



Variations in growth and development indices of *Abelmoschus esculentus* L. Moench cultivated in wet and normal soils in Opolo, Bayelsa State, Nigeria

Mbosowo Monday Etukudo^{1*} and Samuel Eguom Osim²

Received: September 15, 2022 /Accepted: November 21, 2022

© REJOST 2022

Abstract

Variations in growth and development indices of *Abelmoschus esculentus* L. Moench were evaluated in the field using wet and normal soils in Opolo, Bayelsa State, Nigeria. Terrestrial plants growing in soil partially or totally submerged due to environmental hazards exhibit deterioration in certain growth and physiological attributes. The study area is a region characterized by seasonal flooding. This study was conducted to examine the response of the test crop growth and development parameters to extreme moisture stress in the soil as well as the effects of such condition on the chemical properties of experimental soil. Soil samples obtained from the two experimental locations at the depth of 1-20cm were analyzed for physico-chemical characteristics using standard procedures.

✉ Mbosowo Etukudo: mbosombosowo@yahoo.com
Samuel Osim: sammyosim@gmail.com

¹Department of Biology, Federal University
Otuoke, Bayelsa State, Nigeria

²Department of Plant Science and Biotechnology,
University of Cross River State (UNICROSS),
P.M.B 1123, Calabar, Nigeria

Viable seeds of the test crop were sown in the two experimental soils in rows and the experimental set up was maintained for 8 weeks for determination of growth and development parameters. The results of this study revealed that the pH values of both soils were slightly acidic, however, the pH value of the wet soil was significantly ($P < 0.05$) lower than that of the normal soil. The contents of available phosphorus, total nitrogen, calcium, sodium and copper in normal soil were significantly ($P < 0.05$) higher than that of the wet soil, while the magnesium, potassium and iron contents in wet soil were higher than that of the normal soil. The shoot length, leaf number, root length, root number and chlorophyll contents of the test crop in normal soil were significantly ($P < 0.05$) higher than that of the wet soil. This study suggests that the growth and development of *A. esculentus* L. Moench could be negatively affected at extreme level of moisture; therefore, appropriate moisture conditions are required for optimum growth performance of the test crop.

Keywords: growth; development; *Abelmoschus esculentus* L. Moench; wet and normal soils, Bayelsa State.

1.0 Introduction

Soil quality is one of the crucial factors to be considered for optimum growth and development of plants (Osim *et al.*, 2020). Most plants are anchored to the soil medium through their roots, hence any variation on the physical, chemical and biological properties of the soil could result in differences in plant growth and development attributes (Boll *et al.*, 2005; Rossel, *et al.*, 2005; Agbede, 2009). Plants growing in different habitats are influenced by the prevailing soil, atmospheric and climatic factors associated with such habitat (Osuagwu *et al.*, 2013; Etukudo *et al.*, 2015). Therefore, variations in certain soil properties such as type of soil, soil organisms, microbial populations, mineral nutrients and relative amount of pore spaces have a profound effect on plant growth and development (Braidly and Weil, 1999).

In general, the tropical soils of Niger Delta region exhibit an acidic characteristics (Agbede, 2009), however, the soil type as influenced by the physical and chemical properties of a particular soil has a peculiar effect on plants that exist on such habitats (Braidly and Weil, 1999; Udoh *et al.*, 2005). Opolo, is an area in Bayelsa State, which is characterized by both marshy and terrestrial terrain together with the general ecological features of a typical tropical climatic region. The test crop, *Abelmoschus esculentus* L. Moench, commonly called okra belongs to the family Malvaceae. It is one of the highly consumed vegetable crops cultivated widely in the tropics and some parts of the subtropics mainly for its fruit, which is utilized as a vegetable both in the green and dried states. It is an important crop for small and marginal farmers due to its economic value (Udoh *et al.*, 2005; Dhankhar *et al.*, 2009; Kumar *et al.*, 2010). This research becomes greatly significant in view of the fact that most soils in Bayelsa State are either

marsh land or in a normal state. Therefore, this study was conducted in order to examine the effect of differential soil conditions of wet and normal (dry) soil on the growth and development indices of *Abelmoschus esculentus* L. Moench, and the properties of the experimental soils.

