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Abdel-Rahman M. A. Merwad

Zagazig University

Faculty of Agriculture

Soil Science Department

44511 Zagazig

Egypt

Tel: + 055 2554492 / +2 01212144240/ +2 01019203521

Fax: +2 055 2347567

Corresponding author; e-mail: abdo.soil@yahoo.com

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A short running title: Mitigation of salinity stress in Sudan grass by humic
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**Effect of humic and fulvic substances and Moringa leaf extract on Sudan grass
plants grown under saline conditions**

Abdel –Rahman M. A. Merwad

Soils Science Dept., Fac. Agric., Zagazig Univ., Egypt

Abstract

Salinity is the major stress factor, which limits crop cultivation, especially in developing countries. A randomized complete block, factorial (3-factor) experiment was conducted on Sudan grass grown on non-saline and saline soils to assess humic substances with or without foliar spraying Moringa leaf extract (MLE). Factors were : (A) Soil; 3 different levels of salinity i.e. S_1 : non-saline ($EC = 3.01 \text{ dSm}^{-1}$), S_2 : medium saline (6.12 dSm^{-1}) and S_3 : highly saline (12.33 dSm^{-1}) ; (B) humic substances i.e. B_0 : no addition, B_1 : humic acid (HA) as K-humate , B_2 : fluvic acid as K-fulvate and B_3 : HA and FA ; (C) foliar spray with MLE i.e. C_0 : non-treated and C_1 : foliar spray. Results indicated that total chlorophyll, nutrient uptake, available N, P and K significantly decreased within each humic substances application and MLE with increasing salinity concentration. The highest values of fresh, dry weight, total chlorophyll and NPK- uptake under different salinity levels were observed with application of substances and MLE. Spraying of MLE increased cumulative yield and nutrient uptake by Sudan grass compared to the untreated ones. The treatment of HA and FA with or without spraying MLE gave the highest values of available NPK under the salinity levels.

Key words: Saline soil, Moringa leaf extract, humic and fluvic acids

Introduction

Sudan grass is one of the important short-term forage crops of summer season. The Sudan grass and grain sorghum plants are chemically and morphologically similar, and with their hybrids are considered to be one of the emergency forage crops (Kidambi *et al.*, 1993, Khair 1999)

Salinity refers to the total concentration of all soluble salts in the soil i.e., Cl^- , SO_4^{2-} or CO_3^{2-} of Na^+ , Ca^{+2} and Mg^{+2} with the most common salt being NaCl (Jayasekera and Hall 2007). Salts inhibit plant growth by increasing the osmotic stress, nutritional imbalance, and specific ion toxicity. The extent of damage depends on the severity of stress, growth conditions and plant sensitivity to salinity (Cornillon and Palliox 1997). Increasing salinity stress was associated with significant decreases in P-uptake in straw and grain of barley plants (Ahmad 2007). Phosphorus (P) concentration in shoot of wheat was significantly decreased as soil salinity stress increased in both sandy and silty loam soils (Elgharably 2008). Salt stress induced a significant reduction in phosphorus of root. A non- significant effect of salinity stress was obtained on P concentration in leaf and grain rice (Naheed *et al.* 2008). Salinity increased the accumulation of Na^+ and decreased the K^+ content in shoots and roots. The Na^+ content of germinating seeds gradually increased, while K^+ content diminished (Akbarimoghaddam 2011 and Abd EL-Azim and Ahmed 2009). Nutrient uptake (N, P, K) by wheat plants decreased with increasing soil salinity levels (Elrys 2012). Humic substances may play a positive role in regulating the plant root metabolism by inducing or repressing the mechanism of protein synthesis, enzyme activation or inhibition resulting in morphofunctional changes in plant root tissues (Cacco *et al.* 2000 and Türkmen *et al.* 2004). Humic substances might show anti-stress effects under abiotic stress conditions such as, unfavorable temperature, pH, salinity etc.

Humic materials could improve growth of plant under soil condition with enhancing nutrients uptake and reducing toxic elements uptake (Kulikova *et al.* 2005). Sharif *et al.* 2002 found that the humus material has indirect effects on plant growth because it improves soil properties *i.e.*, water holding capacity, permeability, aggregation, hormonal activity, aeration, organic matter mineralization, and solubilization and nutrients availability (Nardi *et al.* 2002). Merwad and Abdel-Fattah (2015) found that the application of chicken manure combined with HA increased growth parameters, total chlorophyll, carotenoids, yield and nutrient uptake of sorghum compared with untreated.

