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EFFECT OF SOME SALINITY AND FERTILIZATION TREATMENTS ON BERMUDA:
B. ROOT GROWTH AND SOME CHEMICAL COMPOSITION

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ABSTRACT: This study was undertaken at the private Farm, Bani Mazar District, Minia governorate. during the two seasons of 2020 and 2021. The aim of this study was to investigate the effect of irrigation water salinity, mineral and biofertilization [effective microorganisms (EM) and *Azotobacter chroococcum* bacteria (AC)] treatments, as well as, their combinations on the root growth and some chemical constituents of bermudagrass (*Cynodon dactylon*, L.), grown in sandy soil. Results showed that the root growth parameters i.e., root length and fresh and dry weights/unit were enhanced with the low and medium levels of salinity (3000 and 6000 ppm), while, they decreased with the high level of salinity (9000 ppm) compared with control, in the third cut during both seasons. On the other hand, all salinity treatments increased Na, Cl, Ca (% in the dry herb) and proline content (in fresh weight), and decreased photosynthetic pigments as well as NPK %. All used mineral and/or biofertilization treatments significantly increased root length and fresh and dry weights/unit comparing with control treatment in 3rd cut, except AC for root length and EM and AC in case of fresh and dry weights/unit, with the highest values that were obtained due to 100% mineral NPK followed by EM + AC during both seasons. N, P, K and Ca % as well as photosynthetic pigments and proline content were increased due to application with any of the sub-plot treatments, while, Na and Cl were decreased. The best interaction treatments which mitigate the adverse effects of salinity (9000 ppm) were 100% mineral NPK followed by biofertilizer (EM + AC).

Keywords: *Cynodon dactylon,* L., salinity, mineral fertilization, biofertilization, root growth, chemical composition.

INTRODUCTION

Bermudagrass (*Cynodon dactylon* (L.) belongs to Family Poaceae that acts as a ground cover (Uddin and Juraimi, 2013). Also, bermudagrass is native to Africa, widely distributed, and commonly found in tropical and sub temperate areas (Taliaferro *et al*., 2004).

Salinity stress is one of the main problems in turfgrass management (Keyikoglu *et al*., 2019). Many authors concluded that root growth was decreased by salinity at high levels such as Pessarakli *et al*. (2008), Uddin *et al*. (2009), Uddin *et al*. (2010) and Badawy *et al*. (2018) on bermudagrass.

bermudagrass was more responded to mineral NPK fertilization as found by Barton *et al*. (2006), Guertal and Evans (2006) and Ihtisham *et al*. (2018). Biofertilizers can produce biological nitrogen fixation. Biofertilizers play an important role in supplying nutrients essential for plants to produce agriculturally sustainable, economical, and environment-friendly products, by improving the absorption of water and nutrients by the root system (Radnezhad *et al*., 2015). Many researchers mentioned that as Hussein and Mansour (2003) on kikuyu grass, Kumar and Nikhil (2016) on netiver grass, Sabry and Abdal-Latife (2017) on four varieties of lawn grasses, and Radnezhad *et al*. (2015) on *Salvia officinalis*.

Therefore, the purpose of this study was to examine the effect of irrigation water salinity and mineral and/or biofertilizers on root growth and some chemical composition of bermudagrass.

MATERIALS AND METHODS

This study was undertaken at the private Farm, Bani Mazar District, Minia governorate. during the two seasons of 2020 and 2021 to investigate the effect of irrigation water salinity and mineral and/or biofertilization treatments, as well as, their interaction on the root growth and some chemical composition of bermudagrass (*Cynodon dactylon*, L.), grown in sandy soil.

The seeds of bermudagrass were obtained from Hamza Co., El-Giza, Egypt. The experiment was arranged in a complete randomized block design in a split-plot design with three replicates.

The main plots (A) included four levels of salinity i.e. 0.0, 3000, 6000 and 9000 ppm, of NaCl:$CaCl_2$ at a rate of 1:1 w/w. While eight treatments of mineral NPK and/or biofertilizers, included control, mineral NPK at 100%, mineral NPK at 75%, effective microorganisms (EM), *Azotobacter chroococcum* bacteria (AC), mineral NPK at 75% + EM, mineral NPK at 75% + AC, and EM + AC occupied the subplots (B).

Therefore, the interaction treatments (A × B) performed 32 treatments. Each replicate area was 10×10 m, such area was dug out to 30 cm depth and separated into the experimental unit (plot) 1.5 × 1.0 m, to prevent seepage, a 1.0 m between the main plot and 0.25 m between sub-plots, using layers of wood, then refilled with sandy soil plus compost at 10 ton/fed for all treatments (3.6 kg/unit area). Seeds of bermudagrass were sown by broadcasting method on April, 28th for both growing seasons at the rate of 60 g/1.5 m^2.

The physical and chemical analysis of the used soil is determined according to Jackson (1973) and is shown in Table (a).

The full dose of mineral NPK (100%) was 300 kg/fed of ammonia nitrate (33.5% N) + 200 kg/fed calcium super phosphate (15.5% P_2O_5) + 100 kg/fed potassium sulphate (48% K_2O), therefore, the NPK 100% = 112.5 + 75 + 37.5 g/1.5 m^2 while 75% NPK = 84.4 + 56.3 + 28.1 g/1.5 m^2.

All assigned calcium superphosphate fertilizer was applied to the sandy soil during soil preparation for bermuda cultivation, while the amounts of N and K fertilizers were divided into three equal doses and were applied in monthly intervals pattern, starting on the second day of June then 2nd July and 2nd August in both seasons.

Table a. Physical and chemical properties of the used soil before planting of bermudagrass during 2020 and 2021 seasons.

