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Growth and Mineral Status of Panicum Plants Responses to Foliar Fertilizers and Salt Stress

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A POT experiment conducted aiming to evaluate the response of three genotypes of panicum to salt stress in the greenhouse of the National Research Centre in Dokki, Cairo, Egypt during the summer season of 2018. The treatments were as follows: Genotypes: Local, White imp and Dark imp. Salinity: Tap water (270 ppm), 3000 and 6000 ppm. The obtained results showed that: the highest stem weight shown by local variety but the lowest was by the weight imported. In case of leaves, the highest weight was by Dark imported variety and the lowest was by local variety. Concerning the top dry weight, the dark imported was the first, and local and white imported seemed to be equal. The concentrations of N, Ca and K increased with the moderate salinity and tended to decreased by the highest level of salinity but still more than the control. The reverse was true for Mn concentration. On the contrarily, Cu and Zn decreased as the concentration of salt increased. But vice versa for Fe concentration. Na ratios to some of the other macronutrients such as Na/K, Na/Ca and Na/Mg as well as Ca (Na + k) differ in different panicum types and level of salinity used.

Keywords: Panicum (*P. virgatum L*)-Salinity-Varieties-Growth-Mineral status.

Introduction

Renewable energy is expect to make a significant contribution to meet global energy needs due to diminishing availability of discoverable fossil fuel reserves and the environmental consequences of exhaust gases from fossil fuel. **The U.S. Energy Information Administration (2014)** reported that renewable energy, excluding hydropower, accounted for 28% of the overall growth in electricity generation from 2012 to 2040. Biofuel, one of the most important types of renewable energy is gaining popularity and the demand for bio fuel is increasing. Ethanol made from lingo-cellulosic feed stocks could play a critical role in promoting energy diversity and reducing carbon dioxide emissions (**Intr. Energy Agency, 2006**).

Switch grass (*Panicum virgatum* L.) plants yielded high dry mass so that it considered one of the most promising crops for bio energy (**Kim**, ***et al*****., 2012**). This plants grown successfully in marginal areas. Mentioned that switch grass is a perennial C4 plants high efficient in conversion solar energy to biomass, thus, it more suitable and used extensively for bio ethanol production (**Deen, 2015). Mitchell, *et al*., (2014**) noticed that switch grass was selected by Bio energy feedstock development program at the USA department of energy. This crop can grown in marginal areas, tolerant to a biotic stresses such as salinity drought and grown in worm environment with high yielding biomass without competition of food crops (**Simmons, *et al*., 2008**). Moreover, **Hull, (2007)** pointed out that switch grass is a perennial warm season grass that is native to North America from 55° N latitude in Canada southwards into the United States and Mexico. It is primarily use for soil conservation forage production, and as an ornamental grass in the U.S. It has been identified as a sustainable source of biomass feedstock for energy production with the potential to produce about 380 liters of ethanol per metric ton.

Switch grass has a broad adaptability, tolerates water and nutrient limitations, and has the ability to produce moderate to high biomass yields on marginal lands (**Jimmy Carter Plant Materials Center, 2011**). Switch grass genotypes or varieties differ in its responses to salt stress (**Zhao, *et al*., 2013**). This expected through different ways of salt effects such as: germination and seedling emergence (**Kim, 2012**); gases exchange and photosynthetic activity (**Koreo, *et al*., 2013**); mineral status disturbance (**Hussein, *et al*., 2008; Hussein and Abu Bakr (2018) and Sun, *et al*., (2018**) or oxidative defense under saline conditions (**Hussein and Orabi, 2008 and Orabi, *et al*., (2018**). Adverse

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environment such as drought, high temperature, salinity and minerals stress more than nutrients deficient considered the main factors which reduced the productivity of soils in arid and semi-arid areas (**Shannon, *et al*., 1994 and Kubban, *et al*., 1999)**. **Uddin, *et al*., (2011)** concluded that salinity increased the accumulation of toxic ions and affecting the osmotic adjustment in geophytes and in halophytes beside the osmotic adjustment the mentioning of salt tolerance mechanisms with accumulation of inorganic ions such as K and organic molecules such as praline. Salt stress and its effect on physiological processes, growth and yield of Panicum were studied by many authors (**Al-Khateeb,2006; Koryo, *et al*., 2013; Khan, *et al*., 2009 and Nakamura, *et al*., 2011 and Uddin, *et al*., 2012**).

