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Effect of Salinity Stress on the Morphological Parameters of *Hura crepitans* L. Ameliorated with *Calapogonium mucunoides* DESV. and Biochar

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Abstract
Salinity is one of the most serious limiting factors for plant growth and production. This study assessed the effect of salinity stress on the morphological parameters of Hura crepitans ameliorated with Calapogonuim mucunoides Desv. and Biochar. Standard methodology was adopted to examine physicochemical properties of the soil and morphological parameters of the plant. The physicochemical properties of the experimental soils was significant at p=0.01. Morphological parameters of shoot length of H. crepitans at 1% non-amended saline soil for week 6 and 7 recorded 4.03±4.03cm which indicated a significant reduction (p=0.01) when compared to control 15.70±3.35 and 19.50±4.43cm respectively. The amelioration of the saline soil at 0.001% KI with biochar and C. mucunoides (21.80±0.05 and 22.43±3.52cm) of H. crepitans shoot length was significant when compared to the control 21.00±4.00cm. The higher the concentration of salinity, the lower the petiole length of H. crepitans for amended treatments. The photosynthetic pigment 56.70±2.47 of H .crepitans at 0.001% was significant (p=0.05) when compared to the control 51.36±2.99.This results showed that salinity causes a detrimental effect on some plant growth parameters. However, amelioration of saline soil with C. mucunoides and biochar recorded a satisfactory remediation effect on the growth of H. crepitans. Based on this research, amelioration treatment such as C. mucunoides and biochar can be use to improve crops planted in saline soil.

Keywords: Biochar, *Calapogonium mucunoides, Hura crepitans*, Saline soil, Significant.

INTRODUCTION
Salinization of soils is one of the most predominant agricultural problems commonly occurring in the arid, semiarid and low-lying coastal areas of the world (Kumar *et al.*, 2010 and Porcel *et al.*, 2012). Globally, salinization of soil is increasing due to rise in the sea levels by climate change and also due to wrong irrigation practices of agricultural lands (Bothe, 2012 and Maathuis *et al.,* 2014). In some areas, it is increasing due to extensive use of salt on roads to prevent frozen glaze in winter (Bothe, 2012).

To improve crop growth and production in the salt-affected soils, the excess salts must be removed from the root zone. Methods commonly used in amelioration of soils are scraping, flushing and leaching. These methods were found to be very expensive. Consequently, soil

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remediation is of great importance for maintaining crop yield and food quality in this area (Cai *et al*., 2021). There are many reported technologies for saline–alkali soil amendment, such as water leaching (Li, 2018), chemical remediation (Wang *et al*., 2014), and phytoremediation (Hamideh *et al*., 2017). However, practical applications of these methods are limited due to low efficiency, high costs, or secondary pollution (Zhou *et al*., 2021). Therefore, a more efficient and environment-friendly method is needed for increasing plant growth, enhancing soil properties, and decreasing salt stress in the coastal saline soil.
Composting is one of the most efficient phytoremediation technologies to improve soil properties and enhance crop yield because of the disposal of organic wastes and the production of compost that is suitable to be a fertilizer or soil amendment (Qayyum *et al*., 2017; Kumar *et al*., 2018; Zahra *et al*., 2021a).Biochar is a polyporus carbon-rich material prepared from various organic waste feedstock under certain thermal combustion with limited oxygen (Yang *et al*., 2021a). Due to the large porosity, high adsorption capacity, abundant surface functional groups, and rich carbon content, biochar could bring multiple benefits to agricultural sustainability such as enhancement of soil nutrient availability and water holding capacity and improvement of soil structure (Verheijen *et al*., 2019; Suo *et al*., 2021).

