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CHANGES IN GROWTH CHARACTERS OF TWO CUCURBITS INOCULATED WITH MYCORRHIZA AND AUGMENTED WITH POULTRY MANURE UNDER SEA SALT STRESS

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ABSTRACT

This study evaluated the influence of arbuscular mycorrhizal fungi *Rhizophagus irregularis* and *Glomus geosporum* inoculation on the growth parameters and photosynthetic pigments of *Cucurbita maxima* and *Telfairia occidentalis* planted in saline soil enriched with poultry manure (PM). Saline soil and salt water were collected from Ibeno, while non-saline soil was obtained from Etinan, Akwa Ibom State, Nigeria. The experiment was set up in triplicates using a complete block design (CBD). Saline soil used had an electrical conductivity (EC) of 6.70 dS/m, while the garden soil had an EC of 0.29 dS/m. Saline soil treatment significantly (p=0.05) reduced percentage germination, shoot length, petiole length, internode length and leaf area. Saline soil treatment significantly (p=0.05) reduced total photosynthetic pigments of the test plants. Inoculation with AMF alone or together with PM increased the growth parameters in the two test plants both in saline and non-saline treatments. The results of this work have shown AMF and PM synergy can enhance the ability of the test plants to resist salt stress through some morphological and physiological changes as well as improved vigour through extensive network of the mycorrhizal roots which increases nutrient uptake.

Keywords: *Cucurbita maxima*; *Glomus geosporum*; *Rhizophagus irregularis*; salinity; *Telfairia occidentalis*.

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 [1,2]. According to the Food and Agricultural Organization (FAO), about 7% of the global soil surface is affected by salt,

out of which 15.7 Mha is in North America, 1.9 Mha in Mexico and Central America, 129.16 Mha in South America, 80.43 Mha in Africa, 85.10 Mha in South and West Asia, 19.98 Mha in Southeast Asia, 211.68 Mha in North and Central Asia, 357.33 Mha in Australia, and 52.08 Mha in Europe [3,4]. 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 [5,6]. In some areas, it is increasing due to extensive use of salt on roads to prevent frozen glaze in winter [5].

Microorganisms such as arbuscular mycorrhizal (AM) fungi are able to colonize plants, in their natural environment. Some microorganisms, particularly beneficial bacteria and fungi can improve plant performance under stress environments and consequently enhance yield [7]. AM fungi are associated with the roots of over 80% terrestrial plant species [8]. AM fungi have been shown to promote plant growth and salinity tolerance by many researchers. They promote salinity tolerance by utilizing various mechanisms, such as: Enhancing nutrient uptake [9], Producing plant growth hormones [10], Improving rhizospheric and soil conditions [11], Improvement in photosynthetic activity or water use efficiency [12], Accumulation of compatible solutes [10] and Production of higher antioxidant enzymes [13].

Cucurbita maxima is a coarse, prostrate or climbing, annual, herbaceous vine, reaching a length of 4 m or more. Leaves are hispid, rounded, 15 - 30 cm in diameter, heart-shaped at the base, shallowly 5-lobed, with finely toothed margins, and often mottled on the upper surface [14]. Flowers are bell-shaped, erect, yellow and about 12 cm long. Fruit is large, variable in shape, fleshy, with a yellow pulp. Seeds are ovoid or oblong, compressed, and about 1.3 centimeters long [14].

Telfairia occidentalis fruit is quite large; one study documented a range of 16–105 cm in length, and an average of 9 cm in diameter [15]. The same study found the seed count in larger gourds to reach upwards of 196 per fruit, typically measuring between 3.4 and 4.9 cm in length [15]. *T. occidentalis* flowers grow in sets of five, with creamy-white and dark red petals, contrasting with the light green colour of the fruit when young, and yellow when ripe [15].

Thus, this research was set up to investigate the impacts of salt stress on growth characters of two (2) different vegetables (*Telfairia occidentalis* Hook F. and *Cucurbita maxima* Duch.) belonging to the family *Cucurbitaceae* and determine if inoculation with arbuscular mycorrhiza (*Rhizophagus irregularis*) and poultry manure augmented their growth.

MATERIALS AND METHODS

Study Area

Saline soil and salt water were 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. The experiment was set up in a safe and secured environment at Mbioto 1, Etinan Local Government Area (Latitude 4.51°N and Longitude 7.50°E), Akwa Ibom State, Nigeria, with an annual rainfall of about 4000 mm and mean temperature variation of 26 – 36°C [16]. Non-saline soil for the control and non-saline treatments was obtained from a farmland in Mbioto 1, Etinan Local Government Area; fresh water was used for watering the non-saline and control treatments. A map showing the saline water/soil collection and experimental set-up locations is presented in Fig. 1.

Propagation and Mycorrhizal Inoculation

Arbuscular Mycorrhizal fungi *R. irregularis* and *G. geosporum* were multiplied on maize grown in the greenhouse of the Department of Botany for 16 weeks. The colonized maize roots were used as an inoculum (25 g fresh weight per pot containing approximately 130 spores) was placed in the pot at 15 cm depth, before planting.

Experimental Design

This experiment was set up in a complete block design with all treatments replicated thrice for both *C. maxima* and *T. occidentalis*. This gave a

total of twelve (12) treatments for each plant with three (3) replicates totaling seventy two (72) combinations for each plant making it 144 combinations for *C. maxima* and *T. occidentalis* (Table 1).

Planting

Five (5) seeds each of *C. maxima* and *T. occidentalis* were sown in their respective plastic pots filled with about 10 kg of sterilized soils. Arbuscular mycorrhiza fungi were inoculated by placing 25g of soil/root fragments containing 60 – 65 spores per 5g in planting hole at 15 cm depth, before planting the *C. maxima* and *T. occidentalis*, 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. This was to ensure the establishment of AM colonization and avoid sudden plant death due to salinity shock. The dose of saline water used was 100 ml per plant pot every 3 days.