Soil character	Values 2020	Values 2021	Soil character	Values 2020	Values 2021
Physical properties			**Nutrients**		
Sand (%)	90.00	91.00	**Total N (%)**	0.01	0.01
Silt (%)	7.30	6.40	**Available P (%)**	2.81	2.96
Clay (%)	2.70	2.60	**Na^+ (mg/100 g soil)**	2.34	2.45
Soil type	Sandy	Sandy	**K^+ (mg/100 g soil)**	0.78	0.83
Chemical properties			**DTPA-extractable nutrients**		
pH (1:2.5)	8.15	8.22	**Fe (ppm)**	1.04	1.10
E.C. (dS/m)	1.11	1.13	**Cu (ppm)**	0.33	0.39
O.M.	0.03	0.04	**Zn (ppm)**	0.34	0.31
$CaCO_3$	13.70	13.85	**Mn (ppm)**	0.56	0.67

Fresh and active biofertilizer, Effective microorganisms containing lactic acid bacteria, photosynthetic bacteria and yeasts (EM) and *A. chroococcum* (AC) strain were obtained from Microbiology Department, Faculty of Agriculture, Mansoura University were sprayed by hand sprayer at the rate of 500 $cm^3/1.5\ m^2$ (each 1.0 ml containing 10^7 cells of bacteria) and (50 $ml/1.5\ m^2$), respectively.

The first dose for EM and AC was applied on 9th June, second dose on 9th July and the last spray was on 9th August (after one week of the dose of mineral fertilizer), and then the plants were irrigated immediately.

Data recorded:

Root length (cm), root fresh and dry weights (g) as well as N, P, K, Na, Ca, Cl (% in dry herb) and proline content (µg/g in the fresh herb) during the third cut, and photosynthetic pigments (mg/g f.w.) during the three cuts, in both seasons.

Chemical analysis:

Photosynthetic pigments (mg/g f.w.), during the three cuts, in both seasons were determined according to Moran (1982). Total N was determined by using the modified micro-kjeldahl method (ICARDA, 2013), P (%) was determined according to Olsen method, K and Na were estimated using flame-photometery method, Ca was determined by versenate method and Cl was determined using silver chloride method. All previous determinations were performed according to ICARDA (2013), as well as proline content was determined according to Bates *et al*. (1973).

The obtained results were tabulated and statistically analyzed according to MSTAT–C (1986), and LSD test at 5% was followed to compare the means of treatments

RESULTS AND DISCUSSION

Root growth measurements:

Root length (cm):

Data presented in Table (1), demonstrated that root length was augmented with the treatments of 3000 and 6000 ppm irrigation water salinity significantly increased compared with the control treatment. Furthermore, it was significantly decreased with the high level of salinity (9000 ppm) compared with (3000 ppm) irrigation water salinity during the third cut in both seasons.

These results were in agreement with those obtained by Adavi *et al*. (2006), Hameed and Ashraf (2008), Pessarakli *et al*. (2008), Uddin *et al*. (2009), Uddin *et al*. (2010) and Badawy *et al*. (2018) on bermudagrass.

Concerning the effect of mineral and/or biofertilization treatments, on the other side, data in Table (1) showed that all used seven treatments significantly increased root length compared with the control treatment during the third cut in the two seasons, except the treatment of AC. Among these treatments, mineral NPK 100%, followed by EM + AC, produced the tallest plants.

Fertilizing plants with mineral NPK produced an increase in root length as recorded by Rodriguez *et al*. (2002), Barton *et al*. (2006) and Ihtisham *et al*. (2018) on bermudagrass, as well as biofertilizers had positive effect on root length as mentioned by Kumar and Nikhil (2016) on netiver grass, Sabry and Abdal-Latife (2017) on four varieties of lawn grasses, and Radnezhad *et al*. (2015) on *Salvia officinalis*.

The interaction treatments were significant for root length during the third cut in both seasons. The effective interaction treatments which reduced the bad impacts of salinity (9000 ppm) were mineral NPK 100%, EM + AC, NPK 75% + EM, NPK 75% and NPK 75% + AC.

Root fresh and dry weights (g):

Data presented in Table (1), showed that root fresh and dry weights were increased due to the application of 3000 and 6000 ppm irrigation water salinity compared with the control, but the application of 9000 ppm decreased root fresh and dry weights