Sandbox tree (*Hura crepitans*) is an evergreen tree that belongs to the spurge family (Euphorbiaceae) that grows in the tropical regions of the world (Wikipedia encyclopedia, 2006). The tree can be recognized by the presence of many dark conical spines that covers the bark and its large heart shaped leaves with prominent secondary veins. The fruits produced are pumpkin shaped pods which are usually green when fresh and brown when dry. The fruit is characterized by its tendency to break with an explosive sound when ripe and dry, splitting the seedpods into segments catapulting the seeds as far as 100 m. In most parts of the world, the trees have been used as shade because of its large spreading branches. In some places, the leaves are used for medicinal purposes (Aviara *et al*., 2009). Thus, this research was set up to investigate the impacts of salt stress on morphological parameters of *Hura crepitans* ameliorated with *C. mucunoides* and biochar to imorove their growth.

MATERIALS AND METHOD

Area of study

This research was carried out in Mkpat Enin Local Government Area of Akwa Ibom State, Nigeria. Mkpat Enin is located in the South-South of Nigeria which sits at an altitude of approximately 185metre (607ft) above the sea level. Mkpat Enin L.G.A has a land mass of 322.352 square kilometers (124.461 sq mi). Mkpat Enin is the second largest Local Government Area in Akwa Ibom State found between latitude (4.7336^0N) and longitude (7.7486^0E), with the population of 226,200 person/km AKSG (2011).

Collection of Samples

Half bags of charcoal were gotten from Akpanadem Market, Udoumana, Uyo. The charcoals were blended into granulated form manually using mortar and pestle

Procedures

The experimental soils were steam sterilized in the oven in bits for two hours at 100^0C to kill weed seeds, soil microorganisms and sieved through a 2mm mesh to remove pebbles.

Matured seeds of *Hura crepitans* were obtained from Army Military Barracks in Ibawa, Abak L.G.A, Akwa Ibom State. The seeds were selected from the pod to eliminate infected seeds and treated to check for its viability by putting them a bucket of water, the viable ones were used for the research.

The matured leaves of *Calapogonium mucunoides* were obtained from around Faculty of Biological Sciences of Akwa Ibom State University Permanent Site, Ikot Enin, Akwa Ibom State. The leaves were washed and sliced into smaller pieces and bagged, which was kept in a dark corner for 3days for fermentation to take place.

Distilled water (0%) was used as control . One thousand millimeters (1000ml) of distilled water was added to ten grams (10g) of KI to give 1% solution of KI. Ninety millimeters (90ml) of distilled water was added to ten millimeters (10ml) of 1% KI to form 0.1% solution of KI . Ninety millimeters (90ml) of distilled water was added ten millimeters (10ml) of 0.1% KI to form 0.01% solution of KI. Ninety millimeters (90ml) of distilled water was added ten millimeters (10ml) of 0.01% KI to form 0.001% solution of KI (Ben-Daniel and Davidson, 2019)

Experimental Design

This experiment was set up in a completely randomized complete design with all treatment replicated thrice the three set up. This gave a total of fifteen (15) treatments for each set up.

Table 1: Experimental Design using Completely Randomized Design for the treatments

Treatments	Meaning
Control	0% Salinity
1%	1% KI
0.1%	0.1% KI
0.01%	0.01% KI
0.001%	0.001% KI
-S + Cm	0% Salinity, + *C. mucunoides*
1% + Cm	1% KI, + *C. mucunoides*
0.1% + Cm	0.1% KI, + *C. mucunoides*
0.01% +Cm	0. 01% KI, + *C. mucunoides*
0.001% + Cm	0.001% KI, + *C. mucunoides*
-S + Bioc.	0% Salinity, + Biochar
1% + Bioc.	1% KI, + Biochar
0.1% + Bioc.	0.1% KI, + Biochar
0.01% + Bioc.	0.01% KI, + Biochar
0.001% + Bioc.	0.001% KI, + Biochar

-S = 0% Salinity, + *C. mucunoides* = Amendment with *C. mucunoides,* + Biochar = Amendment with Biochar.