Many plants grown in saline soils used as a forage for animal feeds such as Dinuba, switch grass, barley, turf, Tuff, torpedo grass and Salicornia.

Selection of salt tolerant genotypes were studied by many authors among of them**: Uddin, *et al*., (2012),** One from the fruitful suggested strategies for economical use of saline water or developing cultivation in saline soil is the breeding of varieties tolerate to salt stress and given considerable growth and yield (**Foolad, 2004**). Despite numerous efforts, few salt-tolerant genotypes have been released (**Flower and You, 1996**), owing to insufficient genetic knowledge of the tolerance traits, lack of effective selection criteria and evaluation methods, and poor understanding of the interaction between salinity and environment (**Jafar, *et al*., 2012**) and (**Lines, *et al*., 2014).**

Therefore, the objective of this work is to investigate the effect of salinity on growth and mineral status of three types of panicum plants.

Materials and Methods

A pot experiment was conducted getting to evaluate the response of three genotypes of panicum to salt stress within the greenhouse of the National Research Centre in Dokki, Cairo, Egypt during the summer season of 2018 some physical and chemical properties of soil were illustrated in Table (1), some chemical properties of irrigation water saline treatments were in table (2), according to **Cottenee, *et al*., (1982).**

Table 1. Partial size distribution and chemical characteristics of the investigated soil.

Course sand %	8.6	Fine sand %	24.4	Silt %	23.9	Clay %	43.1	Soil texture	Clay Loam

pH 1:2.5	EC dSm^{-1}	$CaCO_3$ %	OM %	Soluble cations meq/100g soil				Soluble anions meq/100g soil			
				Na^+	K^+	Ca^{++}	Mg^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
7.49	2.58	3.08	0.87	7.69	0.58	12.4	5.13	-	1.05	12. 8	11.95

Available macro-nutrients%				Available micro-nutrients ppm		
N	P	K	Fe	Zn	Cu	Mn
1.02	0. 22	1.25	4.67	4.08	0.94	4.53

Table 2. Some and chemical properties of of the investigated irrigation water salinity.

Source	pH	EC dSm^{-1}	Soluble cations (mq/L)				Soluble anions (mq/L)			
			Na^+	K^+	Mg^{++}	Ca^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
Sea water	7.94	53	448	11.3	45	26.2	1.7	3.8	505	20

The treatments were as follows:
Genotypes: Local, White (Canadian) imp and Dark (Iranian) imp
Salinity: Tap water 270 ppm, 3000 and 6000 ppm

The experiment included 9 treatments which the combination between three genotypes and three salinity treatments. The experimental design was split plot in 8 replicates. Seeds of the three genotypes of panicum (*Panicum virgatum* L.) were sown in April, 14. 2018. Calcium superphosphate (15.5%P_2O_5) and potassium sulphate (48.5% K_2O) in the rate of and g/pot, respectively were mixed with the upper 10 cm before sowing. Ammonium sulphate (30.5% N) was added in the rate of g/pot in two equal portions, the first 15 days from sowing and the second portion two weeks later. Treatments were started 21 days after sowing. Two plants from every subplot were picked, cleaned, dried in electric oven until weight was fixed and ground in stainless steel mill. Digestion and determination of macro and micronutrients were done as described by **Cottenee, *et al*., (1982).**

All collected Data were subjected to the proper statistical analysis as described by **Snedecor and Cochran (1980).**

Results and Discussion

Dry Weight

- **Genotypes**

Data in Table (3) showed that the highest stem weight was shown by local variety but the lowest was by the weight imported. In case of leaves, the highest weight was by Dark imported variety and the lowest was by local variety. Concerning the top dry weight, the dark imported was the first, and local and white imported seemed to be equal.