Table 1. Effect of salinity concentration, mineral and biofertilization on root length, and root fresh and dry weights/unit of bermudagrass (3rd cut) during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	Root length (cm)									
Control	13.06	18.23	16.93	11.06	14.82	14.13	19.13	18.23	12.20	15.92
Mineral NPK 100%	20.50	27.40	24.06	18.73	22.67	22.16	29.43	25.96	19.96	24.38
Mineral NPK 75%	16.73	21.96	20.30	15.03	18.51	17.10	22.10	21.13	15.90	18.81
EM (500 cm^3/1.5 m^2)	15.13	21.03	19.56	14.00	17.43	16.06	22.36	20.66	15.30	18.60
AC (50 ml/1.5 m^2)	13.66	19.30	18.33	13.13	16.11	15.20	20.00	19.40	14.70	17.33
NPK 75% + EM	18.10	23.60	21.83	16.06	19.90	19.26	24.86	23.03	17.40	21.14
NPK 75% + AC	16.23	21.20	19.46	14.23	17.78	18.03	24.13	21.23	16.33	19.93
EM + AC	18.90	24.90	23.16	17.30	21.07	20.16	26.03	24.53	18.66	22.35
Mean (A)	16.54	22.20	20.45	14.94		17.76	23.51	21.77	16.18	
L.S.D. at 5 %	A: 2.50	B: 2.25	AB: 4.50			A: 2.61	B: 2.29	AB: 4.58		
	Root fresh weight/unit (g)									
Control	152.48	222.45	212.48	156.48	185.97	153	228	220.5	153.00	188.63
Mineral NPK 100%	219.98	300.00	279.98	218.95	254.73	222.98	300.45	285.45	225.45	258.58
Mineral NPK 75%	180.00	240.00	229.95	181.45	207.85	185.48	256	237.98	185.48	216.24
EM (500 cm^3/1.5 m^2)	177.45	234.98	225.00	176.50	203.48	177.98	243	230.48	177.98	207.36
AC (50 ml/1.5 m^2)	169.95	229.95	219.98	171.48	197.84	170.48	232.95	225.45	170.48	199.84
NPK 75% + EM	199.95	262.50	244.95	191.50	224.73	200.48	267.98	247.95	192.98	227.35
NPK 75% + AC	184.95	252.45	237.45	184.00	214.71	180.45	245.48	235.5	183.00	211.11
EM + AC	230.20	292.68	272.65	219.20	253.68	229.19	301.71	276.66	221.69	257.31
Mean (A)	189.37	254.38	240.31	187.45		190.01	259.45	245.00	188.76	
L.S.D. at 5 %	A: 20.11	B: 18.25	AB: 37.50			A: 21.65	B: 21.23	AB: 42.46		
	Root dry weight/unit (g)									
Control	15.25	22.25	21.25	13.75	18.13	15.30	22.8	22.05	14.80	18.74
Mineral NPK 100%	24.20	33.00	30.80	22.59	27.65	24.53	33.05	31.40	24.75	28.43
Mineral NPK 75%	19.80	26.40	25.29	18.47	22.49	20.40	28.38	26.18	20.35	23.83
EM (500 cm^3/1.5 m^2)	17.75	23.50	22.50	15.75	19.88	17.80	24.30	23.05	17.30	20.61
AC (50 ml/1.5 m^2)	17.00	23.00	22.00	15.25	19.31	17.05	23.3	22.55	16.55	19.86
NPK 75% + EM	21.99	28.88	26.94	19.58	24.35	22.05	29.48	27.27	21.18	25.00
NPK 75% + AC	20.34	27.77	26.12	18.75	23.25	19.85	27.00	25.91	20.08	23.21
EM + AC	25.32	32.19	29.99	22.62	27.53	25.21	33.19	30.43	24.34	28.29
Mean (A)	20.21	27.12	25.61	18.35		20.27	27.69	26.11	19.92	
L.S.D. at 5 %	A: 2.25	B: 2.06	AB: 4.12			A: 2.85	B: 2.29	AB: 4.58		

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

compared to the control treatment during the third cut in both seasons.

Similar results were proved by Adavi *et al*. (2006), Hameed and Ashraf (2008), Pessarakli *et al*. (2008), Uddin *et al*. (2009), Uddin *et al*. (2010) and Badawy *et al*. (2018) on bermudagrass.

Regarding the effect of mineral and/or biofertilizers treatments, data in Table (1) stated that root fresh and dry weights were increased due to fertilizing plants with all used seven treatments compared with the control during the third cuts in both seasons, except the biofertilization treatments EM or AC in an individual manner. The heaviest weights overall were produced from mineral NPK 100%, followed by EM + AC treatments.

Fertilizing plants with mineral NPK produced an increase in (fresh and dry weights) of roots as recorded by Rodriguez *et al*. (2002), Barton *et al*. (2006), Guertal and Evans (2006) and Ihtisham *et al*. (2018) on bermudagrass, as well as biofertilizers had a positive effect on roots weights as mentioned by Also biofertilizers increased roots weights as mentioned by Hussein and Mansour (2003) on kikuyu grass, Kumar and Nikhil (2016) on netiver grass, Sabry and Abdal-Latife (2017) on four varieties of lawn grasses.

The interaction treatments were significant for root fresh and dry weights during the third cut in both seasons. The interaction between salinity at 9000 ppm with mineral NPK 100% or EM + AC or NPK 75% + EM or NPK 75% + AC and NPK 75% were suitable treatments to mitigate the adverse effects of salinity, as shown in Table (1).

Effect on chemical composition:

1. Photosynthetic pigments (mg/g f.w.):

Regardless of all the treatments, the chlorophyll a, b and carotenoids content (mg/g f.w.) were increased in the third cut than both of the first and second cuts during both seasons (Tables, 2 to 4).

The three used levels of salinity decreased photosynthetic pigments (chlorophyll a, b and carotenoids content) which reached a significant level starting from 6000 ppm compared with control in the three cuts during both seasons.

These results are in accordance with those clarified by Hameed and Ashraf (2008), Shahba *et al*. (2012), Karimi *et al*. (2018), Sharifiasl *et al*. (2019 and 2020) on bermudagrass.

On the other hand, data presented in Table (2) showed that all seven used treatments of mineral and/or biofertilization significantly increased the chlorophyll a, b and carotenoids content (mg/g f.w.) compared with the control. The treatments of mineral NPK 100% followed by EM + AC were superior in this concern.

Mineral NPK improved photosynthetic pigments as reported by Manoly *et al.* (2008), AbdelKader and Alhumaid (2012), Abd-Elgaber (2012), Ammar (2018), Ihtisham *et al*. (2018 and 2020) and Jena and Mohanty (2020) on *Cynodon dactylon*.

The augmentation of photosynthetic pigments content due to biofertilization was mentioned by Yuojen (2015) and Ali *et al*. (2018) on bermudagrass and Turgeon (2001) on turfgrass.