Fig. 1. Map showing saline water/soil collection and experimental set-up locations

Table 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- (*Ri*)	+ Salinity, + Mycorrhiza (*R. irregularis*), - Poultry
S+ M- P+	+ Salinity, - Mycorrhiza, + Poultry
S+ M+ P+ (*Gg*)	+ Salinity, + Mycorrhiza (*G. geosporum*), + Poultry
S+ M+ P+ (*Ri*)	+ Salinity, + Mycorrhiza (*R. irregularis*), + Poultry
S- M+ P- (*Gg*)	- Salinity, + Mycorrhiza (*G. geosporum*), - Poultry
S- M+ P- (*Ri*)	- Salinity, + Mycorrhiza (*R. irregularis*), - Poultry
S- M+ P+ (*Gg*)	- Salinity, + Mycorrhiza (*G. geosporum*), + Poultry
S- M+ P+ (*Ri*)	- Salinity, + Mycorrhiza (*R. irregularis*), + Poultry
S- M- P+	- Salinity, - Mycorrhiza, + Poultry

Water Analysis and Physico-chemical Properties of Experimental Soils

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

Measurement of Growth Parameters

Determination of seedling emergence

Seedling emergence was calculated as the seedlings emerged from the soil five (5) days after sowing. The seedling emergence in each treatment was calculated using the formula:

$$\% \text{ Emergence} = \frac{\text{Number of seedling emerging}}{\text{Number of seeds sown}} \times \frac{100}{1}$$

Determination of shoot length, petiole length and internode length

Measurement of growth parameters such as shoot length, petiole length and internode length were taken every three (3) weeks following seedling emergence using a measuring tape [18, 19, 20].

Determination of leaf area (cm^2)

The Leaf Area (LA) was determined at 3 weekly intervals after sprouting (WAS), 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 1 cm^2). The correlation factor (K) 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:

$$A = L \times B \times K$$

Where: A = the traced area
L = Leaf length
B = Leaf width
K = Correction factor

The correlation factor (K) for *C. maxima* leaves was 0.72, while, *T. occidentalis* K was 0.85

Determination of leaf number/number of nodes

The nodes of healthy leaves from the experimental plants were counted.

Determination of photosynthetic pigments

The photosynthetic pigments we taken after 9 weeks using SPAD chlorophyll meter.

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 standard error of mean (± S.E.M.) of triplicate experiments. The student's t-test was used to determine the significant difference between means of the soil and water parameters analyzed using Statistical package for social science (SPSS). The differences between the means were separated and compared using the Duncan's multiple range tests. However, a probability level of p=0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The t-test analysis carried out on the physicochemical properties of the experimental soils (saline and garden soils) indicated significant (p=0.05) differences between the two soil types in; pH, total nitrogen, available phosphorus, silt, clay, sand, Ex. Ca, Ex. Mg, Ex. K, OC, Ex. Na and EC (Table 2). Similarly, the t-test analysis carried out on the properties of the experimental irrigation water (saline and freshwater) indicated significant (p=0.05) difference between the two water types in; pH, EC, TDS, alkalinity and salinity (Table 2).

This observation is in line with the work of Miller and Gardiner [21] who reported an increase in pH and EC in saline soils in New Jersey due to salt stress. Deleke and Akomolafe [22] also made similar findings as they observed an 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. Soil organic carbon content is influenced by two opposing factors: reduced plant inputs and reduced rates of decomposition [23].

Table 2. Physicochemical properties of the experimental soils

S/No.	Parameters	Garden Soil	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.	EC. (dS/m)	0.29	6.70	-15.322*
	Water Parameters			
1.	pH	7.70	6.70	3.273
2.	EC (µS/cm)	3080.00	27.70	13.063*
3.	TDS	1021.00	11.00	7.063*
4.	Acidity (mg/l as $CaCo_3$)	80.00	95.40	-1.130
5.	Alkalinity (mg/l as $CaCo_3$)	138.00	53.20	76.468*
6.	Salinity (ppt)	33.21	0.32	20.839*

* Significant at t = 0.05, Ex – Exchange, EC – Electrical conductivity

Growth parameters of *C. maxima* and *T. occidentalis* such as seedling emergence, number of nodes, leaf area, shoot length, petiole length and internode length were all significantly (p=0.05) reduced with salt stress treatments when compared to the control at 3 weeks (Table 3 to 14). Inoculation with AMF however increased the growth parameters of *C. maxima* and *T. occidentalis* in spite of salt stress treatment (Table 3 to 14). Amelioration of the saline soil with poultry manure enhanced growth of the two test plants but a combination of poultry manure and mycorrhiza gave the highest significant (p=0.05) growth and biomass yield in non-saline treatments (Table 3 to 14). The reduction in shoot length of *C. maxima* at 12 WAP is as a result of replicates dying off (Table 3 to 14).