Table 3. Response of dry weight of three genotypes of panicum plant.

Types	Stem	Leaves	Stem+leaves	L/S
Local	40.50	14.08	54.58	0.34
White imp.	32.61	20.50	53.11	0.62
Dark imp.	34.11	27.34	61.45	0.80
LSD 0.5%	N.S	N.S	N.S	-----

Liu, *et al*., (2015) evaluated 195 broomcorn (*Panicum miliaceum L.)* and showed the varietal differences in its growth**. Grigatti, *et al*., (2004)** tested different genotypes and observed the different in growth and yield**. Gollagi (2005**) evaluated different genotypes and detected the differences based on crop performance. There is large genotypic variation in salt tolerance in broomcorn millet, suggesting that it possesses rich genetic resources for improving productivity in saline soil **(Sabir and *et al*., 2011 and Wang, *et al*., 2015).**

- **Salinity**

Negative response was observed to salinity subjection (Table 4) which the stem and leaves dry weight decreased parallel to the increase in salt concentration in irrigation solution. This Data also shown that leaves damages more than stems.

Table 4. Response of dry matter of panicum to salinity.

Salinity	Stem	Leaves	Stem + leaves	L/S
Tap w	45.64	33.84	79.48	0.74
3000	41.12	19.37	60.49	0.47
6000	21.12	11.10	32.22	0.52
LSD	20.78	14.97	26.21	-----

Al-**Khateeb (2006)** found stimulation in shoot and root dry weight of *Panicum turgidum* with low level of salinity (25-5 mM) but significant decreases were shown with high salinity (>100 mM). **Mahmoud and Athar (2003)** concluded that salinity resulted in excessive ion accumulation and K depression, this intern led in great reduction in growth parameters of panicum plants. A**kram, *et al*., (2006**) confirmed these findings. **Jafari, *et al*., (2009)** revealed that plant height, shoot and root weight, and reproductive organs were decreased by salinity, also the same response of relative water and CO2 exchange. CO2 exchange showed the reverse under severe salinity. Salt stress affecting growth and yield through effect on water status and Na+ and CL- toxicity on metabolic processes such as photosynthesis, mineral absorption and distribution; enzymes activity and oxidative defense (**Munns, et al 2003; Gratan and Grive, 2002; Hussein, *et al*., 2008**; **Hussein and El-Greatly; 2007; Hussein, and Oraby, 2008; Koyro, *et al*., 2013 and Hussein, *et al* ., 2015).** In addition, **Koyro, *et al*., (2013**) reported that growth (fresh and dry matter) of panicum plants did not affected by the low level of salinity (125 mM). High salinity affected significantly the correlated physiological processes such as net photosynthetic rate, transpiration rate water use efficiency and electron transport rate. They added that salinity affected decarboxylation and this intern increase oxidative stress, electrolyte leakage and water use efficiency.

- **Genotypes X Salinity**

ct of genotypes and salinity on The interactive effe re presented in Tabgrowth wect (5). As the result of stem and leaves dry weigh, the salt stress (6000 ppm) more effective on stem dry weight to be about half of the control for the three types, but for leaves dry weight. The highest effect was by the same salt concentration with the dark imported panicum followed by that of white imported and the local type comes later.

Table 5. Dry weight of three panicum genotypes response to salinity.

