Asian Journal of Research in Botany

2(3): 1-11, 2019; Article no.AJRIB.49920

Poultry Manure and Arbuscular Mycorrhizal Fungi Synergy Improves Saline Soil Properties, Growth and Physiology in *Cucurbita maxima* Duch

Okon, Okon Godwin[1*]

[1]*Department of Botany, Faculty of Biological Sciences, Akwa Ibom State University, Ikot Akpaden, Nigeria.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

Editor(s):
(1) Dr. Hon H. Ho, Professor, Department of Biology, State University of New York, New Paltz, USA.
Reviewers:
(1) Paola Taydé Vázquez Villegas, Instituto Tecnológico Superior de Cintalapa, México.
(2) Megahed Amer, Egypt.
(3) Kome Georges Kogge, University of Dschang, Republic of Cameroon.
Complete Peer review History: http://www.sdiarticle3.com/review-history/49920

Original Research Article

Received 19 April 2019
Accepted 28 June 2019
Published 08 July 2019

ABSTRACT

Aims: To assess the potential impacts of poultry manure (PM) amendment on saline soil properties and its synergy with arbuscular mycorrhizal fungi (AMF) on biomass yield and survival of *C. maxima.*
Study Design: The experiment was set up in complete block design of four (4) treatments with three (3) replicates.
Place and Duration of Study: Soil samples were obtained from the saline ecosystem of Iwuochang (Latitude 4.56°N and Longitude 7.57°E), Akwa Ibom State, Nigeria. All analysis was carried out in Soil Science Laboratory and Botany Laboratory, Akwa Ibom State University, between January and March 2019.
Methodology: Soil samples were analyzed following the standard procedures outlined for wet acid digestions. Growth parameters were determined using standard methods. At leaf chlorophyll meter was employed in the assessment of the photosynthetic pigments of the experimental plant. Electrolyte leakage was assessed using the HANNA instrument conductivity meter. Leaf relative water content (LRWC), vigour index (VI) and plant salt-tolerant index (PSTI) was calculated using standard formulas.

**Corresponding author: E-mail: okonokon@aksu.edu.ng;*

Results: Physicochemical analysis of the saline and poultry manure augmented soils indicated significant (*P* =.05) difference between the two soil types in pH, available phosphorus, total nitrogen, clay, sand, Ex. Ca, Mg, K, Na, OC and EC. Reduction in shoot length, number of leaves and leaf area as well as Chl a, b, carotenoids and total photosynthetic pigments (from 39.7 to 21.30 mg/kg^{-1}) of *C. maxima* were all significantly (*P* =.05) affected by soil salinity stress. PSTI was significantly reduced while EL increased in saline soil treatments. Inoculation with AMF alone or together with PM significantly (*P* =.05) increased the growth parameters, photosynthetic pigments and physiological parameters in *C. maxima* both in saline and non-saline soil treatments.

Conclusion: The results of this work have shown that AMF and PM synergy can enhance the ability of *C. maxima* to resist salt stress possibly through some morphological and physiological changes which improve vigour.

Keywords: Cucurbita maxima; Glomus geosporum; mycorrhiza; poultry manure; salinity stress.

1. INTRODUCTION

The presence of excessive soluble salts in the soil such as Na^{+2}, Na^{+}/K^{+}, Mg^{+2}/Ca^{+2} and Cl^{-}/NO^{-3} diminishes nutrient and plant water uptake and interrupts the circulation of ions at both the cellular and the whole-plant levels, thereby prompting osmotic and ionic disparities [1]. When salts are present in the soil above certain precarious levels, this can result in numerous physiological and biological complications to plants [2]. First of all, the rate of photosynthesis is greatly affected by soil salinity stress [3]. Plants by increasing their photosynthetic rates are able to produce a higher biomass yield than when their photosynthetic rates are lower; but, under soil salinity conditions, to conserve water, plants adapt by reducing the rate of opening of stomata and as a result reduce the rate of photosynthesis resulting in reduced carbon fixation by plants [3]. Basically, a saline soil is defined with respect to its electrical conductivity (EC) in a 1:5 soil-to-water ratio, wherein a saline soil is one with an EC > 4 dS/m.

Conversely, one of the most essential salinity stress special effects on plants is caused by nutritional imbalances, which result from salinity effect on accessibility, availability, uptake and translocation of the nutrients within the plant [4]. Plant nutrient shortages, as well as ionic toxicity and osmotic stress, are dynamics accredited to the damaging effect of salinity on plant growth and yield [5]. Nevertheless, salts can disrupt apoplastic conveyance between the cells owing to ion buildup and prevent water movement [3]. With respect to plant tissues, high salinity makes the tissues more inelastic and alters the cell wall elasticity [3]. Furthermore, soil salinization with the associated increase in plants' Na^{+} and Cl^{-} levels is supplementary with numerous internal difficulties due to inhibition of protein and enzyme synthesis [6]. Additionally, soil salinity damages the soil particles, plummeting porosity and the ability of plants to absorb water [6].