Table 3. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on shoot length (cm) of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*9.20 ± 0.95[a]	12.46 ± 0.35[a]	38.41 ± 3.12[b]	54.61 ± 3.99[b]
S+ M- P-	2.20 ± 0.39[b]	3.00 ± 0.58[b]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	6.91 ± 2.11[a]	9.24 ± 1.35[a]	13.43 ± 1.23[d]	11.32 ± 1.09[c]
S+ M+ P- (*Ri*)	8.21 ± 1.07[a]	11.60 ± 1.07[a]	15.76 ± 0.98[d]	17.73 ± 0.45[c]
S+ M- P+	5.81 ± 0.11[a]	7.40 ± 0.39[a]	20.43 ± 1.43[c]	19.22 ± 0.78[c]
S+ M+ P+ (*Gg*)	7.40 ± 0.98[a]	10.50 ± 0.95[a]	39.46 ± 1.87[b]	56.65 ± 2.31[b]
S+ M+ P+ (*Ri*)	8.72 ± 1.15[a]	11.00 ± 0.58[a]	38.83 ± 2.11[b]	56.16 ± 2.09[b]
S- M+ P- (*Gg*)	9.50 ± 0.58[a]	13.60 ± 1.15[a]	42.17 ± 3.16[b]	62.54 ± 3.14[a]
S- M+ P- (*Ri*)	9.02 ± 0.55[a]	13.33 ± 0.57[a]	40.40 ± 2.09[b]	59.76 ± 2.13[b]
S- M+ P+ (*Gg*)	8.22 ± 0.57[a]	12.51 ± 0.46[a]	46.23 ± 1.98[a]	66.87 ± 3.96[a]
S- M+ P+ (*Ri*)	8.72 ± 0.59[a]	12.00 ± 0.46[a]	48.71 ± 2.98[a]	69.34 ± 3.07[a]
S- M- P+	8.50 ± 0.46[a]	11.70 ± 0.55[a]	39.92 ± 2.90[b]	56.87 ± 1.88[b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 4. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on shoot length (cm) of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*57.40 ± 3.88 [b]	107.40 ± 3.88 [b]	115.14 ± 2.65 [b]	119.84 ± 3.48 [b]
S+ M- P-	8.74 ± 1.28 [e]	14.28 ± 2.04 [d]	16.54 ± 0.54 [e]	19.59 ± 0.98 [f]
S+ M+ P- (*Gg*)	39.41 ± 2.01 [c]	72.81 ± 1.48 [c]	83.47 ± 0.78 [c]	87.64 ± 1.78 [e]
S+ M+ P- (*Ri*)	42.01 ± 1.39 [c]	76.02 ± 1.81 [c]	86.41 ± 0.95 [c]	92.42 ± 1.66 [d]
S+ M- P+	29.74 ± 1.46 [d]	62.60 ± 2.11 [c]	71.65 ± 1.18 [d]	82.45 ± 0.64 [e]
S+ M+ P+ (*Gg*)	34.21 ± 0.41 [d]	69.81 ± 1.02 [c]	79.53 ± 1.03 [c]	105.75 ± 2.08 [c]
S+ M+ P+ (*Ri*)	36.11 ± 1.32 [d]	72.76 ± 0.41 [c]	83.68 ± 2.12 [c]	121.39 ± 1.73 [b]
S- M+ P- (*Gg*)	62.41 ± 2.41 [a]	111.26 ± 3.42 [a]	127.42 ± 3.57 [a]	132.11 ± 5.22 [a]
S- M+ P- (*Ri*)	63.62 ± 1.81 [a]	114.72 ± 3.04 [a]	129.34 ± 3.48 [a]	136.24 ± 3.74 [a]
S- M+ P+ (*Gg*)	47.32 ± 1.21 [c]	70.00 ± 2.41 [c]	118.45 ± 2.14 [b]	138.57 ± 4.53 [a]
S- M+ P+ (*Ri*)	44.42 ± 0.49 [c]	68.12 ± 1.40 [c]	120.71 ± 1.34 [b]	141.34 ± 5.48 [a]
S- M- P+	40.41 ± 1.48 [c]	68.00 ± 0.42 [c]	82.11 ± 0.56 [c]	121.68 ± 2.46 [b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting)

Shoot length, number of leaves and leaf area of *C. maxima* and *T. occidentalis* were all significantly (p=0.05) affected by salt stress. Similar findings have been reported with *Vigna aconitifolia* L. [24], *Raphanus sativus* L. [25], *Vigna unguiculata* L. [26] and *Vigna mungo* L. [27]. They reported that increased salinity resulting in a decline in the shoot lengths of the plants.