Var	Sal.	Dry weight			Leaves/stem
		Stem	Leaves	Stem+leaves	
Local	Tap W.	56.33	18.60	74.93	0.33
	3000	40.13	15.17	55.30	0.37
	6000	25.03	10.87	35.90	0.43
White imp	Tap W.	46.30	34.33	80.63	0.74
	3000	30.90	15.77	46.67	0.51
	6000	20.63	11.40	32.03	0.55
Dark imp	Tap W.	32.30	48.60	80.90	1.50
	3000	52.33	22.17	74.50	0.42
	6000	17.70	11..03	28.73	0.62
LSD		35.99	N.S	39.84	-----

Genotypes X Salinity

Furthermore, The L/S ratio increased with salinity for the local type but reversely responded for the two imported genotypes. **Uddin, *et al.*, (2012**) reported that the highest level of salinity (528 mM) the least effect on dry weight reduction of shoots was observed in *P. vogenatum* (40%) followed by *C. dactylon*satin (44%) in comparison with the control, however, in root weight the latest reduction with the high level of salinity on root dry weight was by *P. vogenatum* (23%)but followed by *Z. japonica* (29%). **Hester, *et al*., (2001**) found a wide intra-specific variation in halophytes grasses. While, the accumulation of organic solutes to face the low potentiality of water was reported by **Glem, *et al*., (1992)** but **Udden, *et al*., (2012)** indicated that halophytes grasses accumulated K ions in roots which altered the Na uptake and lowering its effect on K/Na ratio. **Liu, *et al*., (2015)** concluded that six genotypes with different levels of salt tolerance were selected based on the growth parameters and ion concentrations in plant at the seedling stage and used for confirmation of the initial salinity response.

All switch grass cultivars under EC 10 had a significant reduction of 50% to 63% in dry weight. Switch grass, on another work, was seeded in substrates moistened with either a nutrient solution of EC 1.2 dS·m−1 (control) or a saline solution of EC of 5.0, 10.0, or 20.0 dS·m−1 (EC 5, EC 10, or EC 20). Treatment EC 5 did not affect the seedling emergence, regardless of cultivar. Compared to the control, EC 10 reduced the seedling mergence of switch grass 'Alamo', 'Cimarron', and 'NL 94C2-3' by 44%, 33%, and 82%, respectively. Dendrogram and cluster of six switch grass cultivars indicated that 'Alamo' was the most tolerant cultivar, while 'NSL 2009-2' was the least tolerant cultivar at both seedling emergence and growth stages **(Sun, *et al*., 2018**). Switch grasses were consistently clustered as the most tolerant and the least tolerant cultivars, respectively (**Sun, *et al*., 2018**).This finding agree with previous reports by **Liu *et al*., (2015),** who reported that the salt tolerance of switch grass varies with cultivar and growth stage. All of these reports suggest that plant physiological adjustment to salinity stress involves trade-offs at different stages.

Mineral status

- **Salinity**

The Data in Table (6) indicated that Na/K, Na/Ca as well as Ca (Na+K) slightly affected with salinity levels. The concentrations of N, Ca and K increased with the moderate salinity and ended to decrease by the highest level of salinity but still more than the control. The reverse was true for Mn concentration. On the contrary, Cu and Zn decreased as the concentration of salt increased, but vice versa for Fe concentration (Table 5). **Al-Khateeb (2006**) noticed that Na increased in shoots and roots as the concentration of NaCL increased.

Table 6. Panicum nutrient concentrations as affected by salinity.

Sal	Macro-nutrients %						Micro-nutrients ppm			
	N	**P**	**K**	**Ca**	**Mg**	**Na**	**Fe**	**Mn**	**Zn**	**Cu**
Tap W.	1.28	0.147	1.13	1.97	0.60	0.65	1529	139	302	17.0
3000	1.85	0.163	1.34	2.03	0.73	0.57	1944	123	131	14.6
6000	1.76	0.150	1.26	1.93	0.85	0.60	2565	141	85	11.9