Physico-chemical Properties of Experimental Soils

Soil samples were analyzed following the standard procedures outlined by the association of Official Analytical Chemist (AOAC, 2005)

Measurement of Morphological Parameters

Determination of Seedlings Emergence

Determination of seedling emergence was calculated as the seedlings emerged from the soil eight (8) days after sowing. The seedling emergence in each treatment was calculated using the formula:

$$\% \text{ Emergence} = \frac{\text{Number of seedlings emerging}}{\text{Number of seedling sown}} \quad X\ 100$$

Determination of Growth Parameters

Measurement of growth parameters such as shoot length, petiole length and internode length were taken every five (5) weeks following seedling emergence using a measuring tape (Giovannetti and Mosse, 1980; Esenowo and Umoh, 1996 and Walker, 2005).

The Leaf Area was determined weekly after sprouting, measurements were obtained using graph paper (grid method). The area (A) of the leaf was determined by tracing the outlines of the leaves on a standard graph paper. The area covered by the outline was then calculated (one small square on the graph represents $1cm^2$). The correlation factor (r) was determined by dividing the area (A) by product of length x breadth of the leaf. Thereafter, the leaf area for each plant was determined using the formula: $A = L \times B \times r$ (0.72) was described by Sparkes (2003).The nodes of healthy leaves from the experimental plants were counted.

The photosynthetic pigments was taken weekly after sprouting, using electronic digital chlorophyll meter (atLEAF) with the model number (PN: 0131 USA) (Okon *et al*., 2021) .

Statistical Analysis

All data in the present study were subjected to analysis of variance (ANOVA) using the statistical package Graph Pad Prism.

RESULTS AND DISCUSSION

PHYSCIOCHEMICAL PROPERTIES OF THE EXPERIMENTAL SOIL

The t-test analysis carried out on the physicochemical properties of the experimental soils (saline soils) revealed a significant ($p=0.01$) increase on some soil fertility parameters. Result of soil pH with 1% KI (6.67±0.33) without amendment showed a significant ($p=0.0001$) increase when compared to control (4.10±0.10). It also revealed 0.001%KI (5.17±0.50) amended with boichar showed a significant ($p=0.0001$) increase when compared to 0.01% (3.20±0.60). Soil moisture of soil with 1%KI (8.83±0.17) without amendment showed a significant ($p=0.01$) increase when compared to control (6.67±0.88). Soil nutrient of soil with 1% KI (6.17±0.17) without amendment showed a significant ($p=0.01$) increase when compared to control (4.67±0.33). Light intensity of soil with 1% KI (1100±0.00) amended with *C. mucunoides* showed a significant ($p=0.01$) increase when compared to control (600±57.73) (Fig 1-3 and table 2-3).