Recently, the increasing demand for chicken meat has led to the rise in poultry farming resulting in the increase in the generation and utilization of organic wastes (e.g. chicken manure) as fertilizers. These organic wastes are very rich in organic matter, mineral nutrients and water [7]. The use of organic wastes such as poultry droppings as manure has been in practice globally for centuries now [8] and modern times [9]. However, the use of poultry droppings as manure has vastly overtaken the use other animal wastes such as cow dung, pig manure, kraal manure etc. because of the rich nitrogen, potassium and phosphorus content [10]. Also, the high price of inorganic fertilizers and their long term negative impacts on the environment has also encouraged the increased patronage of poultry manure. Recent studies have shown a host of nutrient management practices undertaken by smallholder African farmers in favour of poultry manure [11].

Several Investigations carried out to comprehend arbuscular mycorrhizal fungi (AMF)-salinity relations revealed that mycorrhizal fungi decrease the undesirable effects of these stresses and stimulate plant growth and development [12,13]. It has been extensively acknowledged that AMF increases water use efficiency and nutrient uptake of the plant under salt stress conditions, hence facilitating the reduction of the damaging impression of salt stress [1]. AMF lessens the disadvantageous effects of toxic ions on membrane permeability and cell organelle, preserve the level of compatible organic solutes and intensifies antioxidant production (both enzymatic and non-enzymatic), and completely control the expression of salt-related genes [1].

Cucurbita maxima belong to the family *Cucurbitaceae*. They have been reported from many countries in tropical Africa and probably occur in all countries. *C. maxima* are rarely found growing in the wild in Nigeria. It is cultivated in Northern Nigeria for the fruits. In southern Nigeria, in a largely unimproved form, it is cultivated for both the leaves and fruits [14]. The medicinal uses of *C. maxima* include the dried pulp, in the form of confection, used as a remedy for hemoptysis and haemorrhages from the pulmonary tract [15]. For venomous invertebrates' bites such as those of centipedes, the ripe gourd is cut, dried and made into a paste and applied to infected regions. The fresh seeds pulped or in the emulsion, are used as antihelminthic [15].

Keeping abreast the beneficial effects of AMF and poultry manure, there still exist a need to assess the potential impacts of poultry manure on soil chemical properties and its synergy with AMF (*Glomus geosporum*) on crop yield.

Therefore, the objective of this work was to assess the influences of poultry manure on soil physicochemical properties and its synergy with *G. geosporum* on the survival of *C. maxima* under soil salinity stress.

2. MATERIALS AND METHODS

2.1 Experimental Soil Sampling Site

The saline soil used for this study was collected from the saline ecosystem of Iwuochang, Ibeno Local Government Area (Latitude 4.56°N and Longitude 7.57°E), Akwa Ibom State, Nigeria, with an annual rainfall of about 4021 mm and mean temperature variation of 22 – 31°C [16].

2.2 Experimental Setup

This experiment was set up in a complete block design with all treatments replicated thrice for *C. maxima.* This gave a total of four (4) treatments with three (3) replicates totaling twelve (12) combinations (Table 2.1).

2.3 Experimental Soil Treatment and Planting

The experimental soil was steam sterilized in the oven in bits for two hours at 100°C to kill weed seeds and soil microorganisms and sieved through a 2 mm mesh to remove pebbles. The poultry manure was air dried for three days before mixing about 4 kg of the manure to 10 kg of saline soil and left undisturbed for 1 week. AMF (*G. geosporum*) was inoculated by placing about 25 g of soil/root fragments containing about 60 – 65 spores per 5 g in planting hole at 15 cm depth, before planting the *C. maxima*, Following seedling emergence, the plants inoculated were allowed to establish for up to 2 weeks before being treated with the first dose of saline water.

Table 2.1. Experimental design

Treatments	Meaning
S- M- P-	- Salinity, - Mycorrhiza, - Poultry
S+ M- P-	+ Salinity, - Mycorrhiza, - Poultry
S+ M+ P+ (*Gg*)	+ Salinity, + Mycorrhiza (*G. geosporum*), + Poultry
S- M+ P+ (*Gg*)	- Salinity, + Mycorrhiza (*G. geosporum*), + Poultry

2.4 Physicochemical Analysis of Experimental Soils

The experimental soil samples were analyzed following the standard procedures outlined by the Association of Official Analytical Chemist [17] procedure for wet acid digestions.