Foidle *et al.* (2001) reported that MLE have plant growth enhancing capabilities as it is rich in zeatin, carotenoids, phenols, potassium and calcium. Fuglie 2000 reported that spraying MLE increased growth and yield of tomato, peanut, corn and wheat 20 to 35. The solvent of MLE are potential source of natural antioxidants (Siddhuraju and Becker, 2003 ; Arabshahi *et al.*, 2007 and Athar *et al.*, 2008). Foliar spray of MLE exhibit highest antioxidant status as compared to other growth enhancers up to moderate salinity (8dSm^{-1}) except ascorbic acid which continued to be increased up to highest salinity level (12dSm^{-1}). Moreover, the increase in ascorbic acid under MLE application in salinity stress was largest than all other enzymatic and nonenzymatic antioxidants. The objective of the current study was to test the effect of humic substances (humic and fulvic acids) with spraying Moringa leaf extract on yield, and nutrient uptake of Sudan grass grown under saline conditions.

Materials and methods

Experiment set up and design

A pot experiment was conducted under the green house conditions at the farm of the Faculty of Agriculture Zagazig University, Egypt. The design was a randomized

complete block, factorial (3-factor experiment) .The plant was Sudan grass (*Sorghum vulgare* var. *Sudanense*) grown on loamy soils (*Calciorthid*) collected from El-Noubaria, near Alexandria, Egypt. The 3 factors of the experiment were : (A) Soil; 3 different loamy soils of different natural (inherent) salinity (see Table 1 for properties of the soils) i.e. S_1 : non-saline ($EC = 3.01 \text{ dSm}^{-1}$), S_2 : medium saline (6.12 dSm^{-1}) and S_3 (highly saline 12.33 dSm^{-1}) ; (B) humic substances treatment i.e. B_0 :no addition, B_1 : adding humic acid (HA) as potassium humate, B_2 : adding fulvic acid (FA) as potassium fulvate and B_3 : adding humic and fluvic acids. The soil material for the experiment was collected from the surface 0-30-cm of the soil. (C) Foliar spray with MLE i.e. C_0 non-treated and C_1 foliar spray with the MLE. The soil was sieved through 5-mm and thoroughly mixed before filling the pots. Closed bottom PVC pots (10-kg capacity each) of 35-cm diameter and 30-cm height were used. Sudan grass seeds were obtained from the Crops Research Institute, Agriculture Research Centre, Giza, Egypt. Seeds were sown on the 1st of April, 2015. Twenty seeds were sown in each pot. Twelve days after sowing, plants were thinned to 10 per pot. Total of 3 cuts were taken. Physical and chemical properties of the soils were determined according to Piper 1951, Black *et al.* 1965, Jackson 1973.

Fertilization and humic substances application

Before planting, the treatments of humic substances i.e. humic acid (HA) as potassium humate and fulvic acid (FA) as potassium fulvate were thoroughly mixed with the soil at the rate of 0.002 g kg^{-1} (equivalent to about 5 kg ha^{-1}) mixed with fine sand (3 g per pot) as a filling material. Nitrogen was added as ammonium sulphate at the rate of 150 mg N kg^{-1} soil at three equal splits. The first was before the first irrigation while the second and third splits were added after the first and second cuts,

respectively from the first splits. The recommended doses of P and K were added; for all experimental treatments as ordinary super phosphate (65 g P kg^{-1}) at the rate of 15 mg P kg^{-1} soil before sowing. K was added as potassium sulphate (410 g K kg^{-1}) at the rate of 40 mg K kg^{-1} soil before sowing.

Preparation of Moringa leaf extract

An amount of 20 g of young *Moringa oleifera* leaves was mixed with 675 ml of 80% ethanol as suggested by Makkar and Becker (1996). The suspension was stirred using a homogenizer to help maximize the amount of the extract. The solution was filtered using No.2 Whatman filter paper. MLE was used within 5 h from cutting and extracting (if not ready to be used, the extract or the solution prepared was stored at 0°C and only taken out when needed for use). The chemical composition of ethanolic MLE was investigated using Fuglie (2000) and Moyo *et al.* (2011) are represented in Table (2). Extracts used for spray were dilutes of $30 \text{ mL extract L}^{-1}$ of water (3%). Foliar application was done in 9 occasions: 20, 30 and 40 days after germination and before 1st cut, then similar intervals after 1st cut, and also after 2nd cut (cuts are 60 days apart). Control plants (non-treated with MLE) were sprayed with distilled water.