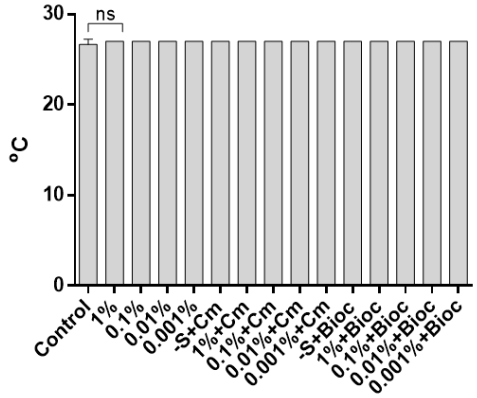

Fig: 1: Soil temperature of the Experimental soil

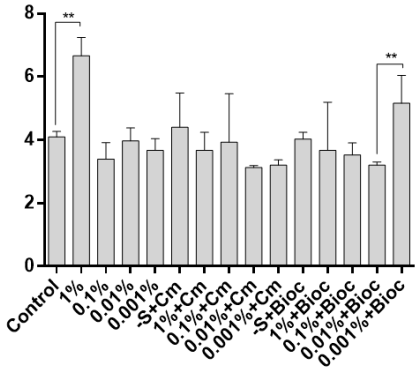

Fig: 2: Soil pH of the Experimental soil

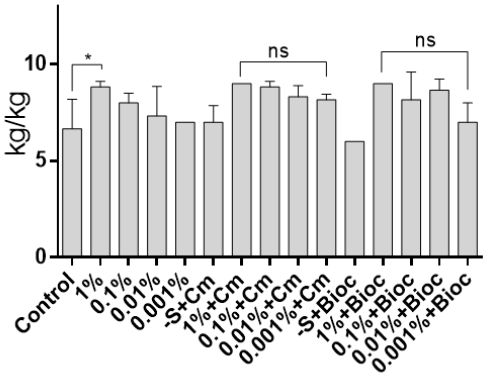

Fig: 3: Soil moisture of the Experimental soil

Table 2: Soil Nutrient of the Experimental soil

Treatment	Replicate 1	Replicate 2	Replicate 3	Mean
Control	5.00	5.00	4.00	4.67± 0.33
1%	6.50	6.00	6.00	6.17 ± 0.17
0.1%	6.00	6.00	5.00	5.67 ± 0.33
0.01%	6.00	6.00	5.00	5.67 ± 0. 33
0.001%	5.00	5.00	5.00	5.00 ± 0.00
-S + Cm	5.00	6.00	5.50	5.50 ± 0.29
1% + Cm	6.50	6.50	6.50	6. 50± 0.00
0.1% + Cm	6.50	6.50	6.00	6. 33 ± 0.17
0.01% + Cm	6.50	6.00	6.00	6. 17 ± 0.17
0.001% + Cm	6.50	5.50	6.50	6.17 ± 033
-S + Bioc	5.00	5.00	4.50	4.83 ± 0.17
1% + Bioc	7.00	6.50	6.50	6.67 ± 0.17
0.1% + Bioc	5.50	6.00	6.50	6.00 ± 0.29
0.01% + Bioc	6.00	7.00	7.00	6.67 ± 0.33
0.001% + Bioc	6.50	5.50	4.50	5.50 ± 0.58

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), Cm(*Calapogonuim mucunoides*), Bioc(Biochar), WAP(Weeks after planting).

Table 3: Light Intensity of the Experimental soil

Treatment	Replicate 1	Replicate 2	Replicate 3	Mean
Control	1000	1000	1000	1000.00±0.00
1%	1060	1080	1100	108.00 ± 11. 54
0.1%	900	960	900	920.00 ±34.64
0.01%	1000	1000	1000	1000.00 ± 0.00
0.001%	900	800	930	876. 67 ± 39. 30
-S + Cm	500	700	600	600.00 ± 57. 73
1% + Cm	1100	1100	1100	1100.00 ± 0.00
0.1% + Cm	1000	1060	1080	1046. 66 ± 24. 03
0.01% + Cm	1000	600	1000	866. 66 ± 133. 33
0.001% + Cm	900	900	500	766. 66 ± 133. 33
-S + Bioc	400	800	500	566. 66 ± 120. 18
1% + Bioc	1060	1060	1060	1060.00 ± 0.00
0.1% + Bioc	900	1000	1000	966. 66 ± 33.33
0.01% + Bioc	700	1000	1000	900.00 ± 100.00
0.001% + Bioc	700	500	800	666. 66 ± 88. 19

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), Cm(*Calapogonuim mucunoides*), Bioc(Biochar), WAP(Weeks after planting).

MORPHOLOGICAL PARAMETETRS OF *Hura crepitans*

Growth parameters of *H. crepitans* such as shoot length, leaf area, petiole length number of nodes, internode length and stem girth were all significant (p=0.05) with saline treatments when compared to control at 5-8 weeks (Table 4-9).

Table 4: Shoot Length of *Hura crepitans* amended with *Calapogonium mucunoides* and Biochar

Treatment	5 WAP	6 WAP	7 WAP	8 WAP
Control	2.50±1.28a	15.70±3.35b	19.50±4.43b	21.00±4.00b
1%	0.93±0.93a	4.03±4.03f	4.03±4.03h	0.00±0.00f
0.1%	2.90±1.45a	16.73±0.80b	17.06±0.31c	15.76±0.46c
0.01%	3.10±0.55a	16.96±2.65b	19.03±2.80b	20.30±3.11b

