International Journal of Plant Research 2020, 10(2): 40-43
DOI: 10.5923/j.plant.20201002.03

Effect of Saline Toxicity Solutions on the Growth Performance of Bambara Groundnut (*Vigna subterranea* L. Verde)

Barka Peter Mshelmbula[1], Solomon Peter Wante[2,*], Sulaiman Bello[1], Joel Osajie[1]

[1]Department of Plant Science and Biotechnology, Federal University Lafia, Nigeria
[2]Department of Biological Sciences, Federal University of Kashere, Nigeria

Abstract The Bambara groundnut (*Vigna subterrenea* (L.) Verde) is an important source of affordable proteins from a vegetable legume in sub-Saharan Africa. Although, the percentage content of amino acids found does not meet the standard recommendation specified by FAO/WHO due to the limited amount of tryptophan. Protein intakes are essential to satisfy the metabolic needs of amino acids and nitrogen balance in humans. The ability of bambara groundnut to survive and grow under harsh environmental conditions has an under turn specific adaptive traits which includes morphological and physiological adaptions. Salinity toxicity is one of the major limiting factors in crop production worldwide. The deleterious effect of saline toxicity depends on the type of plant species. Therefore, here in this study, various concentrations of saline toxicity solutions of 0.25g/l, 1.0g/l, 2.0g/l and 2.5g/l were evaluated in relation to the growth performance of Bambara groundnut. For example, there were as least as 20 leaves in S1L1, compared to S1L5 which had as much as 138 leaves per plant. The toxicity can either be due to Na^+ or Cl^- ion which can rapidly build up in the cytoplasm and inhibits enzyme activity or the build-up in the cell walls and dehydrate the cell.

Keywords Bambara groundnut, Salinity, Protein and Toxicity

1. Introduction

Bambara groundnut (*Vigna subterrenea* (L.) Verde) is a major source of vegetable protein in sub-Saharan Africa. It is also an important source of affordable proteins in the diets compare with the animal source of protein [1]. The crop is richer in essential amino acids than other legumes, for example, it has a protein content of 6% and 10% higher than soya bean and cowpea, respectively [2]. Although, the percentage content of amino acids found does not meet the standard recommendation specified by FAO/WHO due to the limited amount of tryptophan [3]. Protein intakes are essential to satisfy the metabolic needs of amino acids and nitrogen balance in humans [3].

Despite the nutritional value of bambara groundnut, it has not received much research attention compared to other legumes [4]. The plant has been grown under harsh environmental conditions with relatively low labour inputs during cropping. The ability of bambara groundnut to survive and grow under harsh environmental conditions is related to specific adaptive traits which include the production of subterranea pods [5]. Physiological adaptation includes the regulations of osmotic adjustment, leaf area index reduction, an increase in leaf reflectivity, and changes in leaf orientation and stomata regulation [6]. Salinity toxicity is one of the major limiting factors in crop production worldwide [7]. Salinity reduces plants growth through osmotic stress, specific-ion toxicities nutritional imbalances [8]. Although the timing of the deleterious effect of the saline toxicity depends on the type of plant species [8]. Therefore, it was of significance to evaluate the growth performance of Bambara groundnut (*Vigna subterrenea* (L.) Verde) to saline toxicity solutions.

* Corresponding author:
solomonpeterwante@yahoo.com (Solomon Peter Wante)
Published online at http://journal.sapub.org/plant

2. Results and Discussion

In the present study, salinity conditions were created, by saturating 10 kg air-dried soil with 0.25g/l, 1.0g/l, 2.0g/l and 2.5g/l of NaCl solution respectively. Prior to sowing, viable seeds of bambara groundnut were soaked in 0.031%, 0.016%, 0.125% and 0.250% w/w NaN_3 solution for 6 hours. The treated seeds were rinsed in running water to remove excess chemicals and exudates from seeds and then sown on designated experiment buckets bearing each salinity level.

The growth rate of the test plant was calculated every day as the daily millimetric increase in height of plant (Fig. 1). Results showed that plant treatment with the highest growth rate was S2L2 with a rate of 1.98mm/day, followed by C3 (1.88 mm/day). Plants in 1.0g/l salinity levels generally did not show any further increase in growth.