Plant harvesting and analysis

Three cuts were taken from the Sudan grass. Each cut was taken after 60 day of growth. Plant height, fresh weight, dry matter, nutrient concentration and total chlorophyll of Sudan grass were measured at each harvest. Total chlorophyll were determined spectrophotometrically (Metzner *et al.* 1965). Proline concentration was determined according to the method given by Bates *et al.* (1973). Plant samples taken

at three different cuts, and dried at 70°C until constant weight, digested and determining nutrient concentration (Chapman and Pratt 1961).

Soil analysis

Available P was determined using Watanabe and Olsen (1965) method, 5 g of soil sample being shaken with 50 ml 0.5 M NaHCO₃ solution (pH 8.5) with one gram activated charcoal for 0.5 hour and filtered. Available N was determined using method described by (Jackson 1973), 5 g of each soil sample was shaken with 50 ml 2 N KCl solution and filtered. Available N was assayed in the soil extract using kjeldahl apparatus. Available potassium being extracted by 1N NH₄OAC solution and assayed by flame photometer (Jackson 1973).

Statistical analyses

Data of the current study were subjected to analysis of variance for a split-split bloks design, after testing for the homogeneity of error variances. Statistically significant differences between means were compared at $P \leq 0.05$ using Duncan's Multiple Range Test. The statistical analysis was carried out using COSTAT computer software (CoHort Software version 6.303, Berkeley, CA, USA).

Results and discussion

Fresh and dry weight

The application of various humic substances with MLE gave an increase in the total yield of plants in the three cuts grown under different salinity level compared to untreated soil (Table 2). This is explained on the fact that the addition of humic materials improve physical **and** chemical characteristics of saline soil. This finding stands in agreement with those of Nardi *et al.* (2002), Cimrin and Yilmaz 2005, Merwad and Abdel-Fattah 2015 and Thanaa *et al.*, 2017.

Concerning the effect of saline soil salinity, data reveal that, the cumulative yield of Sudan grass was decreased by increasing the soil salinity level. This trend was found true under different humic substances with MLE, at all three cuts. As mentioned above the plants at three cuts were damaged with the control treatment due to extremely high salinity (12.33 dSm^{-1}). Salts inhibit growth of plant by increasing specific ion toxicity, osmotic stress and nutritional imbalance. The extent of damage depends on the severity of stress, growth conditions and plant sensitivity to salinity (Cornillon and Palliox 1997). Elgharably (2008) reported that increasing the salinity during the growing season significantly reduced the total dry matter accumulation, straw and grains yield of wheat.

Regarding the effect of humic substances, data indicate that the application of individual HA or combination with FA gave the higher values of cumulative yield of plants at three cuts under all salinity levels than single fulvic acid addition in the presence of MLE. Main effect of humic materials are as follows $\text{HA and FA} > \text{HA} > \text{FA} > \text{None}$. The highest values of fresh and dry weight at three cuts under S1 (3.01 dSm^{-1}), S2 (6.12 dSm^{-1}) and S3 (12.33 dSm^{-1}) levels were observed with addition of HA and FA (554, 510 and 439 g pot^{-1} , respectively for fresh weight and 92.41, 85.04 and 73.15 g pot^{-1} , respectively for dry weight) under spraying of MLE, while the lowest one (512, 466 and 331 g pot^{-1} , respectively for fresh weight and 85.36, 77.60 and 55.16 g pot^{-1} , respectively for dry weight) was recorded under the control in the absence of MLE. From statistical analysis, results showed that spraying MLE gave significant increase in fresh and dry weight of plants compared to control plants.