The reverse was true for K concentration and K/Na ratio. The Na+ concentration in shoots and roots significantly increased as NaCl concentration increased. The K+ concentration in roots and K/Na ratio in shoots and roots was significantly reduced as salinity concentration increased. The K/Na ratio was greatly affected by higher NaCl concentration**.** **Uddin,** ***et al*****., (2012)** reported the differences in nutrients content and Na/K ratio in different turf species. **Nakamura,** ***et al*****., (2011)** indicated that torpedo grass (*Panicum repenis L*.) accumulated high quantity of calcium and potassium which help plants to tolerate salinity through affect the ion balance and regulation the osmotic condition of plant cells. **Gulzar,** ***et al*****., (2005**) revealed that salinity decrease the water in *Sporoblus ioclados* plants tissues and loss tougher. Moreover, **Akram (2006**) concluded that salinity increased the accumulation of Na ions and decreased K ions and this antagonistic relationship was more in older leaves of panicum. However, salinity affected the mineral content of grain sorghum **Hussein,** ***et al*****., (2011).** But in seeds, Lupine plants subjected to salinity (**Hussein,** ***et al*****., 2019**), for barley, **Hussein,** ***et al*****., (2019)** reported that salt stress affected the seeds mineral status.

It is clear from table 2 that N, K, Ca and Zn decreased with the irrigation using saline solutions, while P concentration increased slightly with moderate saline rate S1 without a significant difference to S0 and tended to decrease with the highest salinity treatment. On the opposite side, the Na concentration increased with salt treatments.

Salinity led to declining growth parameters, i.e. dry matter, uptake of N, P, K, Na and Ca, and yield of cotton as reported by **Hussein,** ***et al*****., (2012)** who added that Na/K ratio increased as salt concentration increased in contrast to Ca/(Na + K) ratio that showed the opposite response. Data presented in table 3 reveal that Na/K increased as the salinity level increased, but Na/Ca and K/Ca ratios increased with the moderate salinity level and tended to decrease, while it is still more than the control. However, Ca / (K + Na) decreased with the first level of salinity and tended to increase with the high level of salinity, but the values of this ratio are still less than those of the control. But, P/Zn ratio increased with the first level of salt and decreased by the high salt stress to be less than the control values (**Hussein and Abu Bakr, 2018**).

- **Genotypes**

Examination Data in Table (7) showed that the highest Na/K and Na/Ca ratios were in D. Imp types and the lowest in Local type. The reverse was true for Ca / (Na+K) ratio.

Table 7. Varieties of panicum nutrient concentrations.

Var.	Macro-nutrients %						Micro-nutrients ppm			
	N	**P**	**K**	**Ca**	Mg	Na	**Fe**	**Mn**	**Zn**	**Cu**
Local	1.34	0.163	1.68	2.26	0.70	0.54	1689	144	208	15.7
W. Imp	1.52	0.130	1.33	2.08	0.74	0.66	1310	123	223	14.5
D. Imp	2.36	0.170	1.32	1.60	0.74	0.74	1689	94	87	13.2

In general, whole-plant salinity tolerance was associated with increased Na^+ concentration and Na^+/K^+ ratio, and salt-tolerant genotypes often had higher root and lower shoot Na^+ concentration than sensitive ones. Na^+ concentration in root was closely related to salt tolerance and may be considered as a selection criterion for screening salt tolerance of broomcorn millet at the seedling or vegetative stages (**Lui,** ***et al*****., 2015**). **Hu,** ***et al*****., (2016)** showed the variation in electrolyte leakage in different lines of switch grass. Several researches had been done showed the differences in varieties of different crops (**Akman and Kara, 2003; Anjum, *et al.*, 2007 and Fereral, *et al* ., 2008**).

Table 8. Varieties leaves of panicum nutrient concentrations as affected by salinity.

Var.	Salinity	Macro--nutrients %						Micronutrients ppm			
		N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Local	Tap W.	1.10	0.13	0.91	1.76	0.55	0.54	1503	130	379	16.1
	3000	1.63	0.19	1.44	2.33	0.71	0.57	1526	164	96	10.3
	6000	1.28	0.17	0.90	2.68	0.84	0.51	959	264	150	20.8
White imp	Tap W.	1.49	0.15	1.30	2.33	0.62	0.78	1714	137	448	19.5
	3000	1.48	0.13	1.21	2.00	0.70	0.61	1400	141	143	16.4
	6000	1.60	0.11	1.48	1.92	0.91	0.59	816	91	77	7.5
Dark imp	Tap W.	2.25	0.16	1.19	1.83	0.64	0.64	1371	150	154	17.0
	3000	2.44	0.17	1.36	1.75	0.78	0.56	907	64	78	15.3
	6000	2.40	0.17	1.40	1.22	0.81	0.69	790	67	28	7.3