The interaction treatments were significant for chlorophyll a, b and carotenoids in both seasons during the three cuts. The best interaction treatments which produced more content of chlorophyll a, b and carotenoids due to plants grown under 3000 ppm and fertilized with mineral NPK 100%, EM + AC, mineral NPK 7% + EM or AC. Also, the best overall interaction treatments which mitigated the harmful effects of high salinity (9000 ppm) were fertilizing plants with mineral NPK 100% or EM + AC.

2. Nitrogen, phosphorus and potassium contents (%):

The percentages of nitrogen, phosphorus and potassium in dry herb were significantly

Table 2. Effect of salinity concentration, mineral and biofertilization on chlorophyll a (mg/g f.w.) of bermudagrass during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	First cut									
Control	2.400	2.500	2.445	2.380	2.431	2.520	2.625	2.567	2.499	2.553
Mineral NPK 100%	2.960	2.830	2.820	2.790	2.850	3.108	2.972	2.961	2.930	2.993
Mineral NPK 75%	2.730	2.730	2.619	2.610	2.672	2.767	2.867	2.750	2.741	2.781
EM (500 cm^3/1.5 m^2)	2.690	2.700	2.600	2.550	2.635	2.725	2.835	2.730	2.678	2.742
AC (50 ml/1.5 m^2)	2.570	2.690	2.540	2.510	2.578	2.699	2.825	2.667	2.636	2.707
NPK 75% + EM	2.810	2.800	2.780	2.700	2.773	2.951	2.940	2.919	2.835	2.911
NPK 75% + AC	2.880	2.805	2.701	2.690	2.769	3.024	2.945	2.836	2.825	2.908
EM + AC	2.900	2.815	2.790	2.740	2.811	3.045	2.956	2.930	2.877	2.952
Mean (A)	2.743	2.734	2.662	2.621		2.880	2.870	2.795	2.752	
L.S.D. at 5 %	A: 0.040		B: 0.025		AB: 0.050	A: 0.045		B: 0.027		AB: 0.054
	Second cut									
Control	2.496	2.575	2.518	2.451	2.510	2.667	2.769	2.708	2.636	2.695
Mineral NPK 100%	3.073	2.915	2.905	2.874	2.942	3.287	3.135	3.124	3.091	3.159
Mineral NPK 75%	2.836	2.812	2.698	2.688	2.759	3.033	3.024	2.901	2.891	2.962
EM (500 cm^3/1.5 m^2)	2.795	2.781	2.678	2.627	2.720	2.988	2.991	2.880	2.825	2.921
AC (50 ml/1.5 m^2)	2.671	2.771	2.616	2.585	2.661	2.855	2.980	2.814	2.780	2.857
NPK 75% + EM	2.918	2.884	2.863	2.781	2.862	3.021	3.102	3.080	2.991	3.049
NPK 75% + AC	2.990	2.889	2.782	2.771	2.858	3.099	3.107	2.992	2.980	3.045
EM + AC	3.011	2.899	2.874	2.822	2.902	3.021	3.118	3.091	3.035	3.066
Mean (A)	2.849	2.816	2.742	2.700		3.046	3.028	2.949	2.904	
L.S.D. at 5 %	A: 0.041		B: 0.027		AB: 0.054	A: 0.042		B: 0.030		AB: 0.060
	Third cut									
Control	2.542	2.650	2.592	2.523	2.577	2.712	2.809	2.747	2.674	2.736
Mineral NPK 100%	3.136	3.000	2.989	2.957	3.021	3.341	3.180	3.168	3.135	3.206
Mineral NPK 75%	2.892	2.894	2.776	2.767	2.832	3.082	3.067	2.942	2.932	3.006
EM (500 cm^3/1.5 m^2)	2.749	2.862	2.756	2.703	2.768	3.038	3.033	2.921	2.865	2.964
AC (50 ml/1.5 m^2)	2.722	2.851	2.692	2.661	2.732	2.903	3.022	2.854	2.820	2.900
NPK 75% + EM	2.977	2.968	2.947	2.862	2.939	3.072	3.146	3.123	3.033	3.094
NPK 75% + AC	3.051	2.973	2.863	2.851	2.935	3.251	3.151	3.035	3.022	3.115
EM + AC	3.072	2.984	2.957	2.904	2.979	3.273	3.163	3.135	3.078	3.162
Mean (A)	2.893	2.898	2.822	2.779		3.084	3.071	2.991	2.945	
L.S.D. at 5 %	A: 0.042		B: 0.029		AB: 0.058	A: 0.045		B: 0.031		AB: 0.062