2.5 Determination of Growth Parameters

The shoot length, leaf area and nodes of healthy leaves from the experimental plants were taken every 3 weeks after sprouting (WAS) using standard methods.

2.6 Determination of Photosynthetic Pigments

The atLeaf handheld chlorophyll meter was used for non-destructive estimation of the total chlorophyll and separated into chlorophyll a, b and carotenoids contents of *C. maxima.*

2.7 Determination of Physiological Parameters

Electrolyte leakage was calculated using the formula EC1/EC2 as described by Shi et al. [18]. Values of FW, TW, and DW were used to calculate LRWC using the formula:

$$\mathrm{LRWC}\ (\%) = \frac{(\mathrm{FW-DW})}{\mathrm{TW-DW}} \times 100$$ Kaya et al. [19]

Plant vigor index in each treatment was calculated using the formula:

Vigor index = Root length + Shoot length x percentage emergence (%) Maisuria and Patel [20]

Plant salt tolerance index (PSTI) was calculated using the formula of Jaarsma et al. [21]

$$\mathrm{PSTI} = \frac{\text{Fresh weight salt treatment}}{\text{Fresh weight control}}$$

2.8 Statistical Analysis

All data in the present study were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences and data are presented as the standard error of the mean (± S.E.M.) of triplicate experiments. The student's t-test was used to determine the significant difference between the means of the soil parameters analyzed. The differences between the means were separated and compared using Duncan's multiple range tests. However, a probability level of *P* =.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

The physicochemical analysis of the experimental soils (saline and poultry manure augmented soils) indicated significant (*P* =.05) difference between the two soil types in parameters such as; pH, available phosphorus, total nitrogen, clay, sand, Ex. Ca, Mg, K, Na, OC and EC. Furthermore, no significant (*P* =.05) difference was observed in parameters such as; silt, Ex. Acidity, Effective cation exchange capacity (ECEC) and base saturation between the two soil types (Table 3.1).

The significant (*P* =.05) increase observed in EC, pH and Ex Na^+ and the decrease in organic carbon, total nitrogen and available phosphorus in saline soil is similar to the results reported by Miller and Gardiner [22], they reported an upsurge in pH and EC in saline soils in New Jersey due to soil salinity. Also, similar increase in pH, EC and Ex Na^+ in saline soils and a decrease in organic carbon, organic matter, total nitrogen and phosphorus in salinity influenced soils in Nigeria were recorded by Deleke and Akomolafe [23].

The use of poultry manure to augment the adverse effect of soil salinity had significant (*P* =.05) alleviatory effect on the soil properties. Oagile and Namasiku [24] reported that the application of poultry manure showed great increase having exceptionally higher contents of exchangeable N, P and Ca as observed in this study.

Results obtained from this research showed that shoot length, number of leaves and leaf area of *C. maxima* were all significantly (*P* =.05) affected by soil salinity stress (Figs. 3.1, 3.2 and 3.3). Several researchers corroborate these findings and reported on plants such as *Raphanus sativus* L. [25],

Table 3.1. Physicochemical properties of the experimental soils

S/No.	Parameters	Saline soil amended with poultry manure	Saline soil	t-values
1.	pH	6.69	7.40	-4.786*
2.	Total Nitrogen (%)	2.36	0.36	2.982*
3.	Available P. (mg/kg)	32.11	21.78	24.750*
4.	Silt (%)	4.55	5.84	-3.400
5.	Clay (%)	3.48	10.22	-15.437*
6.	Sand (%)	91.97	83.94	13.890*
7.	Ex. Ca (cmol./kg)	4.11	3.54	1.121*
8.	Ex. Mg (cmol./kg)	5.61	3.84	4.773*
9.	Ex. Na. (cmol./kg)	0.28	6.48	7.257*
10.	Ex. K. (cmol./kg)	4.05	0.43	70.679*
11.	Organic Carbon (%)	6.48	1.73	-22.922*
12.	Exchangeable acidity (meq/100g)	3.52	3.22	-1.090
13.	ECEC (cmol./kg)	17.57	17.51	-3.401
14.	Base saturation (%)	79.97	81.61	-1.216
15.	EC. (dS/m)	0.29	6.70	-15.322*

** Significant at t = 0.05, Ex – Exchange, ECEC – Effective cation exchange capacity, EC – Electrical conductivity*

Vigna unguiculata L. [26] and *Vigna mungo* L. [27]; they all reported that increased soil salinity results in a decline in the shoot lengths of the plants. NaCl has been revealed to reduce number of leaves in *Phaseolus acutifolius* L., *V. unguiculata* L. and *Phaseolus filiformis* L. [28]. Also, several researches have documented significant reduction in leaf area in *Vicia faba* [29], *Avena sativa* L. [30] and *Fragaria xananssa* L. [31]. This notable decrease in the growth parameters such as shoot length, number of leaves and leaf area in *C. maxima* planted under saline conditions in this study is as a result of the increased absorptions and accumulation of Na^+ and Cl^-. This could be explained by the undesirable influence of salt on photosynthetic processes and subsequently plant overall growth and leaf growth to avoid the escape of water via transpiration and chlorophyll content [32].