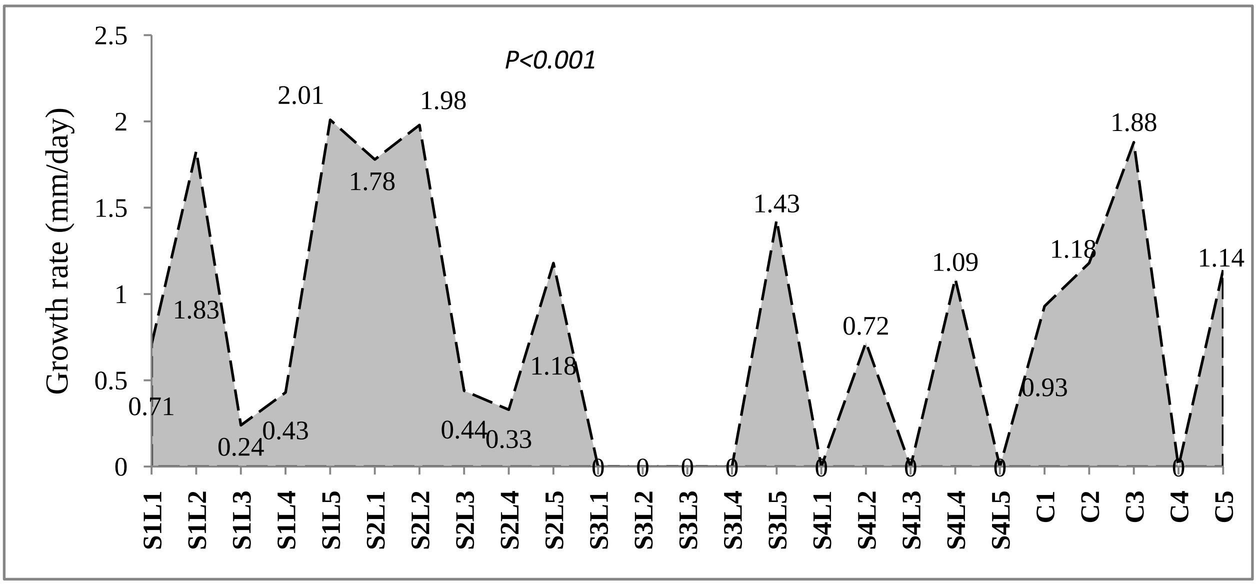

Figure 1. Growth rate of test plants over the 14 weeks observation period. Soil salinity levels of 0g/l, 0.25g/l, 1.00g/l, 2.00g/l and 2.50g/l of NaCl were represented as S1, S2, S3, S4 and S5 respectively, whereas concentrations of sodium azide on which bambara was exposed were 0%, 0.031%, 0.016%, 0.125% and 0.250% w/w and represented by L1, L2, L3, L4 and L5 respectively. C1, C2, C3, C4 and C5 were plants sown in the respective saline soils but not exposed to mutagen