Spraying of MLE increased cumulative fresh weight of Sudan grass plants compared to the untreated ones (Table 2). These increases represent 3.9, 2.3, 3.3 and 2.8% under S1 (3.01 dSm^{-1}) level for the treatments of untreated, HA, FA, HA + FA,

respectively ; 3, 2.9, 1.5 and 2.4%, respectively under S2 (6.12 dSm⁻¹) level and 2.4 , 3.6, 3.2 and 3.3 % , respectively under S3(12.33 dSm⁻¹) level. MLE is a highly nutritive multipurpose plant grown for vegetables, livestock fodder, green manure, biogas, medicine, bio pesticide, and seed production (Fuglie, 2000). Foliar spray with MLE increased plant growth and yield by 20-35% (Foidle *et al.* 2001; Makkar and Becker 1996, Nouman *et al.* 2011, Basra *et al.* 2005 and Merwad 2015a, b). MLE is rich with ascorbic acid, mineral nutrients i.e, Fe, K, Ca and amino acids and had an effect on increasing the plant growth (Makkar and Becker 1996; Basra *et al.* 2009; Merwad and Abdel-Fattah, 2016 and Thanaa *et al.*, 2017).

Plant height, total chlorophyll and proline

Addition of different humic substances as well as foliar spray with MLE caused positive significant effects on plant height, total chlorophyll and proline of Sudan grass grown under salinity level (Table 3). The highest values of plant height, total chlorophyll and proline under S1 (3.01 dSm⁻¹), S2 (6.12 dSm⁻¹) and S3 (12.33 dSm⁻¹) levels (140, 118 and 73.5 cm, respectively for plant height; 1.7, 1.46 and 1.27 mg/g fwt, respectively for total chlorophyll and 16.3, 17.4 and 22.4 mg g⁻¹ dwt, respectively for proline) were obtained by HA and FA under sprayed MLE, while the lowest one was obtained in plants not receiving humus materials as well as MLE. Addition of HA significantly increased plant pigments, i.e. chlorophyll a, total chlorophyll and carotenoids concentrations under calcareous soils conditions (Hanafy *et al.* 2010; Merwad 2015a and Shuixiu and Ruizhen 2001).

Regarding the effect of soil salinity, data reveal that, the plant height and total chlorophyll of Sudan grass was decreased with increasing the soil salinity levels. On the other hand, proline was increased with increasing the soil salinity level. This trend was found true under different humus materials with MLE, at all three cuts. As

mentioned above the plants at three cut died off with the control soil due to extremely high salinity (12.33 dSm^{-1}). Salinity treatments have a depressing effect on various growth parameters was increased prominently with increasing salinity level (Mazher *et al.* 2008 and Parida and Das 2005). Chlorophyll reduction probably is due to the inhibitory effect of accumulation of ions on biosynthesis of different ingredients of chlorophyll (Tejera *et al.* 2006 and Poustini *et al.* 2007).

Spraying MLE increased the plant height by averages 11.5, 17.5, 14.4 and 15.3% under the treatments of untreated, HA, FA, HA+FA, respectively under various level of soil salinity; Moreover it increased proline by averages of 10.3, 10, 8.5 and 9%, respectively. MLE is rich with source of vitamin C, β -carotene, protein, Ca, Fe, K, natural antioxidants such as ascorbic acid, flavonoid, phenolics and carotenoids (Dillard and German 2000, Siddhuraju and Becker 2003, Merwad 2015b Merwad and Abdel-Fattah, 2016; Thanaa *et al.*, 2017 ; Raje and Mestry, 2017; Abusuwar and Abohassan 2017).

Nutrient uptake

Addition of various humic substances as well as foliar of MLE spray caused a positive significant effect on individual and cumulative N,P and K- uptake (mg pot^{-1}) of the successive cuttings of Sudan grass grown under various levels of soil salinity (Table 4). The highest values of N, P and K-uptake were obtained with HA and FA combined with MLE spray under S1 (3.01 dSm^{-1}), S2 (6.12 dSm^{-1}) and S3 (12.33 dSm^{-1}) levels. However untreated plants showed the lowest N, P and K- uptake. Treatments could be arranged in the following order regarding the main effects HA + FA > HA > FA> untreated under various level of soil salinity with foliar spray of MLE (Merwad 2015b). Addition of HA increased plant growth and the nutrients accumulation of wheat (Asik *et al.* 2009 and Arancon *et al.* 2006). The addition of

humus substances showed anti-stress effects under a biotic stress conditions such as, unfavorable temperature, pH, salinity etc.(Kulikova *et al.* 2005). Potassium humate (1.0 %) treated crop plants showed significantly increased on nutrients accumulation of wheat (Patil *et al.* 2011).

