Jordan Journal of Agricultural Sciences, Volume **11**, No.**3** 2015

Impact of Simulated Salinity Gradient on Growth Indices of *Pennisetum purpureum* Schumach

***Odiyi Bridget O.*[1], *Oludare Philips. Amire*[2]✉**

ABSTRACT

Pennisetum purpureum Schumach (Elephant grass) is a fast-growing perennial grass that has been found useful in the control of termite invasion and cattle grazing. This study was conducted to evaluate the effect of salinity gradients on seedling growth of *P. purpureum*, in term of tillers number, total leaf area, dry and wet weight, chlorophyll content and other growth indices. *Pennisetum purpureum* seedling showed a significant decrease in total leaf area, the leaf chlorophyll content, relative growth rate, net assimilation rate, total dry weight, and fresh weight with increasing salinity. Generally, the results indicate a significant decrease in all growth indices of *P. purpureum* with increase in the salinity gradient, hence it is best considered a miohalophyte having the best growth between 0 and 70.00 mM NaCl and low salinity tolerance.

Keywords: Salinity gradient, Growth Indices, *Pennisetum purpureum,* Relative growth rate, Net assimilation rate, Dry and fresh weight.

INTRODUCTION

The increasing human and animal populations with simultaneous increase in demand for food, fodder and feed have exerted tremendous pressure on environment (Annie and John, 2003). Anthropogenic inputs and inputs from other natural occurrence have placed a consistent and increasing modifying effect on ecosystem balance. Reported instances of such anthropogenic activities as irrigation resulting into salinization (Al-Shoabi and Al-Sobhi, 2004; Purbajanti *et al*., 2010) of the soil hence reducing the agricultural productivity of the soil have been documented (Quispe and Jacobsen, 1999). Salinity is just another inimical menace in the environment. Salinity create problem for crop species which are sensitive to the presence of high salt concentration in the soil (Purbajanti *et al*., 2010; Shannon *et al*., 1994). It has been estimated that about one billion hectares of the world's land mass has been affected by high salt concentration, sixty percent of which is being cultivated (Rain and Goyal, 2003). Development of soil salinity by capillary rise of saline ground water is usually considered a temporal problem which can be solved by drainage. On the other hand, soil salinity arising from the application of saline irrigation waters is a more persistent form and poses serious problems for both plant and Man. Poorly managed irrigation system often occur under free enterprise economies and communism in the tropic, sub tropic and to lesser extent in temperate environment.

Pennisetum purpureum is a tall erect perennial plant with thick stems up to 4.5 m high, found on moist soils

[1]Biology Department, Federal University of Technology, P.M.B. 704. Akure, Nigeria
Ecology and Environmental Biology Unit.
[2] Zoology Department, University of Ibadan.
✉darephilips@gmail.com
Received on 23/12/2012 and Accepted for Publication on 24/7/2014.

in areas with over 1000 mm of rainfall annually and widely distributed along the banks of watercourses. It grows best on deep soils of moderate to fairly heavy texture and tolerates short droughts, but does not withstand water logging. The aim of this study is to evaluate the impact of simulated salinity variance on growth indices of elephant grass *Pennisetum purpureum.*

MATERIALS AND METHODS

Rhizome fragments from mature plants of *Pennisetum purpureum* were collected from Benin city in Edo state of Nigeria. Treatment of NaCl super-imposed on nutrient solution were prepared according to Arnon and Hoagland (1940) in 0mM, 70mM, 140mM, 280mM and 560mM concentrations which were used to water the seedlings. The rhizome fragments were planted on white river sand growth medium collected from the Botany department of the University of Benin, Edo state, Nigeria. The growth media were setup in 14cm diameter and 8cm deep plastic bowl and each treatment was replicated five times. Each seedling received 150ml of solution every 24 hours, seedling of higher salinity treatments received a stepwise (interval of 72 hours) salinity increment in order to avoid osmotic shock. The sand was leached with 500ml of water followed immediately by the addition of the appropriate NaCl concentration. This was to prevent the buildup of salinity seedling salt shock. The seedling were carefully harvested after 42 days and the growth parameters such as number of tillers, length of longest leaf, total leaf area, fresh and dry weight were determined following the method of Hunt (1990). The Specific Leaf Area (SLA) or leaf area to leaf was obtained by dividing leaf area by leaf dry weight.