2.0 Materials and Methods

2.1 Study Area

The research was carried out in Opolo, Yenagoa, Bayelsa State, Nigeria. Opolo is located at coordinates of Latitude 4. 9592° - 4.9624°N and Longitude 6. 3659° - 6.3701°E. Opolo, the study site is an area in Bayelsa State, which is characterized by both marshy and terrestrial terrain together with the general ecological features of a typical tropical climatic region. Bayelsa State lies in the heaviest rainfall area of Nigeria with a mean minimum monthly temperature ranging from 25°C to 31°C (Niger Delta Source, 2014).

2.2 Analysis of Soil samples

Soil samples obtained from the two experimental locations at the depth of 1 – 20 cm were analyzed for physico-chemical characteristics using standard procedures. Soil particles were sieved through 2 mm stainless steel sieve, and subjected to chemical analysis. Soil pH was determined by pH meter after preparing the soil: water suspension at ratio 1: 5. 1 N ammonia was used to extract the samples and content of exchangeable potassium (K) was determined by flame photometer. Atomic absorption spectrometer (Unicam model) was used to measure exchangeable calcium (Ca) and magnesium (Mg) contents after extracting the sample using the method Peterson, (2002). Colorimetric method was used to determine available phosphorus (P) content. Total nitrogen (TN) was determined using the modified Kjeldahl distillation methods (Juo, 1979). Copper (Cu) and iron (Fe) were extracted with DTPA and determined by using atomic absorption

spectrometer according to the method of Peterson (2002).

2.3 Germination and Growth studies

Healthy seeds of *Abelmoschus esculentus* obtained from certified dealers in Yenagoa, Bayelsa State, were surface sterilized with 5% sodium hypochloride solution for 5 minutes, thoroughly washed several times with sterile distilled water and air dried. Two areas (wet soil and normal soil) were carefully selected as the experimental soils for the study. Viable seeds of the test crop were sown in the two experimental soils in rows (3 seeds per stand with 20 sampling units) using a completely randomized design. The experimental set up was maintained for 8 weeks for determination of growth and development parameters of the test crop.

2.4 Determination of Shoot Length and Root Length

The shoot length and root length of the seedlings were measured with a meter rule and expressed in centimeters.

2.5 Determination of Chlorophyll Content

Chlorophyll content in the leaves of the test crop was determined by using standard method (Ekanayake and Adeleke, 1996; Lahai *et al.*, 2003). 2 g of leaf tissue was crushed in a mortar and 80 % acetone was added to it, in sufficient quantities to allow the tissue to be thoroughly homogenized. The supernatant was decanted through a filter paper into a 100 ml volumetric flask. Acetone was again added to the residue in the mortar and the extraction procedure repeated. Additional acetone was used to wash off the chlorophyll until the 100 ml mark was attained in the volumetric flask. The resulting solution was thoroughly mixed and 5 ml pipette into a 50 ml flask and made to volume with 80 % acetone.

The absorbance of the extract was measured at 645, 663, and 652 nm wavelengths using model 690 spectrophotometer for chlorophyll a, b and ab respectively, using 80 % acetone as blank. Concentrations of chlorophyll (mg/g fresh leaf weight) were calculated.

2.6 Statistical Analysis

The data generated from this study was examined statistically using Analysis of variance (ANOVA) and differences in the means were tested using Least Significant Differences (LSD) at probability level of 5% (Obi, 2002).