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

Table 3. Effect of salinity concentration, mineral and biofertilization on chlorophyll b (mg/g f.w.) of bermudagrass during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	First cut									
Control	0.793	0.813	0.795	0.773	0.794	0.830	0.855	0.836	0.813	0.834
Mineral NPK 100%	0.980	0.923	0.920	0.910	0.933	1.026	0.971	0.967	0.957	0.980
Mineral NPK 75%	0.903	0.890	0.853	0.850	0.874	0.946	0.936	0.897	0.894	0.918
EM (500 $cm^3/1.5\ m^2$)	0.890	0.880	0.847	0.830	0.862	0.932	0.925	0.890	0.873	0.905
AC (50 $ml/1.5\ m^2$)	0.850	0.877	0.827	0.817	0.843	0.890	0.922	0.869	0.859	0.885
NPK 75% + EM	0.930	0.913	0.907	0.880	0.908	0.974	0.960	0.953	0.925	0.953
NPK 75% + AC	0.953	0.915	0.880	0.877	0.906	0.998	0.962	0.925	0.922	0.952
EM + AC	0.960	0.918	0.910	0.893	0.920	1.005	0.965	0.957	0.939	0.967
Mean (A)	0.907	0.891	0.867	0.854		0.950	0.937	0.912	0.897	
L.S.D. at 5 %	A: 0.013		B: 0.009		AB: 0.018	A: 0.014		B: 0.010		AB: 0.020
	Second cut									
Control	0.830	0.848	0.829	0.807	0.834	0.887	0.913	0.893	0.869	0.891
Mineral NPK 100%	1.023	0.962	0.958	0.948	0.980	1.094	1.035	1.031	1.020	1.045
Mineral NPK 75%	0.944	0.927	0.889	0.886	0.918	1.009	0.998	0.957	0.954	0.980
EM (500 $cm^3/1.5\ m^2$)	0.930	0.917	0.883	0.866	0.905	0.994	0.987	0.950	0.932	0.966
AC (50 $ml/1.5\ m^2$)	0.889	0.914	0.862	0.852	0.885	0.950	0.983	0.928	0.917	0.945
NPK 75% + EM	0.971	0.951	0.944	0.917	0.952	1.039	1.024	1.017	0.987	1.017
NPK 75% + AC	0.995	0.953	0.917	0.914	0.951	1.065	1.026	0.987	0.983	1.015
EM + AC	1.002	0.956	0.948	0.931	0.966	1.072	1.029	1.020	1.002	1.031
Mean (A)	0.948	0.929	0.904	0.890		1.014	0.999	0.973	0.958	
L.S.D. at 5 %	A: 0.013		B: 0.010		AB: 0.020	A: 0.015		B: 0.009		AB: 0.018
	Third cut									
Control	0.857	0.878	0.859	0.836	0.858	0.904	0.931	0.911	0.886	0.908
Mineral NPK 100%	1.055	0.995	0.991	0.981	1.006	1.114	1.055	1.051	1.040	1.065
Mineral NPK 75%	0.974	0.960	0.920	0.917	0.943	1.027	1.017	0.976	0.972	0.998
EM (500 $cm^3/1.5\ m^2$)	0.960	0.949	0.914	0.896	0.930	1.013	1.006	0.969	0.950	0.985
AC (50 $ml/1.5\ m^2$)	0.917	0.945	0.892	0.882	0.909	0.968	1.002	0.946	0.935	0.963
NPK 75% + EM	1.002	0.984	0.977	0.949	0.978	1.057	1.044	1.036	1.006	1.036
NPK 75% + AC	1.027	0.986	0.949	0.945	0.977	1.084	1.045	1.007	1.002	1.035
EM + AC	1.034	0.990	0.981	0.963	0.992	1.091	1.049	1.040	1.021	1.050
Mean (A)	0.978	0.961	0.936	0.921		1.032	1.019	0.992	0.977	
L.S.D. at 5 %	A: 0.014		B: 0.011		AB: 0.022	A: 0.014		B: 0.010		AB: 0.020

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

Table 4. Effect of salinity concentration, mineral and biofertilization on carotenoids (mg/g f.w.) of bermudagrass during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	First cut									
Control	0.848	0.863	0.845	0.823	0.845	0.885	0.905	0.886	0.863	0.885
Mineral NPK 100%	1.035	0.973	0.970	0.960	0.985	1.081	1.021	1.017	1.007	1.032
Mineral NPK 75%	0.958	0.940	0.903	0.900	0.925	1.001	0.986	0.947	0.944	0.970
EM (500 cm^3/1.5 m^2)	0.945	0.930	0.897	0.880	0.913	0.987	0.975	0.940	0.923	0.956
AC (50 ml/1.5 m^2)	0.905	0.927	0.877	0.867	0.894	0.945	0.972	0.919	0.909	0.936
NPK 75% + EM	0.985	0.963	0.957	0.930	0.959	1.029	1.010	1.003	0.975	1.004
NPK 75% + AC	1.008	0.965	0.930	0.927	0.958	1.053	1.012	0.975	0.972	1.003
EM + AC	1.015	0.968	0.960	0.943	0.972	1.060	1.015	1.007	0.989	1.018
Mean (A)	0.962	0.941	0.917	0.904		1.005	0.987	0.962	0.947	
L.S.D. at 5 %	A: 0.019	B: 0.009	AB: 0.018			A: 0.014	B: 0.010	AB: 0.020		
	Second cut									
Control	0.885	0.903	0.884	0.862	0.884	0.942	0.968	0.948	0.924	0.946
Mineral NPK 100%	1.078	1.017	1.013	1.003	1.028	1.149	1.090	1.086	1.075	1.100
Mineral NPK 75%	0.999	0.982	0.944	0.941	0.967	1.064	1.053	1.012	1.009	1.035
EM (500 cm^3/1.5 m^2)	0.985	0.972	0.938	0.921	0.954	1.049	1.042	1.005	0.987	1.021
AC (50 ml/1.5 m^2)	0.944	0.969	0.917	0.907	0.934	1.005	1.038	0.983	0.972	1.000
NPK 75% + EM	1.026	1.006	0.999	0.972	1.001	1.094	1.079	1.072	1.042	1.072
NPK 75% + AC	1.050	1.008	0.972	0.969	1.000	1.120	1.081	1.042	1.038	1.070
EM + AC	1.057	1.011	1.003	0.986	1.014	1.127	1.084	1.075	1.057	1.086
Mean (A)	1.003	0.984	0.959	0.945		1.069	1.054	1.028	1.013	
L.S.D. at 5 %	A: 0.013	B: 0.010	AB: 0.020			A: 0.014	B: 0.009	AB: 0.018		
	Third cut									
Control	0.922	0.943	0.924	0.901	0.923	0.969	0.996	0.976	0.951	0.973
Mineral NPK 100%	1.120	1.060	1.056	1.046	1.071	1.179	1.120	1.116	1.105	1.130
Mineral NPK 75%	1.039	1.025	0.985	0.982	1.008	1.092	1.082	1.041	1.037	1.063
EM (500 cm^3/1.5 m^2)	1.025	1.014	0.979	0.961	0.995	1.078	1.071	1.034	1.015	1.050
AC (50 ml/1.5 m^2)	0.982	1.010	0.957	0.947	0.974	1.033	1.067	1.011	1.000	1.028
NPK 75% + EM	1.067	1.049	1.042	1.014	1.043	1.122	1.109	1.101	1.071	1.101
NPK 75% + AC	1.092	1.051	1.014	1.010	1.042	1.149	1.110	1.072	1.067	1.100
EM + AC	1.099	1.055	1.046	1.028	1.057	1.156	1.114	1.105	1.086	1.115
Mean (A)	1.043	1.026	1.001	0.986		1.097	1.084	1.057	1.042	
L.S.D. at 5 %	A: 0.011	B: 0.011	AB: 0.022			A: 0.012	B: 0.012	AB: 0.024		