Table 5. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on petiole length (cm) of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*8.60 ± 1.53 [a]	10.20 ± 1.25 [a]	12.62 ± 0.72 [a]	14.66 ± 1.11 [a]
S+ M- P-	0.20 ± 2.13 [b]	1.40 ± 2.30 [b]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	5.40 ± 1.20 [a]	7.00 ± 1.25 [a]	6.43 ± 0.78 [b]	8.64 ± 0.54 [b]
S+ M+ P- (*Ri*)	5.60 ± 0.57 [a]	7.32 ±1.07 [a]	5.98 ± 0.55 [b]	8.72 ± 0.12 [b]
S+ M- P+	4.43 ± 0.38 [a]	6.00 ± 0.90 [a]	5.32 ± 0.29 [b]	9.22 ± 0.73 [b]
S+ M+ P+ (*Gg*)	5.00 ± 0.56 [a]	7.70 ± 0.38 [a]	13.01 ± 0.79 [a]	15.54 ± 0.76 [a]
S+ M+ P+ (*Ri*)	5.20 ± 0.53 [a]	7.75 ± 0.96 [a]	12.77 ± 0.65 [a]	14.99 ± 0.55 [a]
S- M+ P- (*Gg*)	8.72 ± 1.25 [a]	11.35 ± 1.25 [a]	14.82 ± 1.54 [a]	17.65 ± 1.01 [a]
S- M+ P- (*Ri*)	8.60 ± 0.57 [a]	11.30 ± 0.56 [a]	13.42 ± 0.99 [a]	15.97 ± 1.21 [a]
S- M+ P+ (*Gg*)	7.42 ± 0.55 [a]	9.42 ± 1.27 [a]	16.11 ± 2.61 [a]	19.22 ± 0.87 [a]
S- M+ P+ (*Ri*)	7.80 ± 0.57 [a]	9.10 ± 0.59 [a]	17.32 ± 2.31 [a]	19.93 ± 0.56 [a]
S- M- P+	6.70 ± 0.47 [a]	8.10 ± 0.39 [a]	13.45 ± 0.84 [a]	15.24 ± 0.41 [a]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 6. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on petiole length (cm) of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*4.70 ± 0.24 [a]	6.76 ± 0.84 [a]	8.94 ± 0.75 [a]	10.12 ± 0.45 [a]
S+ M- P-	0.49 ± 0.82 [b]	0.64 ± 0.71 [c]	1.84 ± 0.22 [c]	2.22 ± 0.47 [c]
S+ M+ P- (*Gg*)	3.26 ± 1.24 [a]	4.71 ± 0.22 [b]	5.22 ± 0.15 [b]	5.81 ± 0.34 [b]
S+ M+ P- (*Ri*)	3.63 ± 0.55 [a]	4.93 ± 0.78 [b]	5.78 ± 0.48 [b]	6.02 ± 0.86 [b]
S+ M- P+	1.81 ± 1.26 [a]	3.89 ± 0.74 [b]	6.24 ± 0.98 [b]	5.41 ± 0.72 [b]
S+ M+ P+ (*Gg*)	3.84 ± 0.62 [a]	4.00 ± 0.49 [b]	6.88 ± 0.82 [b]	9.42 ± 0.91 [a]
S+ M+ P+ (*Ri*)	3.92 ± 0.81 [a]	4.61 ± 0.57 [b]	6.92 ± 0.67 [b]	10.83 ± 0.55 [a]
S- M+ P- (*Gg*)	4.79 ± 0.39 [a]	8.47 ± 0.91 [a]	10.14 ± 0.75 [a]	12.27 ± 0.84 [a]
S- M+ P- (*Ri*)	4.99 ± 0.72 [a]	8.60 ± 0.84 [a]	11.41 ± 0.77 [a]	12.64 ± 0.94 [a]
S- M+ P+ (*Gg*)	2.47 ± 0.84 [a]	3.92 ± 0.12 [b]	9.22 ± 0.34 [a]	12.85 ± 0.75 [a]
S- M+ P+ (*Ri*)	3.72 ± 0.46 [a]	4.07 ± 0.67 [b]	10.11 ± 0.19 [a]	13.24 ± 0.79 [a]
S- M- P+	2.71 ± 1.29 [a]	3.76 ± 0.38 [b]	5.21 ± 0.45 [b]	11.34 ± 0.54 [a]

*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), M- (No mycorrhiza), P- (No poultry manure), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting)

Salt stress has also been reported by several authors to lead to significant reduction in leaf area in *Vicia faba* [28], *V. aconitifolia* L. [24], *Avena sativa* L. [29] and *Fragaria xananssa* L. [30]. This notable decrease in leaf area in saline treatments in this study is as a result of the increased concentrations of Na^+ and Cl^-. This could be explained by the negative effect of salt on photosynthesis and subsequently plant growth, leaf growth to avoid escape of water via transpiration and chlorophyll content [31].

Table 7. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on leaf number of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*5.00 ± 1.89 [a]	7.00 ± 1.49 [a]	12.34 ± 1.28 [b]	18.00 ± 2.04 [b]
S+ M- P-	1.00 ± 2.08 [b]	2.00 ± 0.59 [b]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	4.00 ± 1.05 [a]	6.00 ± 0.96 [a]	8.00 ± 0.56 [b]	8.00 ± 0.54 [c]
S+ M+ P- (*Ri*)	5.00 ± 2.00 [a]	6.00 ± 0.48 [a]	8.00 ± 0.42 [b]	6.00 ± 0.76 [c]
S+ M- P+	4.00 ± 2.00 [a]	5.00 ± 0.54 [a]	10.00 ± 0.54 [b]	6.00 ± 0.11 [c]
S+ M+ P+ (*Gg*)	5.00 ± 1.80 [a]	6.00 ± 0.58 [a]	12.00 ± 0.52 [b]	18.00 ± 0.77 [b]
S+ M+ P+ (*Ri*)	5.00 ± 2.00 [a]	6.00 ± 0.39 [a]	12.00 ± 0.99 [b]	15.00 ± 0.65 [b]
S- M+ P- (*Gg*)	6.00 ± 1.00 [a]	8.00 ± 0.71 [a]	15.00 ± 1.41 [a]	23.11 ± 1.32 [a]
S- M+ P- (*Ri*)	6.00 ± 2.00 [a]	8.00 ± 0.59 [a]	14.00 ± 0.39 [a]	20.54 ± 1.05 [a]
S- M+ P+ (*Gg*)	5.00 ± 1.89 [a]	7.00 ± 0.98 [a]	17.00 ± 0.98 [a]	25.00 ± 0.00 [a]
S- M+ P+ (*Ri*)	5.00 ± 0.58 [a]	5.00 ± 0.82 [a]	19.00 ± 0.82 [a]	28.00 ± 2.19 [a]
S- M- P+	4.00 ± 1.05 [a]	6.00 ± 0.42 [a]	13.00 ± 0.92 [a]	19.00 ± 1.02 [b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 8. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on leaf number of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*9.00 ± 1.91[a]	20.00 ± 1.91[a]	31.12 ± 0.81[a]	36.48 ± 1.76[b]
S+ M- P-	3.40 ± 0.32[b]	4.81 ± 0.37[c]	5.15 ± 0.12[c]	7.65 ± 0.34[e]
S+ M+ P- (*Gg*)	8.73 ± 0.43[a]	16.70 ± 1.13[b]	19.75 ± 0.15[b]	20.91 ± 0.58[c]
S+ M+ P- (*Ri*)	8.91 ± 0.57[a]	16.92 ± 1.82[b]	20.75 ± 0.88[b]	23.45 ± 0.77[c]
S+ M- P+	6.00 ± 0.39[a]	12.81 ± 0.46[b]	16.45 ± 0.75[b]	18.24 ± 0.91[d]
S+ M+ P+ (*Gg*)	6.62 ± 0.47[a]	13.47 ± 0.77[b]	18.45 ± 1.45[b]	35.49 ± 1.22[b]
S+ M+ P+ (*Ri*)	6.78 ± 0.73[a]	15.22 ± 0.46[b]	20.15 ± 1.35[b]	38.93 ± 0.96[b]
S- M+ P- (*Gg*)	9.32 ± 0.54[a]	22.91 ± 2.08[a]	36.47 ± 2.14[a]	39.00 ± 0.93[b]
S- M+ P- (*Ri*)	9.63 ± 0.21[a]	24.72 ± 2.12[a]	39.31 ± 1.95[a]	42.56 ± 2.17[a]
S- M+ P+ (*Gg*)	6.84 ± 1.32[a]	14.24 ± 0.44[b]	34.11 ± 1.22[a]	44.87 ± 1.38[a]
S- M+ P+ (*Ri*)	6.00 ± 0.42[a]	13.79 ± 0.75[b]	36.02 ± 1.45[a]	49.74 ± 3.54[a]
S- M- P+	5.21 ± 0.32[a]	13.22 ± 0.81[b]	19.54 ± 0.78[b]	38.47 ± 0.59[b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting)