0.001%	4.10±0.92a	19.26±0.85a	22.30±2.36a	26.23±2.05a
-S+Cm	3.23±0.82a	17.53±1.13a	19.16±2.36b	21.80±1.40b
1%+Cm	0.00±0.00a	0.00±0.00g	0.00±0.00i	0.00±0.00f
0.1%+Cm	0.60±0.60a	8.40±0.88e	7.46±0.03g	4.30±2.19e
0.01%+Cm	2.33±0.82a	12.96±3.81c	14.73±4.65d	16.70±5.54c
0.001%+Cm	2.57±0.63a	15.50±1.58b	17.90±2.80c	22.43±3.52b
-S+Bioc	2.26±0.17a	16.60±0.20b	20.83±0.88a	22.10±1.45b
1%+Bioc	0.00±0.00a	0.00±0.00g	0.00±0.00i	0.00±0.00f
0.1%+Bioc	0.66±0.66a	10.30±0.45d	9.86±0.98f	8.70±0.85d
0.01%+Bioc	0.93±0.93a	10.86±5.79d	12.76±6.75e	9.17±8.08d
0.001%+Bioc	3.73±0.91a	15.40±0.86b	18.66±0.49b	21.80±0.05b

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), Cm(*Calapogonuim mucunoides*), Bioc(Biochar), WAP(Weeks after planting).

Table 5: Leaf Area of *Hura crepitans* amended with *Calapogonium mucunoides* and Biochar

	5 WAP	6 WAP	7 WAP	8WAP
Control	36.75±18.96c	44.58±18.10c	56.87±17.69c	49.69±11.24d
1%	9.21±9.21e	9.46±9.64f	0.00±0.00e	0.00±0.00f
0.1%	30.38±15.33c	26.98±10.98e	25.39±10.84d	18.24±18.24e
0.01%	31.65±2.88c	50.08±4.44b	51.24±4.51c	41.48±2.13d
0.001%	52.45±5.12a	56/94±8.45b	64.96±12.58b	61.84±9.52c
-S+cm	48.33±9.09b	57.40±3.29b	77.86±5.23a	71.23±3.94c
1%+cm	0.00±0.00f	0.00±0.00g	0.00±0.00e	0.00±0.00f
0.1%+cm	3.23±1.61e	3.39±1.84f	0.00±0.00e	0.86±0.86f
0.01%+cm	25.21±11.75d	36.98±22.59d	53.54±18.22c	143.40±112.36a
0.001%+cm	34.84±8.94c	47.77±12.67c	68.16±15.58b	44.28±13.99d
-S+Bioc	48.33±9.09c	71.23±4.78a	78.61±1.34a	75.63±2.23d
1%_Bioc	0.00±0.00f	0.00±0.00g	0.00±0.00e	0.00±0.00f
0.1%_Bioc	7.81±7.81e	10.85±7.63d	2.01±2.01e	1.80±1.80f
0.01%+Bioc	14.13± 14.13	31.58±17.63d	52.81±29.13c	51.68±28.20d
0.001%+Bioc	41.82±.25b	59.44±1.64b	75.09±2.19a	69.39±6.07b

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), C.m (*Calapogonuim mucunoides*), Bioc (Biochar), WAP(Weeks after planting).

Table 6: Petiole Length of *Hura crepitans* amended with *Calapogonium mucunoides* and Biochar.

	6 WAP	7WAP	8 WAP
Control	5.53±1.02a	5.80± 1.27a	6.23±1.74a
1%	1.00±1.00a	0.00± 0.00a	0.00±0.00b
0.1%	4.90±1.01a	4.73± 1.29a	0.80±0.80a
0.01%	5.33± 0.26a	7.10±051a	7.20± 0.95a
0.001%	7.26± 0.78a	9.56± 180a	10.03± 1.01a

-S+cm	7.13± 1.38a	7.90± 1.55a	9.30 ± 1.47a
1%+cm	0.00± 0.00a	0.00±0.00a	0.00± 0.00b
0.1%+cm	1.06±0.66a	0.40±0.40a	0.00±0.00b
0.01%+cm	4.70± 1.76a	5.66±2.11	6.96±1.62a
0.001%+cm	5.93±1.23a	7.33±1.93a	9.20±2.10a
-S+Bioc	7.26± 0.14a	7.56±1.28a	9.16±0.78a
1%_Bioc	0.00± 0.00a	0.00±0.00a	0.00±0.00b
0.1%_Bioc	2.76±1.07a	2.46± 1.44a	2.66±2.66b
0.01%+Bioc	4.23± 2.45a	4.80±2.66a	6.70±3.37a
0.001%+Bioc	6.96± 0.78a	8.16±0.37a	11.40±0.56a

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), C.m (*Calapogonuim mucunoides*), Bioc (Biochar), WAP(Weeks after planting).