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

decreased by all salinity levels (3000, 6000 and 9000 ppm) in the two growing seasons facing the control, except between control and the low salinity level treatments which failed to reach the level of significance as presented in Table (5).

The harmful impacts of salinity in N, P and K % were proved by several authors such as Hameed and Ashraf (2008) and Badawy *et al*. (2018) on bermudagrass, Shahin *et al*. (2014) on tall fescue, and Mohammed *et al*. (2019) on paspalum.

All used seven treatments significantly increased nitrogen, phosphorus and potassium (%) in dry herb in the two growing seasons facing the control. The treatments of mineral NPK 100% followed by EM + AC produced the highest values of N, P and K (%).

The enhancement of element (N, P and K %) due to mineral NPK appears in our results, also were detected by Manoly (2000), Manoly *et al.* (2008), AbdelKader and Alhumaid (2012), Abd-Elgaber (2012) and Ihtisham *et al*. (2020) on *Cynodon dactylon*.

The enhancing effects of biofertilization in improving element content (dry herb N, P and K %) were proved by Ali *et al*. (2018) on bermudagrass, Hussein and Mansour (2003) on kikuyu grass, Dwivedi *et al.* (2016) on kodo millet (*Paspalum scrobiculatum*, L.

The interaction treatments were significant for dry herb N, P and K % in both seasons. The best interaction treatments which recorded more percentage of N were control without salinity in combination with mineral NPK 100%, followed by EM + AC, then AC in the first season, while in the second season, the highest values of N % were enhanced with mineral NPK 100%, EM + AC, mineral NPK 75% + EM or + AC, and mineral NPK 75% in the 3rd cut. For P %, the highest values in both seasons were obtained with mineral NPK 100%, followed by EM + AC, then mineral NPK 75% + EM or + AC, without significant differences between such three treatments. For K, the interaction treatments of mineral NPK 100%, followed by EM + AC produced the highest values of K % in both seasons, without significant differences between such two superior treatments as shown in Table (5).

3. Sodium, calcium, chloride and proline contents (%):

Data presented in Tables (6 and 7) indicated that all salinity levels significantly increased Na, Ca and Cl (%) as well as proline (µg/g) content in bermuda herb in the two growing seasons facing the control. The percentages and content of previous parameters were increased by a gradual increase in irrigation water salinity. So, the maximum values were obtained with the high level of salinity (9000 ppm).

The effect of salinity in Na, Ca and Cl % as well as proline content were proved by Hameed and Ashraf (2008), Nadeem *et al*. (2012), Badawy *et al*. (2018), Karimi *et al*. (2018) and Sharifiasl *et al*. (2019 and 2020) on bermudagrass.

Concerning the effect of fertilization treatments, all used seven treatments differently affected the above-mentioned traits. Where sodium and chloride were reduced due to all used treatments facing the control. The highest percentages were obtained by control treatment, followed by AC, then EM without any significant differences between such three treatments for Na and Cl (%). Therefore, the lowest values were recorded with mineral treatment NPK 100%, followed by EM + AC treatments compared with control. Concerning the content of proline and calcium (%), they were significantly increased due to all used treatments compering with control, with the highest content obtained from mineral NPK 100%, followed by EM + AC treatments. The influences of biofertilization in element content were mentioned by Mirjalili *et al*. (2015) on *Achillea millefolium*, Kleiber *et al*. (2013) on lettuce.