In general, results of the cumulative N, P and K-uptake as affected by application of various humic substances with moringa spraying gave an increase in the three cuts of plants grown under salinity stress (3.01, 6.12 and 12.33 dSm⁻¹) compared to the control; this result could be due to the high total dry weight as a result of the effects of treated humic substances with MLE (Merwad 2015b).

Regarding the effect of soil salinity, data in Table (4) show that, the N, P and K-uptake by Sudan grass plants was decreased with increasing the soil salinity level. This trend was found true under different humic substances with MLE, at all three cuts. As mentioned above the plants at three cut died off in the control treatment due to extremely high salinity (12.33 dSm⁻¹). Ahmad (2007) found that increasing salinity stress was associated with significant decreases in NPK accumulation by straw and grains of barley plants. Saqib *et al.* (2004) stated the concentration of NPK in wheat plants decreased with increasing the salinity stress. Hadad (2006) reported that the NPK concentration and its uptake by barely plants decreased with increasing EC.

Spraying of MLE increased cumulative N-uptake by Sudan grass plants compared to the untreated ones (Table 4). These increases represent 11, 8.7, 9.4 and 8.3% under S1(3.01 dSm⁻¹) level for the treatments of untreated, HA, FA, HA and FA, respectively ; 10.4, 8.9 , 13.8 and 3.2%, respectively under S2 (6.12 dSm⁻¹) level and 5.1, 7.7, 8.8 and 12 % , respectively under S3 (12.33 dSm⁻¹) level. Treatments under spraying MLE gave higher value of P-uptake than those under untreated. These increases represent 23, 12.4, 17.6 and 10% under S1(3.01 dSm⁻¹) level for the

treatments of untreated, HA, FA, HA and FA, respectively; 17.8, 11, 12.6 and 11%, respectively under S2 (6.12 dSm⁻¹) level and 21, 21, 16 and 14.8% , respectively under S3 (12.33 dSm⁻¹) level. The same trend was found with the potassium uptake (Merwad 2015b; Raje and Mestry, 2017 and Abusuwar and Abohassan, 2017).

Salinity also produces ionic stress leading to ionic imbalances and impairment of root membrane selectivity. Athar et al. 2008 showed that addition of ascorbic acid increased leaves K⁺ accumulation under salinity. Addition of MLE and H₂O₂ decreased concentration of Na⁺ and Cl⁻ along with increased K⁺ in leaves against control (Makkar *et al.*, 2007).

Soil pH and available nutrients

Effect of soil salinity and humic substances with MLE on soil pH, available N, P and K concentration in the soils was illustrated in (Figs 1 and 2). Respecting the soil salinity effect, results reveal that, the available N, P and K in the soils were decreased with increasing the soil salinity level. This trend was found true under different humic substances with spraying MLE. On the other hand, results show that, soil pH was decreased with the application of humus materials with or without MLE under soil salinity level. Obtained results are similar to those reported by Elgharably, 2008 and Vuelvas-Solozano *et al.*, 2009 who observed significant negative effects of soil salinity on availability of N and P in wheat in loam soil. He attributed his results to the inhibitory effects of salinity stress on soil microbial activity, and in turn, on organic N mineralization.

The available N, P and K concentration in the soils were increased with the addition of various humic substances under the salinity levels. The treatment of HA and FA with or without spraying MLE gave the highest values of available N, P and K under the salinity levels , while the lowest were found with untreated soil. The

promotive effect of various humus materials on soil pH, available N, P and K concentrations in the soil may follow the order of: HA and FA > HA > FA > untreated soils (Merwad and Abdel-Fattah 2015; Raje and Mestry, 2017 and Abusuwar and Abohassan, 2017).

Application various humic substances increased the mean values of available N, P and K in soil under salinity levels compared to the untreated ones (Figs 1 and 2). These increases represent 18.5, 48 and 75% for available nitrogen; 25, 64 and 96% for available phosphorus and 22, 36.7 and 76.8 % for available potassium under application HA, FA, HA and FA treatments, respectively. Application of HA combined with P fertilizer significantly increased the content of water-soluble phosphate, strongly retarded the formation of occluded phosphate, and increased P accumulation by 25% (Wang *et al.* 1995). The effect of HA and FA on the dissolution of aluminum phosphate and iron phosphate, and assessed their availability to plants.. Humic acid was more effective than fulvic acid in dissolving the metal phosphates. Addition of HA released the fixed K (Mesut *et al.* 2010). Soil addition of HA at 50 mg kg⁻¹ mixed with P fertilizer at a recommended dose significantly increase availability of soil organic matter, Phosphorus, Potassium and Boron by 16, 60, 4 and 34%, respectively compared to 100% of P fertilizer alone (Sarwar *et al.* 2012)

Relationship between K and Na in Sudan grass as affected by treatments.