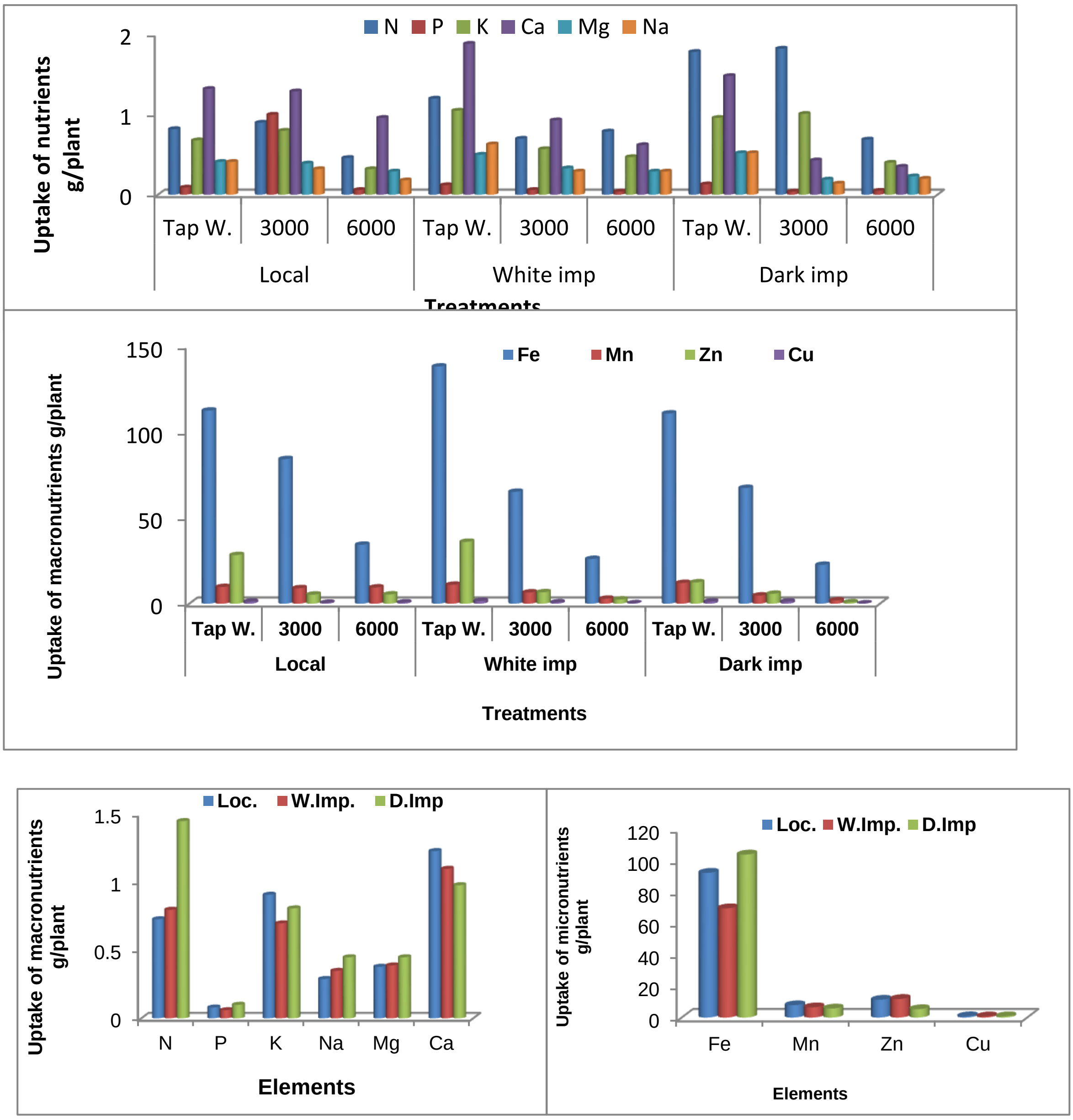

Fig. 1. Nutrients uptake in panicum plant as affected by varieties.