Table 5. Effect of salinity concentration, mineral and biofertilization on N, P and K (%) in dry herb of bermudagrass (3rd cut) during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A) 0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	Nitrogen (%) in dry herb									
Control	3.13	3.12	2.89	2.81	2.99	3.22	3.17	2.96	2.81	3.04
Mineral NPK 100%	3.43	3.32	3.21	3.06	3.26	3.60	3.44	3.33	3.18	3.39
Mineral NPK 75%	3.25	3.23	3.09	2.96	3.13	3.49	3.29	3.15	3.02	3.24
EM (500 cm^3/1.5 m^2)	3.24	3.23	3.00	2.94	3.10	3.44	3.29	3.05	3.00	3.20
AC (50 ml/1.5 m^2)	3.32	3.21	3.01	2.86	3.10	3.42	3.28	3.05	2.97	3.18
NPK 75% + EM	3.29	3.24	3.10	2.97	3.15	3.50	3.30	3.16	3.03	3.25
NPK 75% + AC	3.26	3.24	3.10	2.99	3.15	3.49	3.30	3.16	3.04	3.25
EM + AC	3.38	3.24	3.15	3.02	3.20	3.60	3.38	3.29	3.16	3.36
Mean (A)	3.29	3.23	3.07	2.95		3.47	3.31	3.14	3.03	
L.S.D. at 5 %	A: 0.08	B: 0.06		AB: 0.12		A: 0.18	B: 0.07		AB: 0.14	
	Phosphorus (%) in dry herb									
Control	0.351	0.34	0.322	0.301	0.329	0.351	0.34	0.322	0.301	0.329
Mineral NPK 100%	0.385	0.377	0.356	0.336	0.364	0.385	0.377	0.356	0.336	0.364
Mineral NPK 75%	0.365	0.360	0.345	0.320	0.348	0.365	0.360	0.345	0.320	0.348
EM (500 cm^3/1.5 m^2)	0.363	0.368	0.335	0.308	0.344	0.363	0.368	0.335	0.308	0.344
AC (50 ml/1.5 m^2)	0.364	0.349	0.340	0.315	0.342	0.364	0.349	0.340	0.315	0.342
NPK 75% + EM	0.371	0.370	0.349	0.328	0.355	0.371	0.370	0.349	0.328	0.355
NPK 75% + AC	0.367	0.368	0.346	0.327	0.352	0.367	0.368	0.346	0.327	0.352
EM + AC	0.380	0.372	0.352	0.330	0.359	0.380	0.372	0.352	0.330	0.359
Mean (A)	0.368	0.363	0.343	0.321		0.368	0.363	0.343	0.321	
L.S.D. at 5 %	A: 0.009	B: 0.008		AB: 0.016		A: 0.016	B: 0.008		AB: 0.016	
	Potassium (%) in dry herb									
Control	1.560	1.520	1.480	1.390	1.488	1.609	1.566	1.524	1.432	1.533
Mineral NPK 100%	1.666	1.645	1.548	1.482	1.585	1.718	1.694	1.594	1.526	1.633
Mineral NPK 75%	1.630	1.630	1.505	1.450	1.554	1.681	1.679	1.55	1.494	1.601
EM (500 cm^3/1.5 m^2)	1.628	1.600	1.495	1.420	1.536	1.679	1.648	1.54	1.463	1.583
AC (50 ml/1.5 m^2)	1.620	1.588	1.487	1.412	1.527	1.671	1.636	1.532	1.454	1.573
NPK 75% + EM	1.639	1.638	1.520	1.455	1.563	1.691	1.687	1.566	1.499	1.611
NPK 75% + AC	1.632	1.634	1.518	1.452	1.559	1.683	1.683	1.564	1.496	1.607
EM + AC	1.650	1.640	1.530	1.472	1.573	1.702	1.689	1.576	1.516	1.621
Mean (A)	1.628	1.612	1.510	1.442		1.679	1.660	1.556	1.485	
L.S.D. at 5 %	A: 0.017	B: 0.013		AB: 0.026		A: 0.020	B: 0.012		AB: 0.024	

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

Table 6. Effect of salinity concentration, mineral and biofertilization on Na, Ca and Cl (%) in dry herb of bermudagrass (3rd cut) during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
	Sodium (%) in dry herb									
Control	1.22	1.84	2.91	3.68	2.41	1.24	1.87	2.95	3.74	2.45
Mineral NPK 100%	0.95	1.19	2.05	2.79	1.75	0.97	1.21	2.09	2.85	1.78
Mineral NPK 75%	1.10	1.44	2.77	3.22	2.13	1.12	1.46	2.82	3.27	2.17
EM (500 cm^3/1.5 m^2)	1.14	1.59	2.68	3.38	2.20	1.16	1.62	2.73	3.44	2.23
AC (50 ml/1.5 m^2)	1.19	1.73	2.59	3.49	2.25	1.21	1.76	2.63	3.55	2.29
NPK 75% + EM	1.03	1.31	2.34	3.01	1.92	1.05	1.33	2.38	3.06	1.96
NPK 75% + AC	1.06	1.38	2.53	3.10	2.02	1.08	1.40	2.58	3.16	2.05
EM + AC	0.99	1.26	2.18	2.93	1.84	1.01	1.29	2.22	2.99	1.88
Mean (A)	1.09	1.47	2.51	3.20		1.10	1.49	2.55	3.26	
L.S.D. at 5 %	A: 0.33		B: 0.21		AB: 0.42	A: 0.37		B: 0.23		AB: 0.46
	Calcium (%) in dry herb									
Control	1.08	1.62	2.11	2.24	1.76	1.10	1.64	2.14	2.27	1.79
Mineral NPK 100%	1.99	2.37	2.59	2.91	2.47	2.03	2.42	2.64	2.97	2.51
Mineral NPK 75%	1.50	1.81	2.27	2.52	2.03	1.53	1.84	2.31	2.56	2.06
EM (500 cm^3/1.5 m^2)	1.24	1.74	2.21	2.43	1.91	1.26	1.77	2.25	2.47	1.94
AC (50 ml/1.5 m^2)	1.17	1.71	2.17	2.35	1.85	1.19	1.74	2.21	2.39	1.88
NPK 75% + EM	1.73	2.01	2.39	2.76	2.22	1.76	2.05	2.43	2.81	2.26
NPK 75% + AC	1.62	1.88	2.33	2.69	2.13	1.65	1.91	2.37	2.74	2.17
EM + AC	1.87	2.26	2.48	2.83	2.36	1.91	2.31	2.53	2.89	2.41
Mean (A)	1.53	1.93	2.32	2.59		1.55	1.96	2.36	2.64	
L.S.D. at 5 %	A: 0.21		B: 0.11		AB: 0.22	A: 0.25		B: 0.12		AB: 0.24
	Chloride (%) in dry herb									
Control	1.11	1.99	2.57	3.48	2.29	1.13	2.02	2.61	3.53	2.32
Mineral NPK 100%	1.01	1.50	1.78	2.29	1.65	1.03	1.53	1.82	2.34	1.68
Mineral NPK 75%	1.07	1.73	2.23	2.87	1.98	1.09	1.76	2.27	2.92	2.01
EM (500 cm^3/1.5 m^2)	1.09	1.80	2.29	2.93	2.03	1.11	1.83	2.33	2.98	2.06
AC (50 ml/1.5 m^2)	1.10	1.91	2.40	3.13	2.14	1.12	1.94	2.44	3.18	2.17
NPK 75% + EM	1.04	1.6	1.99	2.48	1.78	1.06	1.63	2.03	2.52	1.81
NPK 75% + AC	1.06	1.67	2.12	2.62	1.87	1.08	1.70	2.16	2.67	1.90
EM + AC	1.02	1.55	1.87	2.36	1.70	1.04	1.58	1.91	2.41	1.73
Mean (A)	1.06	1.72	2.16	2.77		1.08	1.75	2.19	2.82	
L.S.D. at 5 %	A: 0.51		B: 0.28		AB: 0.56	A: 0.47		B: 0.29		AB: 0.38

