكورة أعلاه لنبات نجيل جزر البحر مع العناصر الصغرى متناهية الصغر بمعدلات 0,50 و 1,00 جم/لتر مقارنةً بالكنترول (الرش بماء الصنبور) في كلا الموسمين. بشكل عام، يمكن التوصية باستخدام 0,50 و 1,00 جم/لتر من العناصر الصغرى متناهية الصغر لأنه أدي إلى التخفيف من تثبيط نمو نجيل جزر البحر وجودته تحت ظروف الإجهاد الملحي عند المستوى المنخفض (8000 جزء في المليون) مع زيادة في مؤشر تحمل الملوحة.