Under saline conditions, high levels of external Na⁺ not only interfere with K⁺ acquisition by the roots, but also may disrupt the integrity of root membranes and alter their selectivity. The selectivity of the root system for K⁺ over Na⁺ must be sufficient to meet the levels of K⁺ required for metabolic processes, the regulation of ion transport, and for osmotic adjustment (Hu and Schmidhalter 2005).

The relation between K and Na concentration (g kg^{-1}) in Sudan grass at different cuts was shown in (Figure 3). The potassium concentration in Sudan grass plants at three cuts was reported to be decreased with increasing soil salinity stress. However, the Na concentration tended to increase with increasing the soil salinity. Overall, there was a positive relationship between K and Na concentration in Sudan grass at three cuts. The correlation coefficient (r) values between K and Na concentration in Sudan grass were 0.96, 0.93 and 0.88 at the 1st, 2nd and 3rd cuts. This adverse relationship between K and Na concentration in plant tissues was found true at all cuts under all treatments. Hossain *et al.* (2006) reported that the various soil salinity of NaCl decreased mineral ion accumulation in wheat plants; the acculturation of Na increased while that of K decreased in the salt treated plants.

Conclusion

Salinity is a major limiting factor for plant growth and productivity. The decrease was proportional to the increase in salinity concentration. Applying humic acid as K-humate or fluvic acid as K-fulvate singly or combined to the soil alleviated the negative effect caused by salinity to plant growth (Sudan grass, three cuts). The effect was strengthened with spraying the plants with MLE. Increases occurred in plant growth parameters of yield, chlorophyll, NPK-uptake. Treatments also showed a decrease in Na content in plant. Spraying of MLE combined with addition of humic substances and materials can be a practical preposition to help plants endure salinity when grown on saline soils increasing their yields and nutrient uptake. The available N, P and K in the soils were decreased with increasing the soil salinity level. Soil pH was decreased with addition of humic materials with or without MLE under soil salinity level. Generally, the best results of all of the growth characteristics, nutrients uptake and available NPK in soil were obtained from HA and FA application with

MLE within every individual salinity concentration. More research may be needed to clarify the mechanisms of alleviation done by fulvic and humic acids and their salts.

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Table1. Some physical and chemical properties of the soils under study

Soil	Sand	Silt	Clay	Texture	pH ^a	EC ^b	CaCO ₃	OM ^c	Available nutrients		
									N	P	K
						-----%-----			dSm ⁻¹	-----g kg ⁻¹ -----	mg kg ⁻¹
S1	42	37	21	Loam	7.89	3.01	55.32	6.42	60.42	8.95	92.14
S2	47	30	23	Loam	7.83	6.12	61.35	7.41	58.45	8.12	91.02
S5	43	29	28	Loam	8.02	12.33	62.71	8.63	49.50	5.74	87.21
Note: ^a soil paste					^b soil paste extract			^c organic matter			

Table 2.Chemical composition of *Moringa oleifera* leaves per dry weight (dw).

Component	Value
Protein	273 g kg ⁻¹ dw
Phosphorus (P)	3.90 „ „
Potassium (K)	21.70 „ „
Calcium (Ca)	24.0 „ „
Magnesium (Mg)	4.5 „ „
Iron (Fe)	0.582 „ „
Vitamin A (β-carotene)	163 mgkg ⁻¹
Vitamin B1(thiamine)	26 „ „
Vitamin B2 (riboflavin)	210 „ „
Vitamin B3(nicotinic acid)	800 „ „
Vitamin C (ascorbic acid)	1700 „ „
Vitamin E (tochopherol acetate)	1130 „ „

Table 3. Effect of humic substances and foliar spray of Moringa leaf extract on fresh and dry weight of Sudan grass plants grown under salinity stress.