Relative growth rate was determined by the method of Hunt (1990),

RGR = $(\log e\ W_2 - \log eW_1)/(T_2 - T_1)$

Where: W_2 = final weight

W_1 =initial weight

T_2 =final time

T_1 = initial time.

Chlorophyll content was determined using Arnon (1949) method .Total chlorophyll content of the leaves was determined following the method of Arnon (1949). Three grammes of the youngest leaves of each seedling was ground with few grains of washed sand (sand washed with concentrated H_2SO_4 and then thoroughly washed with distilled water). Chlorophyll was extracted with 20 ml of 80 % acetone and centrifuged at 2500 r.p.m for 15minutes. The clear supernatant was collected and the absorbance read at 645nm and 663nm on Spectronic 20 Spectrophotometer with 80 % acetone as reference blank. Chlorophyll a and b was calculated as follows:

Chlorophyll a $=12.7_{D663}-2.69_{D645}$ X Vmg/1000W (mgg $^{-1}$).

Chlorophyll b = $22.9_{D645}-4.68_{D663}$ X Vmg/1000W (mgg $^{-1}$).

Total chlorophyll (chlorophyll a & b) = $20.2_{D645}-8.02_{D663}$ X V/1000W.

Where D_x = absorbance of the extract at the wavelength X nm.

V = total volume of the chlorophyll solution (ml).

W = weight of the tissue extracted (g).

Net assimilation rate (NAR) was also calculated according to the method of Hunt (1990).

NAR = $W_2 - W_1 / T_2 - T_1$ X $\log_e A_2 - \log_e A_1 / A_2 - A_1$

Where W_1 and W_2 is the total dry weights at the beginning and end of the experiment

T_2 and T_1 is the duration between the final and initial sampling time, A_2 and A_1 is the total leaf area per plant at the beginning and end of the experiment.

All data obtained were statistically analyzed using the Statistical Package for Social Sciences, Version 15.0

(SPSS, 2003). Statistical means were separated using the New Duncan Multiple Range Test.

RESULTS AND DISCUSSION

The effect of salinity gradient on seedling percentage (%) survival and Tillers number is presented in figure 1. Seedlings of *Pennisetum purpureum* did not survive at concentration higher than 140 mM NaCl, while the highest tiller number was recorded at 70 mM NaCl followed by subsequent decrease in higher concentration. Leaf length also decreased as the concentration gradient increased from 0 mM NaCl as shown in figure 2. The effect of salinity on the total leaf area, fresh weight , dry weight and the specific leaf area of *Pennisetum purpureum* is presented in Table 1. Total leaf area decreased with increasing concentration from 0 to 280 mM NaCl. The fresh and dry weights decreased with increasing salinity. Specific leaf area increased slightly at 70 mM NaCl (0.08 m^2g^{-1}) compared to control (0.06m^2g^{-1}) but decreased with a further increase in salinity. Table 2 shows the effect of salinity on the leaf chlorophyll content, the relative growth rate and the net assimilation rate. The leaf chlorophyll content decreased with increasing salinity concentration. Relative growth rate and net assimilation rate also decreased with increasing NaCl concentration.