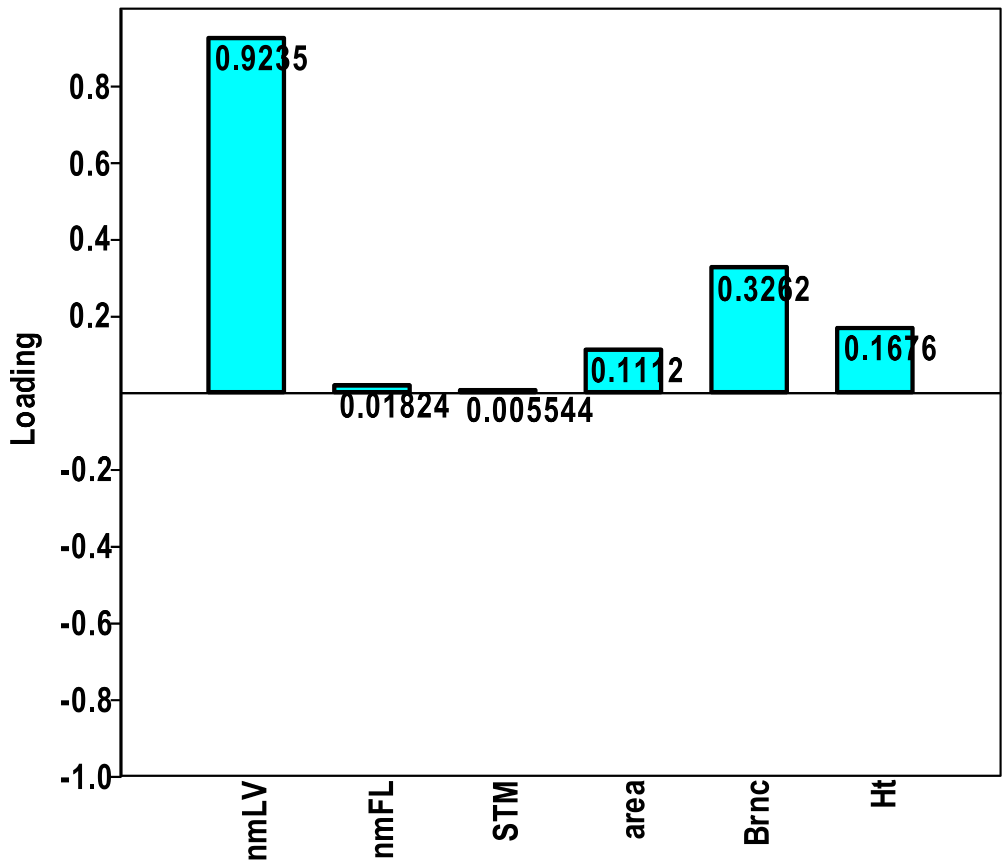

Figure 2. Loadings of principal component biplot establishing relationship among plant characteristics assessed during the study. Key: nmLV – number of leaves per plant; nmFL – number of flowers; STM – stem girth; Area – leaflet area; Brnc – stem branches; Ht – plant height

Table 1. Selected plant characteristics observed at 14 weeks after sowing

	*No. of leaves	*No of flowers	Stem girth (cm)	leaflet area (cm^2)
S1L1	21^{d}	7^{cd}	0.23^{b}	9.52^{abc}
S1L2	77^{bc}	11^{b}	0.73^{a}	12.93^{ab}
S1L3	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S1L4	12^{d}	6^{cd}	0.27^{b}	4.77^{c}
S1L5	138^{a}	7^{cd}	0.73^{a}	13.56^{a}
S2L1	120^{a}	18^{ab}	0.73^{a}	13.26^{a}
S2L2	71^{bc}	14^{bc}	0.70^{a}	14.95^{a}
S2L3	1.7^{e}	0^{e}	0.27^{b}	4.59^{c}
S2L4	21^{d}	4^{d}	0.27^{b}	5.03^{c}
S2L5	61^{bc}	5^{c}	0.50^{ab}	9.54^{abc}
S3L1	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S3L2	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S3L3	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S3L4	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S3L5	59^{c}	3^{d}	0.47^{ab}	8.65^{bc}
S4L1	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S4L2	22^{d}	0^{e}	0.20^{b}	4.51^{c}
S4L3	0^{e}	0^{e}	0.00^{c}	0.00^{d}
S4L4	25^{d}	7^{cd}	0.50^{ab}	7.31^{b}
S4L5	0^{e}	0^{e}	0.00^{c}	0.00^{d}
C1	64^{bc}	15^{b}	0.47^{ab}	11.44^{ab}
C2	81^{b}	23^{a}	0.50^{ab}	12.67^{ab}
C3	118^{a}	27^{a}	0.77^{a}	14.88^{a}
C4	0^{e}	0^{e}	0.00^{c}	0.00^{d}
C5	68^{bc}	17^{b}	0.40^{ab}	10.05^{ab}
p-value	<0.001	<0.001	<0.001	<0.001

*Rounded off to the nearest whole integer. Means on the same column with similar alphabetic superscripts do not differ from each other (p>0.05). Soil salinity levels of 0g/l, 0.25g/l, 1.00g/l, 2.00g/l and 2.50g/l of NaCl were represented as S1, S2, S3, S4 and S5 respectively, whereas concentrations of sodium azide on which bambara was exposed were 0%, 0.031%, 0.016%, 0.125% and 0.250% w/w and represented by L1, L2, L3, L4 and L5 respectively. C1, C2, C3, C4 and C5 were plants sown in the respective saline soils but not exposed to mutagen.