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

Table 7. Effect of salinity concentration, mineral and biofertilization on proline content (µg/g f.w.) of bermudagrass (3rd cut) during the two growing seasons (2020 and 2021).

Mineral and biofertilization treatments (B)	Salinity concentrations (ppm) (A)									
	0.0	3000	6000	9000	Mean (B)	0.0	3000	6000	9000	Mean (B)
	The 1st season (2020)					The 2nd season (2021)				
Control	218	254	274	312	265	221	258	278	317	268
Mineral NPK 100%	314	362	398	434	377	320	369	406	443	385
Mineral NPK 75%	252	293	319	355	305	256	298	324	361	310
EM (500 $cm^3/1.5\ m^2$)	241	275	296	334	287	245	280	301	340	291
AC (50 $ml/1.5\ m^2$)	230	263	273	323	272	234	267	278	328	277
NPK 75% + EM	281	336	358	395	343	286	342	364	402	349
NPK 75% + AC	266	311	342	378	324	271	317	348	385	330
EM + AC	297	350	379	413	360	303	357	387	421	367
Mean (A)	262	306	330	368		267	311	336	375	
L.S.D. at 5 %	A: 23	B: 16	AB: 32			A: 24	B: 18	AB: 36		

EM: Effective microorganisms and AC: *Azotobacter chroococcum* bacteria

The interaction treatments were significant for dry herb Na, Ca and Cl % as well as proline content in both seasons. The highest values of Na and Cl percentages were obtained from control under 9000 ppm, followed by 9000 ppm × AC or EM. While the best interaction treatments for Ca were recorded with 9000 ppm with mineral NPK 100%, 9000 ppm × AC + EM, mineral NPK 75% + EM or with AC in both seasons. The proline content was the highest with mineral NPK 100%, followed by EM or AC under 9000 ppm as shown in Tables (6 and 7).

CONCLUSION

From the previous results, it might be concluded that the beneficial and distinctive role of mineral NPK and biofertilization were responsible for alleviating the harmful effects of salinity led to different physiological processes, which reflect on stimulating the vegetative and root growth, and some chemical constituents (photosynthetic pigments, proline, Ca and NPK%) and reduced Na and Cl % of bermudagrass (*Cynodon dactylon*, L.).

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تأثير بعض معاملات الملوحة والتسميد علي نباتات البرمودا
ب. نمو الجذور وبعض المكونات الكيميائية

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أجريت هذه الدراسة بمزرعة خاصة بمركز بني مزار، محافظة المنيا، مصر خلال موسمي النمو ٢٠٢٠ و ٢٠٢١ لبحث تأثير ملوحة مياه الري ومعاملات التسميد المعدني و/أو الحيوي، وكذلك التفاعل بينها على نمو الجذور وبعض المكونات الكيميائية للبرمودا (*Cynodon dactylon*, L.) المنزرع في التربة الرملية. أظهرت النتائج أن صفات نمو الجذر (طول الجذر والأوزان الطازجة والجافة/وحدة) قد تحسنت بمستويات الملوحة المنخفضة والمتوسطة (٣٠٠٠ و ٦٠٠٠ جزء في المليون) ، بينما انخفضت هذه الصفات مع ارتفاع مستوى الملوحة (٩٠٠٠ جزء في المليون) مقارنة بمعاملة الكنترول، في الثلاث حشات خلال الموسمين. أدت جميع معاملات الملوحة إلى زيادة النسبة المئوية للصوديوم والكلور والكالسيوم وكذلك محتوى النبات من البرولين، بينما أدت إلي انخفاض صبغات التمثيل الضوئي وكذلك النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم. أدت جميع معاملات التسميد المعدني و / أو الحيوي المستخدمة إلى زيادة طول الجذر والأوزان الطازجة والجافة / الوحدة بشكل كبير مقارنةً بمعاملة الكنترول في الحشات الثلاث ، باستثناء معاملة الـ AC لطول الجذر ومعاملتي الـ EM و AC في حالة الأوزان الطازجة والجافة/وحدة، مع أعلى القيم حيث تم الحصول عليها باستخدام معاملة ١٠٪ NPK معدني يليه معاملة EM + AC خلال الموسمين. زادت النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم والكالسيوم وكذلك صبغات التمثيل الضوئي والمحتوى من البرولين نتيجة إضافة أي من معاملات عامل الثانوي ، بينما انخفض الصوديوم والكلوريد.