Data in Table (8) cleared that D. Imp type surpassed the other two types in N and K while Loc. Type superior in P, Ca and Mg, but W. Imp only has the higher content of Na.

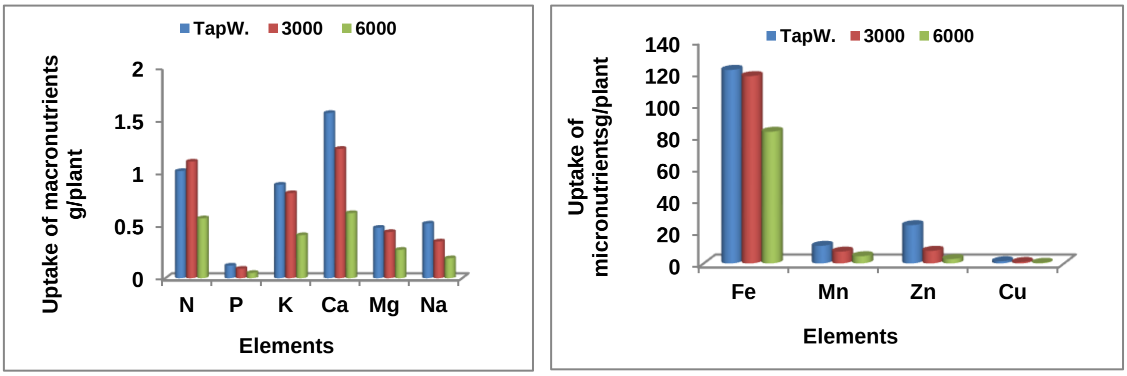

Fig. 2. Nutrients uptake in panicum plant as affected by salinity.

A negative relationship was detect between nutrient content and salinity. This may be due to the damages caused by salinity in the dry mass of different types of panicum plants.

Data in Table (6) showed the interaction effect of genotypes and salinity on the nutrient contents of panicum plants. Screening for genetic diversity in physiological characters has been proposed and could be effective in salt tolerance breeding **(Sabir, *et al*., 2011**). Ion uptake is a character of particular interest, and Na^+ exclusion and grain K^+/Na^+ ratio have been suggested as reliable traits for salt-tolerant crop selection (**Rahnama, *et al.*, 2011**). Salinity treatments decreased Ca, K and Mg content and K/Na ratio and the reverse for Na content in shoots as well as roots of turf species plants. *P. vogenatum* the lesser in accumulation of Na than the all species under different salinity levels followed by *D. didactlya the higher reducing K but P. vogenatum* was the lesser. *P.vogenatum* also showed the highest K/Na ratio followed by *Z. japonica* (**Uddin, *et al.*, (2012**). **Hu, *et al.*, (2016)** reported the differences in lines of switch grass under saline and alkaline conditions. **Lui, *et al.*, (2015)** found that the Na^+ concentration in root was greater than that in shoot, confirming that root was the first organ exposed to salt stress. The concentration of Na^+ varied significantly among genotypes under salt stress.

Conclusion

The highest stem weight was shown by local variety but the lowest was by the weight imported. In case of leaves, the highest weight was by Dark imported variety and the lowest was by local variety. Concerning the top dry weight, the dark imported was the first, and local and white imported seemed to be equal.

Negative response was observed to salinity subjection (Table 4) which the stem and leaves dry weight decreased parallel to the increase in salt concentration in irrigation solution. This Data also shown that leaves damages more than stems.of stem and leaves dry weigh, the salt stress (6000 ppm) more effective on stem dry weight to be about half of the control for the three types, but for leaves dry weight. The highest effect was by the same salt concentration with the dark imported panicum followed by that of white imported and the local type comes later.

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