3.0 Results and Discussion

The chemical properties of the experimental soils are presented in Table 1. The pH values of both soils were slightly acidic, however, the pH value of the wet soil (5.10) was significantly ($P < 0.05$) lower than that of the normal soil (5.40). The contents of available phosphorus, total nitrogen, calcium, sodium, copper, zinc and manganese in normal soil were significantly ($P < 0.05$) higher than that of the wet soil (Table 1). The magnesium, potassium and iron contents in wet soil were higher than that of the normal soil (Table 1). Reduction in the contents of nitrogen, phosphorus and potassium in tissues of *Phaseolus vulgaris* has been reported as caused by flooding (Etukudo and Onu, 2021). There is a relationship between total soil nutrients, availability in soil and the actual contents in plant tissues. Soil lost due to erosion has been shown to result in leaching of valuable plant-available nutrients and organic matter, most especially, water soluble nutrients such as nitrate and potassium are affected (Clark, 2000). Variations in the chemical properties of the two experimental soils used for this study may be attributed to the distinct overriding factors that operate in wet and normal soil. The proportion of

micronutrients in top soil has been reported to be dependent on the different types of parent material, vegetation, topography, climate and nutrient application as well as type of land use (Wang *et al.*, 2008). It is important to state that

the two experimental soils are characterized by different cultural and ecological conditions, which could affect the soil properties of the habitat (Maynard and Hochmuth, 2007).

Table1: Chemical properties of Experimental soils

Parameters	Sampling Points	
	Normal soil	Wet soil
pH	5.40±0.33	5.10±0.11
Avail. Phosphorus (mg/100g)	10.07±0.25	4.24±0.53
Total N (%)	2.77±0.30	1.86±0.10
Calcium (mg/100g)	3.27±0.29	2.64±0.21
Magnesium (mg/100g)	2.86±0.58	5.20±0.74
Sodium (mg/100g)	4.06±0.48	3.02±0.19
Potassium (mg/100g)	2.16±0.11	6.07±0.27
Copper (mg/100g)	0.72±0.03	0.04±0.02
	0.06±0.02	0.19±0.02

Mean ± standard error from three replicates

The growth parameters of *Abelmoschus esculentus* L. Moench are presented in Table 2. The shoot length, leaf number, root length and root number of the test crop in normal soil were significantly ($P < 0.05$) higher than that of the wet soil (Table 2). This study is in line with several studies on the effects of flooding on plants (Jackson, 2004; Jackson and Colmer, 2005). Although different plant species show variability in their responses to flooding, most crops exhibit negative response when exposed to excessive moisture (Jackson, 2004). Plants have been reported to be subjected to stress conditions under flooding condition, leading to reduction in growth, species distribution and Agricultural productivity (Jackson and Colmer, 2005). Soil condition in wet land is characterized by poor aeration, hence promotes oxygen deficiency for the respiring tissues and less adapted species (Huang *et al.*, 2003; Vartapetian *et al.*, 2003). Oxygen is one of the basic requirements for plant growth, therefore, reduction in oxygen level in soil does not only limits aeration in soil but

also impairs respiration in root tissues with the overall negative effects on plant growth and development (Parent *et al.*, 2008). This may have accounted for the reduction in the test crop growth parameters in wet soil relative to the normal soil. The chlorophyll contents of the test crop are presented in Table 3. The chlorophyll a, b and ab contents of the test crop in normal soil were significantly ($P < 0.05$) higher than that of the wet soil (Table 3). The reduced chlorophyll a, b and ab contents in *A. esculentus* grown in wet soil relative to the normal soil may be attributed to nutrient deficiency. Studies on the deleterious effects of flood water on chlorophyll efficiency have been reported by Visser *et al.* (2003) and Ransom, (2013) that inundation of shoots and roots leads to higher stress on plants resulting from prevention of flow of carbondioxide for photosynthesis. Deficiency of P, Mn and N has been reported in wet lands, thus, resulting in distortion of metabolic activities in plant tissues (Gutierrez –Boem *et al.*, 1996; Clark, 2000).