Inoculation of *C. maxima* with arbuscular mycorrhizal fungi (AMF) (*Glomus geosporum*) and poultry manure (PM) synergy in combined form significantly (*P* =.05) increased the growth of *C. maxima* above the control in both saline and non-saline soil treatments. Similar observations have been made by Okon et al. [33] while working on AMF *Glomus deserticola* inoculation and mulch on *Manihot esculenta*. This can be attributed to the PM conserving moisture and nutrients, thus making the soil conditions conducive for the AMF colonization [33]. Similar observations have been made by Tanmay et al. [34] on *Oryza sativa,* Islam et al. [35] on hybrid rice.

Total photosynthetic pigments, chlorophyll a, b and carotenoids contents of *C. maxima* were significantly (*P* =.05) reduced by soil salinity (Fig. 3.4). Non-mycorrhizal *C. maxima* treatment was more severely affected than the mycorrhizal inoculated plants. Jing et al. [36] reported a significant reduction in the total chlorophyll content of *Suaeda aralocaspica* exposed to high soil salinity, this reduction was ascribed to the decrease or destruction of the chloroplast structure. Wu et al. [12] reported that they observed increased photosynthetic rates and stomatal conductance in AMF over non-AMF plants under soil salinity stress. The increased rate of photosynthesis in AMF-colonized plants under salinity stress has been correlated with lower intercellular CO_2 concentration in mycorrhizal plants since the higher photosynthetic capacity increases water use efficiency for the assimilation of more carbon per unit water transpiration [37].

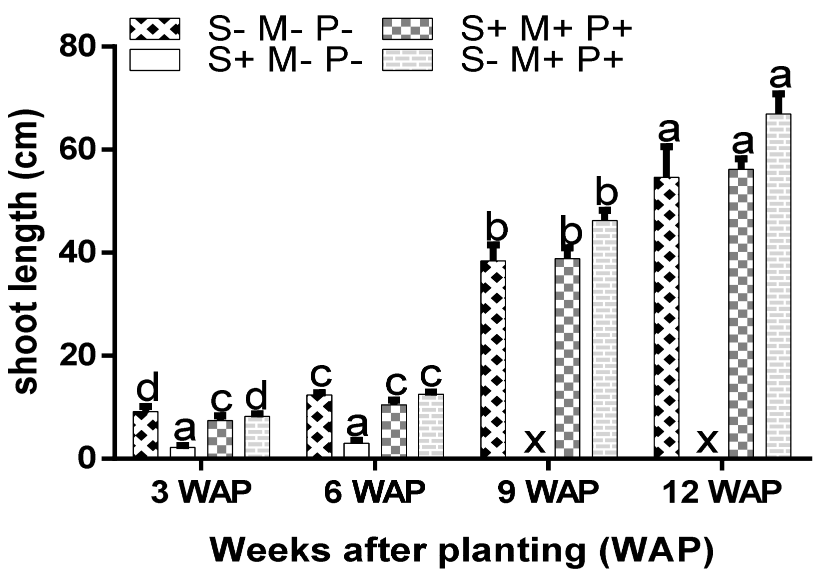

Fig. 3.1. Influence of Poultry manure and AM Fungi synergy on shoot length of *C. maxima* grown in saline soil. Bars followed by same letter are not significantly different at *P* =.05 level. 'x' indicates that the plants died off