Sodium chloride has been shown to reduce numbers of leaves in *Cirer arietinum* L. [32], *Phaseolus acutifolius* L., *V. unguiculata* L. and *Phaseolus filiformis* L. [33].

Table 9. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on internode length (cm) of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*1.40 ± 2.04[a]	3.50 ± 1.31[a]	9.18 ± 0.59[b]	10.33 ± 1.72[b]
S+ M- P-	0.42 ± 0.00[b]	0.48 ± 0.00[c]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	1.20 ± 2.00[a]	2.80 ± 0.72[a]	6.10 ± 0.72[b]	6.23 ± 0.24[c]
S+ M+ P- (*Ri*)	1.22 ± 1.35[a]	3.10 ± 0.78[a]	6.17 ± 0.72[b]	6.54 ± 0.66[c]
S+ M- P+	0.78 ± 0.58[b]	1.40 ± 0.52[b]	8.20 ± 0.22[b]	6.20 ± 0.71[c]
S+ M+ P+ (*Gg*)	1.32 ± 0.57[a]	2.73 ± 0.59[a]	9.73 ± 0.54[b]	11.42 ± 0.72[b]
S+ M+ P+ (*Ri*)	1.30 ± 0.58[a]	3.00 ± 0.38[a]	9.00 ± 0.31[b]	10.77 ± .0.59[b]
S- M+ P- (*Gg*)	2.60 ± 0.57[a]	4.70 ± 1.32[a]	12.70 ± 1.92[a]	14.22 ± 1.00[b]
S- M+ P- (*Ri*)	1.67 ± 1.02[a]	4.53 ± 1.32[a]	12.23 ± 1.35[a]	13.68 ± 0.44[b]
S- M+ P+ (*Gg*)	1.39 ± 0.23[a]	3.51 ± 1.02[a]	15.71 ± 1.42[a]	18.89 ± 1.78[a]
S- M+ P+ (*Ri*)	1.40 ± 0.57[a]	2.51 ± 0.79[a]	17.73 ± 1.79[a]	20.22 ± 2.05[a]
S- M- P+	1.00 ± 0.35[a]	2.94 ± 0.41[a]	9.93 ± 0.71[b]	10.83 ± 1.43[b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 10. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on internode length (cm) of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*7.40 ± 1.40[a]	9.44 ± 1.45[a]	10.59 ± 0.55[a]	12.47 ± 0.78[a]
S+ M- P-	0.13 ± 0.29[b]	1.92 ± 0.14[b]	2.11 ± 0.46[b]	3.62 ± 0.47[c]
S+ M+ P- (*Gg*)	6.48 ± 0.57[a]	8.02 ± 0.65[a]	8.99 ± 0.77[a]	9.54 ± 0.44[b]
S+ M+ P- (*Ri*)	6.84 ± 1.01[a]	8.47 ± 0.41[a]	9.27 ± 1.22[a]	9.96 ± 0.77[b]
S+ M- P+	4.62 ± 0.91[a]	6.23 ± 0.19[a]	7.67 ± 0.75[a]	8.13 ± 0.67[b]
S+ M+ P+ (*Gg*)	4.80 ± 1.44[a]	6.79 ± 0.58[a]	8.22 ± 0.87[a]	12.42 ± 0.45[a]
S+ M+ P+ (*Ri*)	5.00 ± 1.28[a]	7.12 ± 1.71[a]	9.07 ± 1.81[a]	12.65 ± 0.82[a]
S- M+ P- (*Gg*)	7.46 ± 0.72[a]	9.62 ± 1.02[a]	12.15 ± 1.22[a]	13.41 ± 0.35[a]
S- M+ P- (*Ri*)	7.49 ± 0.77[a]	9.84 ± 1.31[a]	13.71 ± 2.54[a]	14.87 ± 0.75[a]
S- M+ P+ (*Gg*)	5.42 ± 1.01[a]	7.21 ± 0.84[a]	11.92 ± 0.36[a]	14.94 ± 0.81[a]
S- M+ P+ (*Ri*)	5.00 ± 1.21[a]	7.02 ± 0.78[a]	11.99 ± 1.08[a]	15.22 ± 0.55[a]
S- M- P+	4.00 ± 0.32[a]	6.11 ± 0.35[a]	8.79 ± 0.56[a]	12.54 ± 0.77[a]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 11. Effect of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on leaf area (cm^2) of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*22.57 ± 6.72[a]	26.43 ± 3.10[a]	56.21 ± 0.72[b]	89.42 ± 2.21[a]
S+ M- P-	6.93 ± 6.33[c]	7.25 ± 0.39[c]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	15.30 ± 1.76[b]	18.41 ± 1.25[b]	20.74 ± 1.65[d]	18.82 ± 1.04[b]
S+ M+ P- (*Ri*)	15.80 ± 1.76[b]	18.64 ± 1.48[b]	25.44 ± 1.32[d]	16.42 ± 0.65[b]
S+ M- P+	12.32 ± 0.58[b]	15.24 ± 1.55[b]	32.26 ± 2.55[c]	16.72 ± 0.45[b]
S+ M+ P+ (*Gg*)	14.40 ± 0.86[b]	16.41 ± 2.15[b]	58.71 ± 2.05[b]	92.22 ± 3.13[a]
S+ M+ P+ (*Ri*)	15.30 ± 0.57[b]	17.32 ± 1.75[b]	57.90 ± 1.21[b]	90.10 ± 2.02[a]
S- M+ P- (*Gg*)	27.40 ± 0.55[a]	30.44 ± 2.39[a]	62.64 ± 1.39[a]	94.75 ± 3.43[a]
S- M+ P- (*Ri*)	25.72 ± 0.51[a]	29.51 ± 2.12[a]	60.31 ± 1.12[a]	92.77 ± 2.11[a]
S- M+ P+ (*Gg*)	22.20 ± 1.07[a]	26.24 ± 3.10[a]	68.41 ± 3.80[a]	96.23 ± 1.98[a]
S- M+ P+ (*Ri*)	22.47 ± 0.58[a]	25.82 ± 1.37[a]	69.17 ± 2.37[a]	98.59 ± 2.10[a]
S- M- P+	21.47 ± 1.02[a]	24.32 ± 1.02[a]	58.77 ± 2.02[b]	92.22 ± 2.90[a]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Table 12. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on leaf area (cm^2) of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*84.30 ± 1.39 [a]	115.53 ± 10.24 [a]	119.58 ± 6.45 [a]	122.54 ± 4.11 [b]
S+ M- P-	13.51 ± 1.05 [e]	15.40 ± 3.30 [d]	15.75 ± 1.74 [c]	17.57 ± 0.46 [f]
S+ M+ P- (*Gg*)	70.42 ± 1.55 [b]	82.63 ± 0.99 [b]	91.48 ± 2.37 [b]	95.15 ± 1.45 [d]
S+ M+ P- (*Ri*)	73.70 ± 1.59 [b]	88.46 ± 1.10 [b]	94.85 ± 1.48 [b]	98.43 ± 2.01 [d]
S+ M- P+	53.21 ± 0.41 [d]	70.00 ± 0.39 [c]	81.27 ± 1.66 [b]	86.75 ± 0.78 [e]
S+ M+ P+ (*Gg*)	63.42 ± 0.59 [c]	80.10 ± 1.44 [b]	84.65 ± 0.65 [b]	118.22 ± 2.44 [c]
S+ M+ P+ (*Ri*)	65.72 ± 1.57 [c]	83.14 ± 1.37 [b]	88.38 ± 1.37 [b]	124.41 ± 2.11 [b]
S- M+ P- (*Gg*)	86.33 ± 1.25 [a]	120.20 ± 6.42 [a]	124.41 ± 6.59 [a]	126.63 ± 3.03 [b]
S- M+ P- (*Ri*)	86.59 ± 1.57 [a]	122.80 ± 6.09 [a]	126.85 ± 7.25 [a]	131.10 ± 6.22 [b]
S- M+ P+ (*Gg*)	57.21 ± 0.39 [d]	73.82 ± 1.02 [c]	120.11 ± 5.75 [a]	140.24 ± 6.64 [a]
S- M+ P+ (*Ri*)	53.79 ± 0.32 [d]	70.42 ± 0.83 [c]	122.58 ± 6.15 [a]	144.97 ± 6.78 [a]
S- M- P+	51.00 ± 0.59 [d]	68.72 ± 0.59 [c]	93.25 ± 1.68 [b]	124.62 ± 2.45 [b]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting)