Table 7: Number of nodes of *Hura crepitans* amended with *Calapogonium mucunoides* and Biohar.

	5 WAP	6 WAP	7 WAP	8WAP
Control	4.00±2.08b	6.66±1.85a	6.33±1.45a	6.66±1.85a
1%	1.33±1.33b	1.00±1.00a	0.00±0.00a	0.00±0.00a
0.1%	2.00±2.00b	4.33±0.88a	3.33±1.20a	1.33±1.33a
0.01%	3.66±0.33b	5.00±0.57a	7.00±1.00a	7.66±1.20a
0.001%	5.33±0.66b	6.66±0.33a	7.66±0.33a	7.66±0.88a
-S+cm	5.66±0.66b	5.66±1.20a	6.33±0.33a	7.00±0.00a
1%+cm	0.00±0.00b	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%+cm	1.66±0.88b	1.66±1.20a	0.33±0.33a	0.00±0.00a
0.01%+cm	3.33±8.35b	4.66±1.20a	5.66±1.76a	7.00±1.52a
0.001%+cm	5.66±0.88b	6.00±1.00a	6.33±0.33a	8.00±0.57a
-S+Bioc	5.00±0.57b	6.33±0.33a	7.00±057a	7.33±0.33a
1%_Bioc	0.00±0.00b	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%_Bioc	1.00±1.00b	2.33±0.88a	0.66±0.66a	0.66±2.96a
0.01%+Bioc	1.66±1.66b	3.66±2.02a	4.66±2.60a	5.66±2.96a
0.001%+Bioc	4.66±0.33b	7.00±0.00	7.66±0.33a	8.00±0.57a

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), Cm(*Calapogonuim mucunoides*), Bioc(Biochar), WAP(Weeks after planting).

Table 8: Internode Length of *Hura crepitans* amended with *Calapogonium mucunoides* and Biochar

	5 WAP	6 WAP	7 WAP	8WAP
Control	1.70±0.35a	2.03±0.31a	1.86±0.40a	1.96±0.48a
1%	0.13±0.13a	0.13±0.13a	0.00±0.00a	0.00±0.00a
0.1%	1.10±0.56a	1.03±0.13a	1.26±0.38a	0.33±0.33a
0.01%	1.30±0.37a	2.06±0.46a	2.36±0.64a	2.20±0.49a
0.001%	1.80±0.55a	2.33±0.49a	2.20±0.41a	3.83±1.09a

-S+cm	1.40±0.23a	2.06±0.06a	1.90±0.30a	2.86±0.69a
1%+cm	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%+cm	0.00±0.00a	0.23± 0.23a	0.00±0.00a	0.00±0.00a
0.01%+cm	0.83±0.44a	1.16±0.49a	1.26±0.49a	2.63±0.77a
0.001%+cm	1.03±0.21a	1.70±0.37a	1.93±0.34a	1.76±0.38a
-S+Bioc	1.30±0.17a	2.10±0.20a	2.40±0.40a	2.30± 0.66a
1%_Bioc	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%_Bioc	0.40±0.00a	0.30±0.17a	0.16±0.16a	0.10±0.10a
0.01%+Bioc	0.36±0.20a	1.06±0.60a	1.16±0.16a	1.33±0.67a
0.001%+Bioc	1.26±0.49a	2.36±0.21a	2.23±0.14a	2.53±0.03a

Mean of three replicates ±SEM [a]Values of each column followed by the same letter are not significantly different at p=0.05 level. -S(No salinity), Cm(*Calapogonuim mucunoides*), Bioc(Biochar), WAP(Weeks after planting).