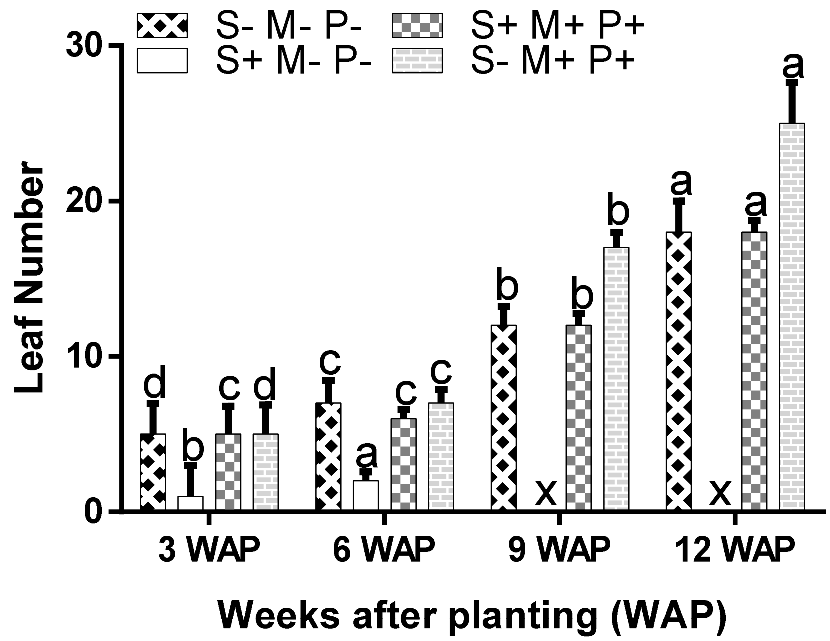

Fig. 3.2. Influence of Poultry manure and AM Fungi synergy on leaf number of *C. maxima* grown in saline soil. Bars followed by same letter are not significantly different at *P* =.05 level. 'x' indicates that the plants died off

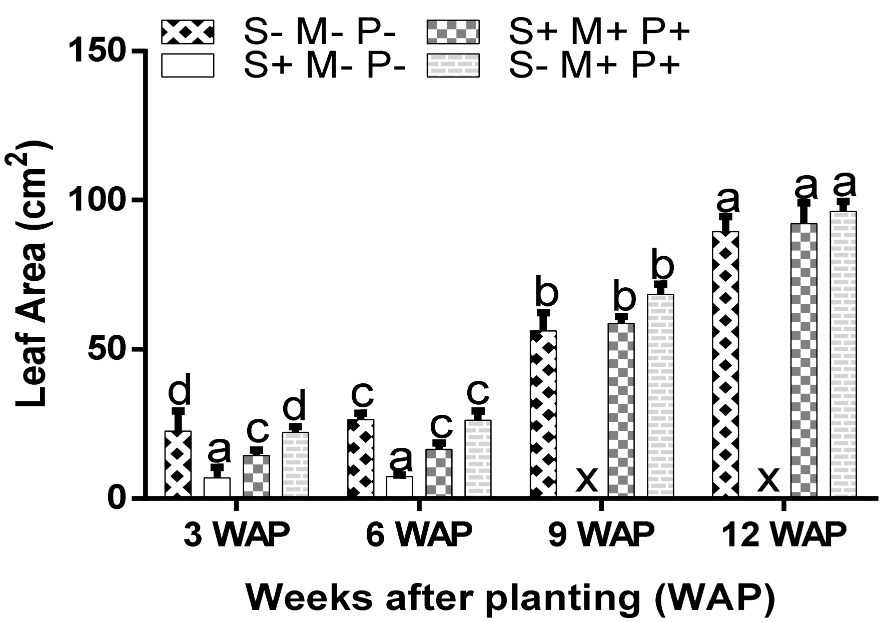

Fig. 3.3. Influence of Poultry manure and AM Fungi synergy on leaf area of *C. maxima* grown in saline soil. Bars followed by the same letter are not significantly different at *P* =.05 level. 'x' indicates that the plants died off

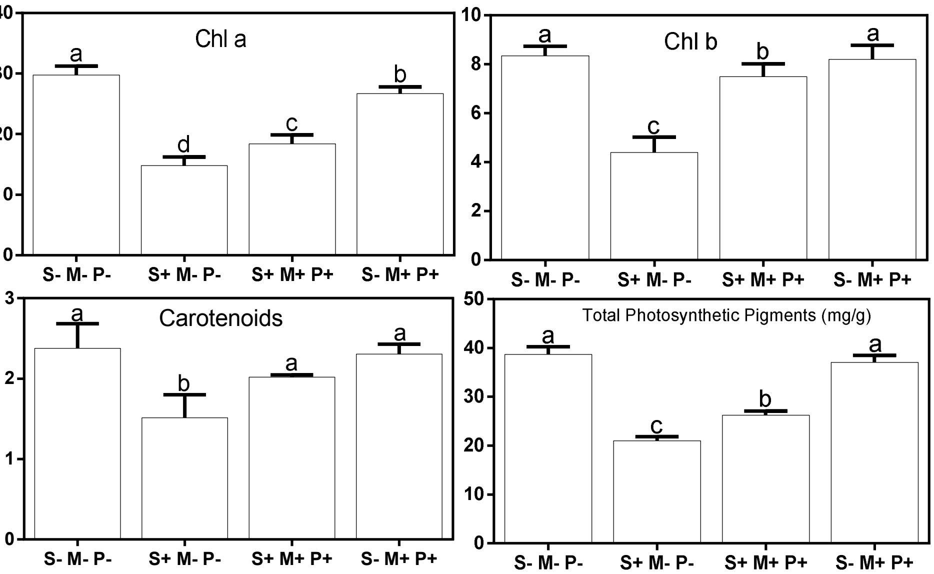

Fig. 3.4. Influence of Poultry manure and AM Fungi synergy on chlorophyll a, b, c and total photosynthetic pigments of *C. maxima* grown in saline soil. Bars followed by the same letter are not significantly different at *P* =.05 level