Table 13. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on germination (%) of *C. maxima*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*73.33 ± 0.43 [b]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M- P-	26.66 ± 0.39 [f]	34.33 ± 0.35 [c]	0.00 ± 0.00	0.00 ± 0.00
S+ M+ P- (*Gg*)	40.00 ± 0.00 [d]	66.67 ± 0.76 [b]	100 ± 0.00 [a]	86.67 ± 0.83 [b]
S+ M+ P- (*Ri*)	33.00 ± 0.00 [e]	100 ± 0.00 [a]	100 ± 0.00 [a]	73.33 ± 0.33 [c]
S+ M- P+	33.33 ± 0.32 [e]	100 ± 0.00 [a]	100 ± 0.00 [a]	70.00 ± 0.00 [c]
S+ M+ P+ (*Gg*)	33.33 ± 0.33 [e]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M+ P+ (*Ri*)	40.00 ± 0.00 [d]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P- (*Gg*)	80.00 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P- (*Ri*)	66.66 ± 0.38 [c]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P+ (*Gg*)	40.00 ± 0.20 [d]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P+ (*Ri*)	46.00 ± 0.00 [d]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M- P+	33.33 ± 0.38 [e]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting), 0.00 (means the plants were dead)

Inoculation of *C. maxima* and *T. occidentalis* with arbuscular mycorrhizal fungi (AMF) (*Rhizophagus irregularis* and *Glomus geosporum*) and poultry manure (PM) amelioration in combined form significantly (p=0.05) increased the growth of *C. maxima* and *T. occidentalis* above the control in both saline and non-saline soil treatments in both cropping seasons. Similar observations have been made by Okon et al. [34] 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 [34].