Table 2: Growth parameters of *Abelmoschus esculentus* L. Moench

Parameters	Sampling Points	
	Normal soil	Wet soil
Shoot length (cm)	41.21±0.10	10.33±0.48
Leaf number	5.16±0.60	4.09±0.21
Root length (cm)	6.33±0.32	6.02±0.38
Root number	6.04± 0.11	5.30±0.72

Mean ± standard error from three replicates

Table 3: Chlorophyll contents of *Abelmoschus esculentus* L. Moench

Parameters	Sampling Points	
	Normal soil	Wet soil
Chlorophyll a (mg/g)	1.830±0.17	1.494±0.85
Chlorophyll b (mg/g)	1.639±0.40	1.212±0.34
Chlorophyll ab (mg/g)	3.460±0.22	2.697±0.62

Mean ± standard error from three replicates

4.0 Conclusion

This study revealed that there are marked variations in response of *A. esculentus* to wet and normal soil conditions. The normal soil conditions enhanced the growth and development parameters of the test crop than that of the wet soil. In addition, the normal soil supported the chemical properties of soil than that of the wet soil. Although, the pH values of both soils were slightly acidic, the pH value of the wet soil was lower than that of the normal soil. The contents of mineral elements such as available phosphorus, total nitrogen, calcium, sodium and copper in normal soil were comparatively higher than that of the wet soil, while the magnesium, potassium and iron contents in wet soil were higher than that of the normal soil. The shoot length, leaf number, root length, root number and chlorophyll contents of the test crop in normal soil were relatively higher than that of the wet

soil. *Abelmoschus esculentus* L. Moench should be grown in soil medium where there is optimum soil moisture in order to enhance better growth and yield components.

Acknowledgments

We are grateful to other members of our research team who had worked relentlessly during the field and laboratory work as well as their various roles throughout the various stages of this manuscript.

References

- Agbede, O.O., 2009. Understanding soil and plant nutrition. Nigeria Salmon Press and Co. Nigeria Ltd, 20 – 60.
- A.O.A.C., 2003. Association of Official Analytical Chemist. Methods of analysis, Washington DC., U.S.A.

- Boll, T., Svenning, J.C., Vormisto, J., Normand, J., Grandez, C., Balslev, H., 2005. Spatial distribution and environmental preferences of the piassaba palm *Aphandra Natalia* (Arecaceae) along the Pastaza and Urituyacu rivers in Peru". *Forest Ecology and management*, pp. 175-183.
- Braidy, C., Weil, I., 1999. *Soil organic matter, the nature and properties of soil*. 12th Edition, Prentice Hall, New Jersey.
- Clark, J., 2020. *Managing soil and soil fertility after flooding*. South Dakota State University Extension.
- Dhankhar, B. S., Singh, R., 2009. *Okra Handbook: Global production, processing, and crop improvement*. HNB Publishing.
- Ekanayake, I. J., Adeleke, M.T.V., 1996. *Selected procedures for instrumentation in ecophysiological studies of root crops, procedures manual no.3* (IITA Ibadan, Nigeria: Crop Improvement Division (CID).
- Etukudo, M. M., Hamilton-Amachree, A., Roberts, E.M.I. 2015. *Eco-physiological studies of elemental and proximate contents of *Gnetum africanum* Welw and *Telfairia occidentalis* Hook seeds from two ecological zones of Akwa Ibom State"*. *European International Journal of Science and Technology*, 4(6), 47-53.
- Etukudo, M. M., Onu, B., 2021. *Developmental and morphological indices of *Phaseolus vulgaris* L. and soil physico-chemical properties during serial flooding in Bayelsa State, Nigeria*. *Nigerian Journal of Pharmaceutical and Applied Science Research* (NIJOPHASR), 10(1), 55-60.
- Gutierrez- Boem, F. H., Lavado, R. S., Pprcelli, C., 1996. *Note on the effects of winter and spring waterlogging on growth, chemical composition and yield of rapeseed"*. *Field Crops Research*, 47, 175–179.
- Huang, S., Greenway, H., Colmer, T. D., 2003. *Responses of coleoptiles of intact rice seedlings to anoxia: K⁺ net uptake from the external solution and translocation from the caryopses*. *Annals of Botany*, 91, 271–278.
- Jackson, M. B., 2004. *The impact of flooding stress on plants and crops*. http://www.plantstress.com/Articles/water_logging_i/waterlog_i.htm.
- Jackson, M. B., Colmer, T. D., 2005. *Response and Adaptation by Plants to Flooding Stress*. *Annals of Botany*, 96(4), 501–505.
- Juo, A. S. R., 1979. *Selected methods for soil and plant analysis*. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
- Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, D., Kouame, C., 2010. *Okra (*Abelmoschusspp.*) in West and Central Africa: Potential and progress on its improvement"*. *African Journal of Agricultural Research*. 5(25), 3590-3598.
- Lahai, M. T., Ekanayake, I. J., George, J. B., 2003. *Leaf chlorophyll content and tuberous root yield of cassava in inland valley*. *African Crop Science Journal*, 2(11), 107-117.
- Maynard, D. N., Hochmuth, G. J., 2007. *Knott's Handbook for Vegetable Growers*. 5th ed. Hoboken, New Jersey: John Wiley & Sons, Inc.