Table 9: Stem Girth of *Hura cerpitans* amnended with *Calapogonium mucunoides* and Biochar.

	5 WAP	6 WAP	7 WAP	8WAP
Control	1.86±0.40a	1.70±0.34a	1.86±0.24a	2.20±0.35a
1%	0.60±0.60a	0.66±0.66a	0.00±0.00a	0.00±0.00a
0.1%	2.00±0.15a	2.00±0.05a	1.96±0.08a	1.73±0.03a
0.01%	2.03±0.14a	1.86±0.06a	1.90±015a	1.86±0.03a
0.001%	2.13±0.08a	2.10±0.05a	2.00±0.17a	2.20±0.17a
-S+cm	2.10±0.17a	2.13±0.17a	2.13±0.16a	2.33±0.16a
1%+cm	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%+cm	1.50±0.30a	1.40±0.25a	1.20±0.60a	0.00±0.00a
0.01%+cm	1.46±0.44a	1.36±0.52a	1/60±0.49a	1.80±0.46a
0.001%+cm	1.66±0.28a	1.83±0.21a	1.93±0.32a	2.00±0.23a
-S+Bioc	1.90±0.05a	2.23±0.08a	2.46±0.06a	2.43±0.12a
1%_Bioc	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a
0.1%_Bioc	1.56±0.03a	1.26±0.33a	1.40±0.15a	0.80± 0.26a
0.01%+Bioc	1.23±0.62a	1.40±0.70a	1.40±0.73a	1.70±0.86a
0.001%+Bioc	1.96±0.18a	2.23±0.29a	2.26±0.12a	2.30±0.17a

Data were processed and expressed as mean ± SD of three replicates. [a]Values of each column followed by the same letter are not significantly different.

The shoot length at weeks 5-8, seedlings of *H. crepitans* without amendment under different levels of salt stress recorded a significant (p=0.01) increase when compared to those amended with *C. mucunoides* and biochar. Shoot length of *H. crepitans* seedlings at week 8 without amendment under 0.001% KI (26.23±2.05cm) recorded a significant (p=0.0001) increase when compared to control (21.00±4.00 cm). Shoot length of *H. crepitans* at 1% non-amended saline soil for week 6 and 7 recorded 4.03±4.03cm which indicated a significant reduction (p=0.01) when compared to control (15.70±3.35 and 19.50±4.43cm) respectively. The amelioration of the saline soil at 0.001% KI with biochar and *C.*

mucunoides (21.80±0.05 and 22.43±3.52cm) of *H. crepitans* was significant when compared to the control (21.00±4.00cm). In weeks 6- 8, *H. crepitans* under salt stress and amended with biochar were the most affected and there were significantly (p=0.05) reduced when compared to the control and those amended with *C. mucunoides* (Table 4).

The leaf area of *H. crepitans* under salt stress were significantly (p=0.05) reduced as planting weeks increases. At week 5, *H. crepitans* under 0.001% of KI without amendment recorded the highest leaf area (52.45±5.12cm^3) and was significantly (p=0.01) increased when compared to all other groups with amendment, while Leaf area under 0.1% of KI amended with *C. mucunoides* recorded the least (3.23±1.61cm^3). At week 6 and 7, all leaf area of *H. crepitans* under salt stress of both amended were significantly (p=0.05) reduced when compared to their control. However, at week 8, *H. crepitans* under 0.01% KI amended with *C. mucunoides* recorded the highest leaf area (143.40±112.36 cm^3). The results from this study agreed with the findings of Kotagiri and Kolluru (2017) who reported that decrease in leaf area of plants under stress is to make osmotic adjustment by carbohydrates accumulation in the tissues. This is because leaves are directly involved in regulating all the plant physiological processes, therefore, determining critical salinity and tolerance level is crucial, beyond which salinity stress severely affects these processes, leading to the adverse effect on the plant growth and development.