The PM single treatment showed slight but not significant improvement in growth parameters of *C. maxima* and *T. occidentalis* in saline soil. Similar observations have been made by Tanmay et al. [35] on *Oryza sativa,* Islam et al. [36] on hybrid rice, Leithy et al. [37] on *Arachis hypogaea* L. *Rhizophagus irregularis* single treatment and in combination with PM inoculation showed better colonization and growth improvements than *G. geosporum* and PM treatments under saline and non-saline conditions. This was attributed to the aggressive nature of *R. irregularis* [38]. The beneficial effects of mycorrhizal fungi on plant growth under saline conditions have been demonstrated in various plant species like *Solanum lycopersicum* [39] and *Capsicum* species [40]. Also, mycorrhizal symbiosis delays senescence, increases leaf area, modifies root architecture, improves the growth of plants under a range of salinity stress conditions [40], and enhances phosphorous (P) absorption, especially when P availability is limited.

Analysis carried out to assess the photosynthetic pigments contents showed that salinity significantly (p=0.05) reduced the total photosynthetic pigments contents in *C. maxima* and *T. occidentalis* in both mycorrhizal and non-mycorrhizal plants. Non-mycorrhizal plants in saline soil treatments were more severely affected than the mycorrhizal plants (Fig. 2 and 3). Slight reduction in chlorophyll *"a", "b*" and carotenoids contents of *C. maxima* and *T. occidentalis* was observed for both first and second cropping seasons. This observation is in agreement with the work of Jing et al. [41] who reported that the total chlorophyll content significantly decreased in *Suaeda aralocaspica* exposed to high salinity. They attributed the decrease to the destruction of the chloroplast structure. Amira and Abdul [28] also recorded decrease in chlorophyll 'a', 'b', and total chlorophyll in *V. faba* exposed to saline stress. Also, Tort and Turkyilmaz [42] reported that the exposure of barley (*Hordeum vulgare* L.) to zero, 120, and 240 mM of sodium chloride led to decrease in chlorophyll 'a', chlorophyll 'b' and total chlorophyll content.

Table 14. Effects of salt stress and arbuscular mycorrhizal fungi (AMF) inoculation on germination (%) of *T. occidentalis*

Treatments	3 WAP	6 WAP	9 WAP	12 WAP
S- M- P-	*100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M- P-	44.44 ± 0.14 [e]	66.66 ± 0.68 [c]	55.55 ± 0.55 [b]	52.22 ± 1.22 [b]
S+ M+ P- (*Gg*)	88.88 ± 0.83 [b]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M+ P- (*Ri*)	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M- P+	66.66 ± 0.66 [c]	88.88 ± 0.85 [b]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M+ P+ (*Gg*)	66.66 ± 0.61 [c]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S+ M+ P+ (*Ri*)	66.66 ± 0.66 [c]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P- (*Gg*)	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P- (*Ri*)	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P+ (*Gg*)	55.55 ± 0.55 [d]	88.88 ± 0.84 [b]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M+ P+ (*Ri*)	55.55 ± 0.61 [d]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]
S- M- P+	55.55 ± 0.64 [d]	100 ± 0.00 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]

*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), M- (No mycorrhiza), P- (No poultry droppings), S+ (Plus salinity), M+ (Plus mycorrhiza), P+ (Plus poultry manure), (*Gg*) – *Glomus geosporum*, (*Ri*) – *Rhizophagus irregularis,* WAP (Weeks after planting)