C. maxima leaf turgid weight (LTW), leaf relative water content (LRWC), vigor index (VI) and salt tolerance index (STI) were significantly reduced by soil salinity, while electrolyte leakage (EL) was higher in saline soil treatment than non-saline soil treatments (Table 3.2). However, inoculation of *C. maxima* with AMF (*G. geosporum*) in conjunction with poultry manure amendment significantly (P=0.05) increased the LTW, LRWC, VI and STI in both saline and non-saline soil treatments. However, electrolyte leakage (EL) reduced with mycorrhizal inoculation (Table 3.2).

Ali and Hassan [38] reported that under salt stress because of inadequate water uptake, RWC was significantly decreased in relation to salinity in chamomile herb. Shou-Jun et al. [39] also reported that under no saline condition, leaf relative turgidities in non-mycorrhizal and mycorrhizal plants remained at a comparatively steady-state level from 53.75% to 54.56% throughout the experiment. Mycorrhizal inoculation led to relatively higher leaf turgidity compared to non-mycorrhizal plants in this study. The phenomenon is ascribed to the improved hydraulic conductivity of plants with a longer root and an altered root system morphology induced by AM fungi [39]. Sheng et al. [38] reported that plants inoculated with AMF maintain relatively higher water content compared with uninoculated plants. Inoculation with AMF often results in increased nutrient uptake, accumulation of an osmoregulator, an increase in photosynthetic rate and water use efficiency, suggesting that salt stress alleviation by AMF results from a combination of nutritional, biochemical and physiological effects [40].

Mumtaz et al. [41] reported that electrolyte leakage was enhanced with increasing salinity levels as compared to the control in salt-sensitive cucumber plants as compared to the salt tolerant cultivar. This observation has been reported by other investigators in cucumber [42] and tomato [43]. A major effect of environmental stress (i.e., salt, drought) on the plant is membrane modification, which results in cell membrane perturbed function or total dysfunction. Changes in membrane leakage and injury can be measured by the extent of EL (Electrolyte Leakage) in tissues [43]. The positive effects of AMF inoculation may result in improving integrity, vigour and stability of the membrane since the membrane permeability has been found to be reduced by AMF inoculation. Plants inoculated with AMF have been shown to maintain a lower electrolyte concentration than the non-mycorrhizal ones and hence maintain membrane stability [39].

Table 3.2. Impact of poultry manure and arbuscular mycorrhizal fungi (AMF) synergy on the physiological parameters of *C. maxima* grown in saline soil

Treatments	Leaf Turgid Weight (LTW) (g)	Leaf Relative Water Content (LRWC) (%)	Salt Tolerance Index (STI)	Vigor Index (VI) (%)	Electrolyte Leakage (EL) (dS/m)
S- M- P-	*1.67 ± 0.06[b]	38.00 ± 2.51[b]	1.00 ± 0.01[a]	7481.00[b]	0.81 ± 0.24[c]
S+ M- P-	0.50 ± 0.10[c]	11.30 ± 0.40[c]	0.10 ± 0.03[c]	150.00[d]	3.04 ± 0.70[a]
S+ M+ P+ (*Gg*)	1.26 ± 0.11[b]	36.00 ± 1.24[b]	0.36 ± 0.08[b]	4303.00[c]	2.02 ± 0.67[b]
S- M+ P+ (*Gg*)	2.74 ± 0.61[a]	45.21 ± 2.01[a]	1.06 ± 0.54[a]	10088.00[a]	0.75 ± 0.44[c]

**Mean of three replicates ± SEM. [a]Means within of each column followed by different letters are significantly different at P =.05 according to Duncan's Multiple Range Test. (Gg) – Glomus geosporum*