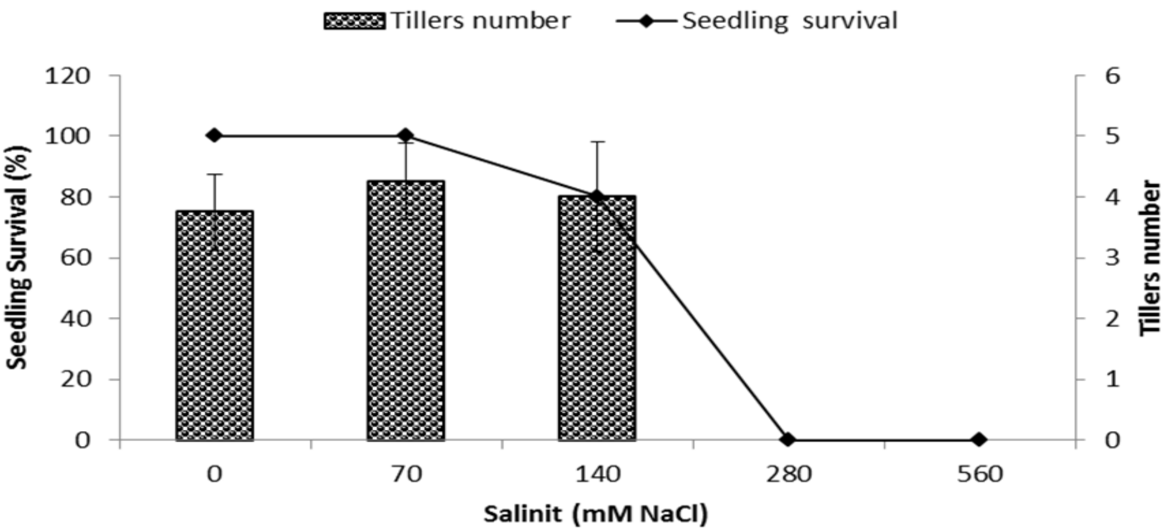

Fig 1: Effect of salinity on seedling percentage (%) survival and Tillers number

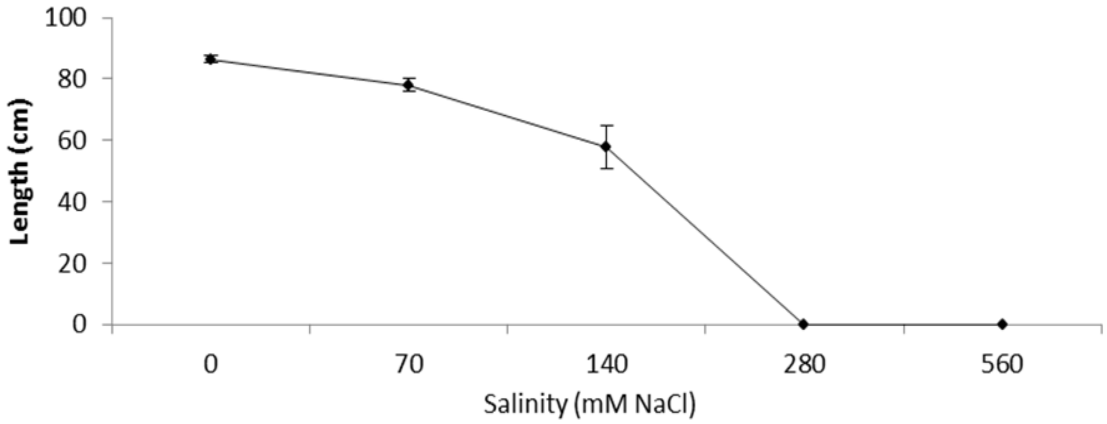

Fig. 2: Effect of salinity on length of longest leaf of Pennisetum purpureum.

Table 1. Effect of salinity on the total leaf area, fresh weight, dry weight and specific leaf area of *Pennisetum purpureum*

Salinity (mM NaCl)	Total leaf area (m^2g^{-1})	Fresh weight (g)	Dry weight (g)	Specific leaf area (m^2g^{-1})
0.0	1.35 ± 0.17a	267.03 ± 21.19a	58.62 ± 4.32a	0.08 ± 0.03a
70.0	1.09 ± 0.19b	167.19 ± 10.87b	36.44 ± 3.61b	0.06 ± 0.02b
140.0	0.55 ± 0.21c	110.95 ± 6.52c	32.76 ± 2.84b	0.05 ± 0.01b
280.0	----	----	----	----
560.0	----	----	----	----

Each value is a mean of ± standard error of four replicates. Means within the same column followed by the same letter are not significantly different at (P>0.05) from each other using New Duncan Multiple Range Test.

Table 2. Effect of salinity on the leaf chlorophyll content, relative growth rate and the net assimilation rate of *Pennisetum purpureum*

Salinity (mM NaCl)	Leaf chlorophyll content (mgg^{-1})	Relative growth rate (gd^{-1})	Net assimilation rate ($m^2g^{-1}d^{-1}$)
0.0	1.657	0.06 ± 0.02a	1.57 ± 0.12a
70.0	1.373	0.04 ± 0.01b	1.40 ± 0.09b
140.0	0.316	0.03 ± 0.01b	0.64 ± 0.03c
280.0	----	----	----
560.0	----	----	----

Each value is a mean of ± standard error of four replicates. Means within the same column followed by the same letter are not significantly different at (P>0.05) from each other using New Duncan Multiple Range Test.