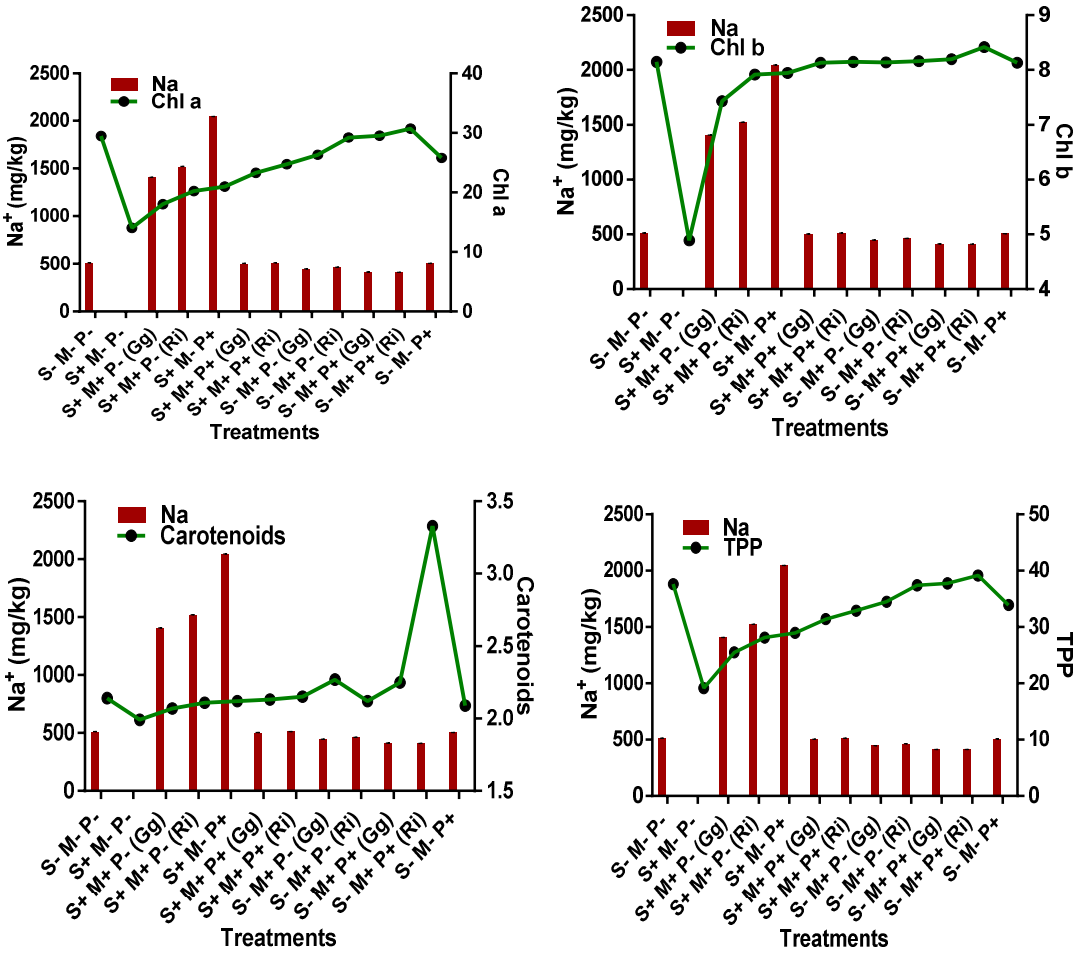
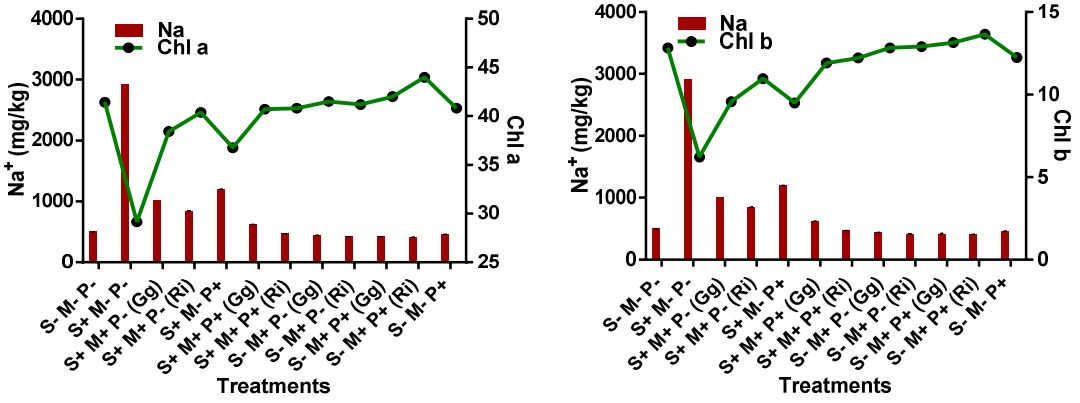


Fig. 2. Comparative assessment of influence of a foliar Na^+ accumulation on chlorophyll a, b, carotenoids and total photosynthetic pigments (TPP) in *C. maxima*



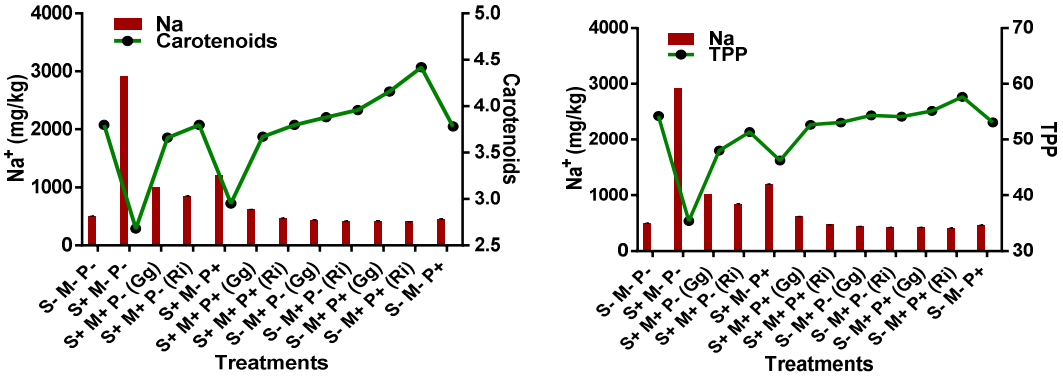


Fig. 3. Comparative assessment of influence of a foliar Na^+ accumulation on chlorophyll a, b, carotenoids and total photosynthetic pigments (TPP) in *T. occidentalis*

The inoculation of *C. maxima* and *T. occidentalis* with arbuscular mycorrhizal fungi (AMF) (*R. irregularis* and *G. geosporum*) together with poultry manure (PM) soil amendment significantly (p=0.05) increased the chlorophyll contents of *C. maxima* and *T. occidentalis* above the control in both saline and non-saline soil treatments when compared to either AMF inoculation or PM amendment. The influence of AMF on photosynthesis has been reported in many mycorrhizal plants growing under salinity stress [12, 43]. Inoculation with AMF (*R. intraradices, Claroideoglomus etunicatum*, and *Septoglomus constrictum*) isolated from the rhizosphere of *Asteriscus maritimus* gave improved performance of photosystem II and higher stomatal conductance in maize plants subjected to different levels of salinity, indicating that AMF minimized salinity-induced damage to the photosynthetic machinery and enhanced transpiration rates [12, 44].

CONCLUSIONS

Soil salinity is one of the most severe abiotic stresses affecting plant establishment, growth and production worldwide. Results of this study revealed that salt stress negatively affected physicochemical properties of the saline soil when compared to the garden soil, thus resulting in negative effects on growth parameters and photosynthetic pigments of *C. maxima* and *T. occidentalis*. The effects of mycorrhizal symbiotic association on *C. maxima* and *T. occidentalis* showed improvements on the growth of the treated plants. Using different mechanisms *C. maxima* and *T. occidentalis* by itself or in association with arbuscular mycorrhizal fungi and poultry manure (PM) can tolerate or survive soil salinity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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