The petiole length at weeks 6 and 7, the salt stress revealed no significant (p=0.05) effect on the seedlings of *H. crepitans* grown on amended and non-amended saline soil. However at week 8, *H. crepitans* grown on 0.1% KI without amendment and those amended with biochar recorded 0.80±0.80 and 2.66±2.66 cm, respectively were significantly (p=0.05) reduced when compared to the control (6.23±1.74 and 9.16±0.78 cm) (Table 6). However, for number of nodes, internode and stem girth, salt stress did not have any significant effect when compared to control. The results of this study agreed with the findings of Kumar *et al*. (2021) who reported that salt stress modified the morphological parameters of *M. dubia*, and the increase in salinity stress caused reduction in the leaf length, leaf width, petiole length, and internodal length. The ionic imbalance and lesser water availability with increasing salinity levels adversely affect these parameters, which ultimately produces the alteration in physio-biochemical processes and morphological parameters of plants. Hence, this study shows the gradual increasing severity of effects of salinity depending on saline stress concentration, thus supporting previous conclusions that the varying stress levels differently affect seedling growth in various species, such as (sugar beet and cabbage; Jamil, 2004, lentil; Foti *et al*., 2019 and soybean; Pavil, 2021).

The total photosynthetic pigment of seedlings of *H. crepitans* on saline soil with or without amendment were significantly reduced when compared to control except for seedlings grown on soil with 0.001% of KI and amended with *C. mucunoides* which was significantly increased (56.70±2.48) when compared to control (51.37±2.99) and other seedlings under salt stress (Fig 4). In this study seedlings of *Hura crepitans* grown on saline soil with 0.001% of KI had the highest total photosynthetic pigment compared to other seedlings under salt stress. This study is in line with the findings of Parida *et al*. (2004) on *B. parviflora*, who reported that photosynthetic rate in plant under salt stress is increased at low salinity compared to high salinity.

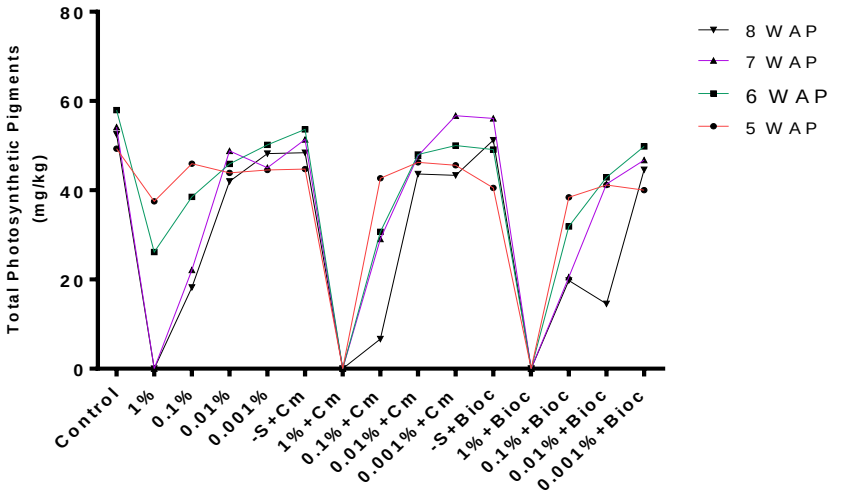

Fig 4 Total Photosynthetic Pigments of *H. creptians* Seedlings at week 5 to 8

CONCLUSION

The study revealed that addition of *C. mucunoides* and Biochar as amendments acted as ameliorant to saline soils of varying salt concentration. In this study, individual effect of the amendments was more effective in changing soil chemical properties. The application of *C. mucunoides* and biochar amendments improved the soil chemical properties by reducing the soil temperature, pH, moisture, nutrient except for light intensity . Among the treatments *C. mucunoides* and biochar had a remarkable effect in reducing soil salinity. The yield of *H. crepitans* from *C. mucunoides* and biochar treatments was more influenced compared with the control treatment. However, based on the research findings, amelioration treatment such as *Calapogonium mucunoides* and Biochar can be used to improve crops planted in saline soil by agriculturist and horticulturist.

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