4. CONCLUSION

Despite the complexity of the arbuscular mycorrhizal fungi, poultry manure and plant interaction in these experiments, the work presented in this research provide insights into the role of mycorrhiza (*G. geosporum*) treatments in conjunction with poultry manure in alleviating salt stress of *C. maxima*. The findings of this research improves our understanding of the morphological and physiological responses of *C. maxima* to mycorrhizas in the context of salinity stress and shed more light on the importance of several factors, such as AMF type and enhancement by synergistic interaction between AMF and poultry manure, in determining the outcome of the fungus-plant relationship under salt stress to enhance plant growth and crop productivity, thus opening new horizons for future research.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Saxena B, Giri B, Shukla K. Arbuscular mycorrhizal fungi and tolerance of salt stress in plants. *In*: Q. S. Wu, (Editor), Arbuscular mycorrhizas and stress tolerance of plants. Springer Nature Singapore Pte Ltd, Singapore. 2017;73.
2. Taiz L, Zeiger E. Fisiologia vegetal. 4th Edition. Editora ARTMED, Porto Alegre. 2009;848.
3. Ebrahim KE. Role of arbuscular mycorrhizal fungi in fighting soil salinity. PhD Thesis. Royal Holloway-University of London, London, England. 2014;45.
4. Munns R, Tester M. Mechanisms of salinity tolerance. Annual Review of Plant Biology. 2008;59:651-681.
5. Nublat A, Desplans J, Casse F, Berthomieu P. An arabidopsis mutant over accumulating sodium in the shoot, shows deficiency in the control of the root radial transport of sodium. The Plant Cell. 2001;13:125-137.
6. Rengasamy P. Transient salinity and subsoil constraints to dry land farming in Australian sodic soils: An overview. Australian Journal of Experimental Agriculture. 2002;42:351–361.
7. Brady NC, Weil RR. The nature and properties of soils. 11th Edition. Prentice Hall International, Inc.; 1996.
8. Straub D. A hot issue-chicken manure. Tilth producers quarterly. A Journal of Organic and Sustainable Agriculture; 1977.
9. López-Masquera ME, Cabaleiro F, Sainz MS, López-Fabal A, Carral E. Fertilizing value of broiler litter: Effects of drying and pelletizing. Bioresource Technol. 2008;99: 5626-5633.
10. Schjegel AJ. Effect of composted manure on soil chemical properties and nitrogen use by grain sorghum. J. Prod. Agric. 1992;5:153-157.
11. Place F, Swallow BM, Wangila JW, Barrett CB. Lessons for natural resource management technology adoption and research. In Barrett (Eds.). Natural Resources Management in African Agriculture: Understanding and Improving Current Practices. Oxon and New York: CABI Publishing. 2002;275-285.
12. Wu QS, Zon YN, Liu W. Alleviation of salt stress in citrus seedlings inoculated with mycorrhiza: Changes in leaf antioxidant defense systems. Plant Soil Environment. 2010a;56:470–475.
13. Wu QS, Zou YN, He XH. Contributions of arbuscular mycorrhizal fungi to growth, photosynthesis, root morphology and ionic balance of citrus seedlings under salt stress. Acta Physiology of Plant. 2010b;32: 297–304.
14. Agbagwa IO, Ndukwu BC. Cucurbita L. species in Nigeria: Under-exploited food and vegetable crops. Niger Delta Biological. 2004;4(2):11–15.
15. Villasenor IM, Bartolome ALO. Microbiological and pharamcological studies on extracts of *Cucurbita maxima*. Phytotherapy Research. 1995;9(5):376-378.
16. AKSG. Geography and location about Akwa Ibom State. Available:http://www.aksg.online.com (Retrieved on 27th January 2017)
17. AOAC (Association of Official Analytical Chemists). Official methods of analysis. 10th and 17th Edition. Association of Official Analytical Chemists, Washington D.C. 2005;98.
18. Shi Q, Bao Z, Zhu Z, Ying Q, Qian Q. Effects of different treatments of salicylic acid on heat tolerance, chlorophyll fluorescence, and antioxidant enzyme activity in seedlings of *Cucumis sativa* L. Plant Growth Regulation. 2006;48:127–135.