The results obtained from the study showed that *Pennisetum purpureum* is a miohalophyte, having the best growth between 0.0 and 70.00mM NaCl, with a very low salinity tolerance. Salt stress resulted in a reduced percentage survival and tillers number of *P. purpureum.* Seedling survival and tillers number was also significantly reduced by salinity treatment in *Honekenya peploides* (Gagne and Houle, 2002). When the percentage of dead leaves in *Hordeum* species reached about 20% of the total, the rate of leaf production slowed down and some plants died (Garthwaite *et al*., 2005). Previous research reveals that increased salinity causes growth reduction in plants (Debez *et al*., 2004). Salinity has been found to reduce growth and productivity of many crops such as tomatoes (Li, 2000; Tantawy *et al.*, 2009). Although increased salinity exerted a significant influence on survival and growth of *Pennisetum purpureum* but it was able to survive up to 140 mM NaCl salinity level. Morant-Manceau *et al.,* (2004) observed that although salinity stimulate growth in *Secale cereal*, high salinity levels inhibited growth and when salt stress was too severe, it caused death of seedlings. The fact that all seedlings of *P. purpureum* died above 140mM NaCl in addition with the significant decrease in total dry weight with increasing salinity in the other plant support the work of Garthwaite *et al*., 2005.

P. purpureum exhibited a high growth rate at 140 mM NaCl, this may be due to the efficiency of the assimilatory organs in producing new growth since a high net assimilation rate is also recorded at 140mM NaCl. Further work needs to be carried out to determine the underlining causes of the high growth rate of *P. purpureum* under salt stress conditions.

The reduction in the specific leaf area of *Pennisetum purpureum* with increased salinity leads to a reduction in photosynthesis, according to Lambers and Poorter (1992), there is a close association between the potential growth rate of a species and its specific leaf area. The decrease in chlorophyll content of *P. purpureum* with increasing salinity might also be responsible for the growth reduction and decreasing percentage survival with increasing salinity (Brugnoli and Lauteri 1991). Georgiev and Atkins (1993) observed in their various research work that salt stress can lead to stunted plant growth and reduction in available photosynthesis. Yamane *et al*., (2004) reported the reduction in chlorophyll by salt stress and concluded that salt – induced in chloroplasts is dependant on light. Relative growth rate and net assimilation rate were highest in non-saline control. Munns and James (2003) reported a decrease in the relative growth rate and net assimilation rate of *Triticum turgidum* due to osmotic effect of salinity. NaCl also caused a decline in RGR all *Hordeum* species studied (Garthwaite *et al*., 2005).

CONCLUSION

Pennisetum purpureum being only tolerant to low salinity may be useful in stabilizing moderately saline and nutrient rich beaches. Also, being useful as a forage grass, its tolerant of low salinity makes it a species of agronomic interest.

REFERENCES

Al- Shoabi, A.A and Al- Sobhi, O.A. 2004. The effect of salinity on the growth of Elephant grass (*Pennisetum purpureum*). Prod second Saudi Sci. conf., Fac Sci., KAU, 15-17 Pp. 141-147

Annie, A.and John D.D. 2003**.** The Effect of NaCl on growth, N_2 fixation (acetylene reduction), and percentage total nitrogen in *Leucaena leucocephala* (Leguminosae) var. K-8. ***American Journal of Botany***. 90:683-692.

Arnon, D.I. and Hoagland, D.R.1940. Crop production in artificial culture solution and in soil with reference to factors influencing yields and absorption of inorganic nutrient. ***Soil Sci***.50: 463-483.

Brugnoli, E and Lauteri M. 1991. Effects of salinity on stomatal conductance, photosynthetic capacity, and carbon isotope discrimination of salt-tolerant (*Gossypium hisutum* L.) and salt-sensitive (*Phaseolus vulgaris* L.) C_3 non-halophytes. ***Plant Physiology*** 95: 628-635.

Debez, A., Benhamed, K., Grignon, C. and Abdelly, C. 2003. Salinity effects on germination, growth and seed production of the halophyte *Cakile maritima*. ***Plant and Soil***, 262 (1-2): 179-189.

Gagna, J.M. and Houle,G.2002. Factors responsible for *Honekenya peploides* (Caryophyllaceae) and *Leymus mollis* (Poaceae) spatial segregation on subaretic coastal dunes. ***American Journal of Botany.*** 89: 479- 485.

Garthwaite, A.J., Bothmer, R. and Colmer, T. D. 2005. Salt tolerance in wild *Hordeum* species is associated with restricted entry of Na and Cl into the shoots. ***Journal of Experimental Botany***. 56 (419): 2365- 2378.

