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 terms 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 the environment (Annie and John, 2003). Anthropogenic inputs and inputs from other natural occurrences 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...
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 superimposed 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),

\[
RGR = \frac{\log W_f - \log W_i}{(T_f - T_i)}
\]

Where: \(W_f\) = final weight  
\(W_i\) = initial weight  
\(T_f\) = final time  
\(T_i\) = 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 H2SO4 and then thoroughly washed with distilled water). Chlorophyll was extracted with 20 ml of 80 % acetone and centrifuged at 2500 r.p.m for 15 minutes. 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\(D_{663}\) - 2.69\(D_{645}\) X V/1000W (mgg⁻¹).

Chlorophyll b = 22.9\(D_{665}\) - 4.68\(D_{663}\) X V/1000W (mgg⁻¹).

Total chlorophyll (chlorophyll a & b) = 20.2\(D_{663}\) - 8.02\(D_{663}\) 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).

\[
NAR = \frac{W_f - W_i}{T_f - T_i} \times \frac{\log A_f - \log A_i}{A_f - A_i}
\]

Where \(W_i\) and \(W_f\) is the total dry weights at the beginning and end of the experiment

\(T_f\) and \(T_i\) is the duration between the final and initial sampling time, \(A_f\) and \(A_i\) 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.
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 m² g⁻¹) compared to control (0.06 m² g⁻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](image-url)
Table 1. Effect of salinity on the total leaf area, fresh weight, dry weight and specific leaf area of *Pennisetum purpureum*

<table>
<thead>
<tr>
<th>Salinity (mM NaCl)</th>
<th>Total leaf area (m²/g)</th>
<th>Fresh weight (g)</th>
<th>Dry weight (g)</th>
<th>Specific leaf area (m²/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.35 ± 0.17a</td>
<td>267.03 ± 21.19a</td>
<td>58.62 ± 4.32a</td>
<td>0.08 ± 0.03a</td>
</tr>
<tr>
<td>70.0</td>
<td>1.09 ± 0.19b</td>
<td>167.19 ± 10.87b</td>
<td>36.44 ± 3.61b</td>
<td>0.06 ± 0.02b</td>
</tr>
<tr>
<td>140.0</td>
<td>0.55 ± 0.21c</td>
<td>110.95 ± 6.52c</td>
<td>32.76 ± 2.84b</td>
<td>0.05 ± 0.01b</td>
</tr>
<tr>
<td>280.0</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>560.0</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

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*

<table>
<thead>
<tr>
<th>Salinity (mM NaCl)</th>
<th>Leaf chlorophyll content (mg/g)</th>
<th>Relative growth rate (gd⁻¹)</th>
<th>Net assimilation rate (m²/g/d⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.657</td>
<td>0.06 ± 0.02a</td>
<td>1.57 ± 0.12a</td>
</tr>
<tr>
<td>70.0</td>
<td>1.373</td>
<td>0.04 ± 0.01b</td>
<td>1.40 ± 0.09b</td>
</tr>
<tr>
<td>140.0</td>
<td>0.316</td>
<td>0.03 ± 0.01b</td>
<td>0.64 ± 0.03c</td>
</tr>
<tr>
<td>280.0</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>560.0</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

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**


Annie, A.and John D.D. 2003. The Effect of NaCl on growth, N₂ fixation (acetylene reduction), and


تأثير تدرج الملوحة على مؤشرات النمو في نبات أعلاف حشيشة الفيل

Pennisetum purpureum Schumach

اوديي بريدجيث١ واوليدار فيليب٢

ملخص

هو من الأعشاب المزهرة سريعة النمو التي تم العثور عليها بأنها مفيدة في السيطرة على النمل الأبيض والكغو بسبب رعي الناشئة. وقد أجربت هذه الدراسة لقياس تأثير التدرج في الملوحة على نمو البذورات من نبات حشيشة الفيل، من خلال عدد الفروع (tillers)، ومجموع مساحة الورقة، الوزن الجاف والرطب، ومحتوى الكلوروفيل ومؤشرات النمو الأخرى. وقد أظهرت نباتات حشيشة الفيل انخفاضاً ملحوظاً في إجمالي مساحة الورقة، ومحتوى الكلوروفيل في الورقة، ومعدل النمو النسيبي، صافي معدل التثبيت (assimilation)، مجموع الوزن الجاف والوزن الرطب مع زيادة الملوحة. عموماً، فإن النتائج تشير إلى انخفاض ملحوظ في جميع مؤشرات نمو نبات حشيشة الفيل مع زيادة في تدرج الملوحة، وبالتالي هو أفضل لديه أفضل نمو بين 0 و 70.00 مل مول كلوريد الصوديوم وانخفاض تحميل الملوحة.

الكليمات الدلالة: التدرج في الملوحة، مؤشرات النمو

Pennisetum purpureum: نبات الفيل، و معدل النمو النسيبي، assimilation: صافي معدل التثبيت