19. Kaya C, Kirnak H, Higgs D, Saltati K. Supplementary calcium enhances plant growth and fruit yield in strawberry cultivars grown at high (NaCl) salinity. Science Horticulture. 2003;26:807–820.
20. Maisuria KM, Patel ST. Seed germinability, root and shoot length and vigour index of soybean as influenced by rhizosphere fungi. Karnataka Journal of Agricultural Sciences. 2009;22(5):1120-1122.
21. Jaarsma R, Rozemarijn SM, Albertus H. Effect of salt stress on growth, Na+ accumulation and proline metabolism in potato (*Solanum tuberosum*) cultivars. PLoS ONE. 2013;8(3):60-183.
22. Miller RW, Gardiner DT. Soils in our environment. 9th Edition, Prentice Hall-Incorporated, Upper. Saddle River, New Jersey 07458. 2007;452.
23. Dedeke OA, Akomolafe GF. Influence of salinity on soil chemical properties and surrounding vegetation of awe salt mining site, Nasarawa State, Nigeria. African Journal of Environmental Science and Technology. 2013;7(12):1072–1075.
24. Oagile D, Namasiku M. Chicken manure-enhanced soil fertility and productivity: Effects of application rates. Journal of Soil Science and Environmental Management. 2010;1(3):46-54.
25. Jamil M, Rehman SU, Lee KJ, Kim JM, Rha HK. Salinity reduced growth ps2 photochemistry and chlorophyll content in radish. Science Agriculture (Piracicaba, Braz.). 2007;64(2):111–118.
26. Taffouo VD, Kouamou JK, Ngalangue LMT, Ndjeudji BAN, Akoa A. Effects of salinity stress on growth, ions partitioning and yield of some cowpea (*Vigna ungiuculata* L. Walp) cultivars. International Journal of Botany. 2009;5(2):135–143.
27. Kapoor K, Srivastava A. Assessment of salinity tolerance of *Vinga mungo* var. pu-19 using *ex vitro* and *in vitro* methods. Asian Journal of Biotechnology. 2010;2(2): 73–85.
28. Raul L, Andres O, Armado L, Bernardo M, Enrique T. Response to salinity of three grain legumes for potential cultivation in arid areas (plant nutrition). Soil Science and Plant Nutrition. 2003;49(3):329–336.
29. Amira MS, Abdul Q. Effect of salt stress on plant growth and metabolism of bean plant *Vicia faba* (L.). Journal of the Saudi Society of Agricultural Sciences. 2010;10: 7–15.
30. Zhao GQ, Ma BL, Ren CZ. Growth, gas exchange, chlorophyll fluorescence and ion content of naked oat in response to salinity. Crop Science. 2007;47(1):123–131.
31. Yilmaz H, Kina A. The influence of NaCl salinity on some vegetative and chemical changes of strawberries (*Fragaria xananassa* L.). African Journal of Biotechnology. 2008;7(18):3299–3305.
32. Netondo GW, Onyango JC, Beck E. Crop physiology and metabolism sorghum and salinity ii – gas exchange and chlorophyll fluorescence of sorghum under salt stress. Crop Science. 2004;44(3):806–811.
33. Okon IE, Solomon MG, Osonubi OO. The effects of arbuscular mycorrhizal fungal inoculation and mulch of contrasting chemical composition on the yield of cassava under humid tropical conditions. The Scientific World Journal. 2010;10: 505–511.
34. Tanmay D, Mizanor R, Sultan UB, AK. Use of organic amendment for amelioration of salinity stress in transplanted aman rice Cv. BRRI dhan41. International Journal of Natural and Social Sciences. 2015;2(5):82-94.
35. Islam MT, Sharma PC, Gautam RK, Singh D, Singh S, Panesar B, Ali S. Salt tolerance in parental lines of rice hybrids through physiological attributes molecular markers. International Journal of Nuclear Agriculture. 2011;14(1):63-69.
36. Jing C, Xiu YL, Ling C, Jia JX, Hai YL. Effects of salinity on the growth, physiology and relevant gene expression of an annual halophyte grown from heteromorphic seeds. AoB PLANTS. 2015;7:112.
37. Sheng M, Tang M, Chan H, Yang B, Zhang F, Huang Y. Influence of arbuscular mycorrhizae on photosynthesis and water status of maize plants under salt stress. Mycorrhiza. 2008;18:287–296.
38. Shou-Jun Y, Zhong-Lan Z, Yuan-Xia X, Zhi-Fen Z, Shu-Yi S. Arbuscular mycorrhizal fungi increase salt tolerance of apple seedlings. Botanical Studies. 2014;55(70):4–7.
39. Ali EF, Hassan FAS. Alleviatory effects of salt stress by mycorrhizal fungi and gibberellic acid on chamomile plant. International Journal of Science and Research. 2014;3(11):109–111.
40. Evelin H, Kapoor R, Giri B. Arbuscular mycorrhizal fungi in alleviation of salt

stress: A review. Annuals of Botany. 2009;104:1263–1280.
41. Mumtaz KM, Ruqaya S, Al-Mas'oudi M, Al-Said F, Khan I. Salinity effects on growth, electrolyte leakage, chlorophyll content and lipid peroxidation in cucumber (*Cucumis sativus* L.). International Conference on Food and Agricultural Sciences. 2013;55:30–32.
42. Kaya C, Higgs D, Kirnak H. Effects of supplementary phosphorus and potassium on physiological development and mineral nutrition of cucumber and pepper cultivars grown at high salinity (NaCl). Journal of Plant Nutrition. 2001;24:1457-1471.
43. Atilla LT. Influence of foliarly applied different triazole compounds on growth, nutrition, and antioxidant enzyme activities in tomato (*Solanum lycopersicum* L.) under salt stress. Australian Journal of Crop Science. 2014;8(1):71–79.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/49920