- Niger Delta Source: Bayelsa State. (2014). <http://nigeriadeltasource.com/bayelsa>
- Obi, I. U., 2002. Statistical methods of detecting differences between treatment means and research methodology issues in laboratory and field experiments. Nigeria, AP Express Publishers Limited.
- Osim, S. E., Etukudo, M. M., Eze, U. P., Okoye, S. U., Ekwueme, D.C., 2020. Assessment of tolerance of *Zea mays* L. and physico-chemical properties of soil at flood affected site in Bayelsa State, Nigeria. International Journal of Scientific and Research Publications, 10(10), 397-400.
- Osuagwu, A. N., Ekpo, I. A., Okpako, E.C., Out, P., Ottoho, P. 2013. The Biology, Utilization and Phytochemical composition of the fruits and leaves of *Gongronema latifolium* Benth. Agrotechnol. 2, 115.
- Parent, C. C., Nicolas, A., Berger, M., Crevecoeur, M. F., 2008. An overview of plant response to soil waterlogging. Plant stress. Global Science Books. 2(1), 20-27.
- Peterson, L. 2002. Analytical method of soil, water, plant material fertilizers (eds.). Soil resources management and analytical services. Soil Resources Development Institute. Danida. pp. 5-16.
- Ransom, J., 2013. Impacts of flooding/ waterlogging on crop development. USDA National Institute of Food and Agriculture. Extension Agronomist for Cereal Crops.
- Rossel, R.A.V., Rizzo, R., Dematte, J. A.M., et al. 2010. Spatial modeling of soil fertility index using visible-near-infrared spectra and terrain attributes. Soil Science American Journal, 74, 1293- 12300.
- Udoh, D. J., Ndon, B. A., Asuquo, P. E., Ndaeyo N. U., 2005. Crop production techniques for tropics. Nigeria: Concept Publication Ltd.
- Vartapetian, B. B., Andreeva, I. N., Generozova, I. P., Polyakova, L.I., Maslova, I. P., Dolgikh, Y. I., Stepanova, A.Y.U. 2003. Functional electron microscopy in studies of plant response and adaptation to anaerobic stress. Annals of Botany, 91, 155–172.
- Visser, E. J. W., Voesenek, A. C. J., Vartapetian, B.B., Jackson, M.B., 2003. Flooding and Plant Growth. Annal. Bot. 91(2), 107–109.
- Wang, S.Y., Yu, T., Wang, J. L., Yang, L., Yang, K., Lu, P., 2008. Preliminary Study on Spatial Variability and Distribution of Soil Available Microelements in Pinggu County, Beijing, China. Agricultural Sciences in China; 7(10), 1235-1244.