Georgiev, G. I. and Atkins C. A. 1993. Effects of salinity on N_2 fixation, nitrogen metabolism

Hunt, R. (1990). Basic Growth Analysis. Plant growth analysis for beginners. Academic Press. London, UK. Pp 82.

Lambers, H. and Poorter, H. 1992. Inherent variation in growth rate between higher plants: a search for physiological causes and ecological consequences. ***Adv. Ecol. Res***. 23: 187–261.

Li, Y.2000. Analysis of greenhouse tomato production in relation to salinity and shoot environment. Ph.D. thesis, Wageningen Agricultural University, Pp 295

Morant- Manceau, A., Pradier, E. and Tremblin, G. 2004. Osmotic adjustment, gas exchange and chlorophyll fluorescence of a hexaploid triticale and its parental species under salt stress. ***Journal of Plant Physiology***,161 (1): 25-33.

Munns, R. and James, R.A. 2003.Screening methods for salinity tolerance: a case study with tetraptoid wheat. ***Plant Soil,*** 253: 201-218.

Purbajanti, E.D., R.D.Soetrisno, E.Hanudin and S.P.S.Budhi. 2010. Photosynthesis And Yields Of Grasses Grown In Saline Condition. ***J. Indonesian Trop. Anim. Agric***. 35: 46-58.

Quispe, H.and Jacobsen,S.1999. Response of Quinua (*Chenopodium quinoa* Wild) and Amaranth (*Amarantus caudatas*) to salinity. In: Crop development for cool and wet climate of Europe. ***The Commission of the European Communities***. *EUR* 19227, Pp 326-330.

Shannon, M.C.,Grieve, C.M. and Francoi, L.E.1994. In R.E.Wilkinson (ed.) Whole-plant response to salinity. Marcel Dekker, New York. Pp 199-244.

SPSS. 2003. Statistical package for social sciences (SPSS 15.0 Inc., Chicago, U.S.A).

Tantawy, A.S., Abdel-Mawgoud, A.M.R., El-Nemr, M.A. and Chamoun, Y.G. 2009. Alleviation of salinity effects on tomato plants by application of amino acids and growth. ***European Journal of Scientific Research*,** 30(3): 484-494.

Yamane, K., Rahman, M.S., Kawaski, M., Tniguchi, M. and Miyake, H. 2004. Pretreatment with antioxidants decreases the effects of salt stress on chloroplast ultra-structure in rice leaf. ***Plant Production and Science***, 7: 292-300.

تأثير تدرج الملوحة على مؤشرات النمو في نبات أعلاف حشيشة الفيل
Pennisetum purpureum Schumach

اوديي بريدجيث [1] واوليدار فيليب [2] ✉

ملخص

يعد نبات حشيشة الفيل Pennisetum purpureum Schumach هو من الأعشاب المعمرة سريعة النمو التي تم العثور عليها بانها مفيدة في السيطرة على النمل الأبيض والغزو بسبب رعي الماشية. وقد أجريت هذه الدراسة لتقييم تأثير التدرج في الملوحة على نمو البادرات من نبات حشيشة الفيل، من خلال عدد التفرعات (tillers)، ومجموع مساحة الورقة، الوزن الجاف والرطب، ومحتوى الكلوروفيل ومؤشرات النمو الأخرى. وقد أظهرت شتلات نبات حشيشة الفيل انخفاضاً ملحوظاً في إجمالي مساحة الورقة، ومحتوى الكلوروفيل في الورقة، ومعدل النمو النسبي، صافي معدل التثبيت للنيتروجين (assimilation)، مجموع الوزن الجاف والوزن الرطب مع زيادة الملوحة. عموما، فإن النتائج تشير إلى انخفاض ملحوظ في جميع مؤشرات نمو نبات حشيشة الفيل مع زيادة في تدرج الملوحة، وبالتالي هو أفضل miohalophyte لديه أفضل نمو بين 0 و 70.00 ملي مول كلوريد الصوديوم وانخفاض تحمل الملوحة.

الكلمات الدالـة: التدرج في الملوحة، مؤشرات النمو، Pennisetum purpureum نبات الفيل، ومعدل النمو النسبي، صافي معدل التثبيت assimilation ،الوزن الجاف والوزن الرطب.

[1] قسم الأحياء، الجامعة الفيدرالية للتكنولوجيا، نيجيريا.

[2] قسم علم الحيوان، جامعة ابادان.

✉darephilips@gmail.com

تاريخ استلام البحث 2012/12/23 وتاريخ قبوله 2014/7/24.