Table 1 shows selected plant characteristics observed at 14 weeks after sowing. There were as least as 20 leaves in S1L1, compared to 77 in S1L2. S1L5 had as much as 138 leaves per plant. The C3 plant had 118 leaves. The highest number of flower collected from the plants was 2, altogether; some other plants never had flowers (p<0.05). S1L2 was profusely branched (27 branches) as much as S2L1 (40 branches) compared to S1L4, which had only 4 branches. The loadings of the PCA biplot presented in Fig. 2 showed that the plant parameter that contributed the highest level of variability to the study was "number of leaves", whereas the least was contributed by "number of flowers". Munns [9] reported that the primary site of specific-ion toxicity in plants is considered to be the leaf where salt accumulates to the stage exceeding the cells ability to compartmentalise ions in the vacuole. Because the toxicity can either be due to Na^+ or Cl^- ion then there is also a tendency to rapidly build up in the cytoplasm which inhibits enzyme activity or the build-up in the cell walls and dehydrate the cell [10].

Other studies of salinity toxicity reported inhibition in the development of plants [9], here in this study the data presented an insignificant lower value of flower formed. The development of plant tolerant to salinity toxicity is of paramount importance. The present study assists in the understanding of saline toxicity solutions on the morphological parameters of Bambara groundnut (*Vigna subterrenea* (L.) Verde).

3. Conclusions

In conclusion, the present findings have contributed to the understanding of salinity toxicity on the growth performance of Bambara groundnut (*Vigna subterrenea* (L.) Verde). From the results of this study, we can interpret that the salinity toxicity concentrations alone have not caused much of the detrimental damage to the growth parameters of the bambara groundnut plant compared with the combined effect of the NaCl with sodium azide concentrations. Therefore, we presumed that combination of NaCl with sodium azide concentrations may have formed optimal concentrations enough to damage the physiological properties of the bambara groundnut seedlings which may have altered the cell plasma membrane to allowed influx or efflux of ions. There is substantial evidence from this study that combined effect NaCl with sodium azide concentrations has induced morphological developmental parameters of the bambara groundnut plants. For example, S1L5 had as much as 138 leaves per plant compare with S2L3 which has fewer than 2 leaves.

REFERENCES

[1] Mubaiwa, J., Fogliano, V., Chidewe, C., & Linnemann, A. R. Bambara groundnut (*Vigna subterranea* (L.) Verdc.) flour: A functional ingredient to favour the use of an unexploited sustainable protein source. *PloS one* 2018, *13*(10).

[2] Plahar, W. A., & Yawson, R. M. *Dissemination of Improved Bambara Processing Technologies Through a New Coalition Arrangement to Enhance Rural Livelihoods in Northern Ghana*. Paper presented at the A Report on the End-of-Project Stakeholders' Workshop, Gilbt Conference Room, Tamale, Ghana 2004.

[3] FAO. *Dietary protein quality evaluation in human nutrition*. Report of an FAO Expert Consultation 2011.

[4] Bamshaiye, O., Adegbola, J., & Bamishaiye, E. Bambara groundnut: an under-utilized nut in Africa. *Advances in Agricultural Biotechnology* 2011, *1*(1), 60-72.

[5] Chapman, S., Ludlow, M., Blamey, F., & Fischer, K. Effect of drought during early reproductive development on growth of cultivars of groundnut (*Arachis hypogaea* L.). I. Utilization of radiation and water during drought. *Field Crops Research* 1993, *32*(3-4), 193-210.

[6] Collinson, S., Berchie, J., & Azam-Ali, S. The effect of soil moisture on light interception and the conversion coefficient for three landraces of bambara groundnut (*Vigna subterranea*). *The Journal of Agricultural Science* 1999, *133*(2), 151-157.

[7] Zhang, H.-X., Hodson, J. N., Williams, J. P., & Blumwald, E. Engineering salt-tolerant Brassica plants: characterization of yield and seed oil quality in transgenic plants with increased vacuolar sodium accumulation. *Proceedings of the National Academy of Sciences* 2001, *98*(22), 12832-12836.

[8] Kopittke, P. M. Interactions between Ca, Mg, Na and K: alleviation of toxicity in saline solutions. *Plant and Soil* 2012, *352*(1-2), 353-362.

[9] Munns, R. Comparative physiology of salt and water stress. *Plant, Cell & Environment* 2002, *25*(2), 239-250.

[10] Flowers, T., Hajibagheri, M., & Clipson, N. Halophytes. *The Quarterly Review of Biology* 1986, *61*(3), 313-337.