Factor of study [†]			Fresh weight (g pot ⁻¹)			Cumulative fresh weight (g pot ⁻¹)	Dry weight (g pot ⁻¹)			Cumulative dry weight (g pot ⁻¹)
			1 st	2 nd	3 rd		1 st	2 nd	3 rd	
Effect of soil salinity (A)										
S1 ₃ (3.01 dSm ⁻¹)			600a	576a	427a	1603a	100a	95.92a	71.15a	267a
S2 ₃ (6.12 dSm ⁻¹)			568b	531b	367b	1465b	94.58b	88.54b	51.23b	234b
S3 ₃ (12.33 dSm ⁻¹)			534c	489c	182c	1205c	89.03c	81.58c	30.36c	201c
Effect of humic substance (B)										
Untreated			559d	518d	253d	1331d	93.21d	86.40d	42.19d	222d
HA			570b	535b	349b	1455b	94.92b	89.24b	58.14b	242b
FA			563c	528c	340c	1433c	93.84c	88.10c	56.59c	239c
HA + FA			578a	546a	360a	1483a	96.26a	91.0a	60.05a	248a
Effect of moringa leaf extract (C)										
Without			561b	525b	317b	1403b	93.45b	87.55b	52.90b	234b
With			573a	539a	333a	1445a	95.66a	89.82a	55.59a	241a
Effect the interaction (A*B*C)										
S1 ₃ (3.01 dSm ⁻¹)	Untreated	Without	584ef	551d	401g	1536g	97.32ef	91.89d	66.86g	256g
		With	603c	572c	422e	1597d	100c	95.38c	70.28e	266e
	HA	Without	595d	570c	426de	1593de	99.18d	95.32c	71.03de	265de
		With	610a	581b	439b	1630b	101b	96.87b	73.21b	272b
	FA	Without	585de	566c	415f	1566f	97.57de	94.39c	69.23f	261f
		With	607bc	580b	429cd	1616c	101bc	96.72b	71.45cd	269cd
	HA + FA	Without	601c	582b	433c	1616c	100c	97.08b	72.11c	269c
		With	614a	599a	450a	1663a	103a	99.77a	75.05a	277a
S2 ₃ (6.12 dSm ⁻¹)	Untreated	Without	552kl	510i	335m	1397m	91.98kl	85.02i	55.78m	233m
		With	563ij	516h	361k	1440lm	93.87ij	85.99h	60.25k	240k
	HA	Without	565ij	533f	362k	1460k	94.22ij	88.77f	60.25k	243k
		With	578fg	543e	383h	1504h	96.32fg	90.52e	63.82h	251h
	FA	Without	564jk	527g	353l	1445l	94.14jk	87.75g	58.82l	241l
		With	568hi	530fg	370j	1468i	94.69hi	88.31fg	61.69j	245j
	HA + FA	Without	574gh	542e	377i	1493i	95.60gh	90.31e	62.80i	248i
		With	582ef	550d	399g	1531g	96.95ef	91.73d	66.43g	255a
S3 ₃ (12.33 dSm ⁻¹)	Untreated	Without	522q	470m	000r	992r	87.07q	78.40m	0.00r	165r
		With	528op	490k	000r	1018r	88.05op	81.73k	0.00r	169r
	HA	Without	531op	482l	234q	1247q	88.52op	80.37l	38.9q	207q
		With	542m	502j	250o	1294o	90.25m	83.65j	41.62o	215o
	FA	Without	526pq	474m	229q	1229q	87.59pq	79.02m	38.19q	205q
		With	534no	494k	241p	1269p	89.04no	82.41k	40.18p	211p
	HA+ FA	Without	537mn	493k	245op	1276op	89.53mn	82.30k	40.76op	213op
		With	549n	509i	259n	1317n	91.52l	84.77i	43.16n	219n
Effect of the interaction (B*C)										
Untreated	Without	553e	511f	245h	1309h	92.12e	85.10f	40.88h	218h	
	With	565d	526d	261g	1352g	94.15d	87.70d	43.51g	225g	
HA	Without	564d	529d	340e	1433e	93.97d	88.15d	56.75e	238e	
	With	577b	542b	357b	1476b	96.09b	90.35b	59.55b	246b	
FA	Without	559e	522e	332f	1413f	93.10e	87.06e	55.42f	235f	
	With	570c	535c	347d	1452d	94.95c	89.15c	57.78d	242d	
HA + FA	Without	571c	539b	351c	1461c	95.12c	89.90b	58.56c	244c	
	With	582a	553a	369a	1504a	96.96a	92.09a	61.55a	251a	

Note: Mean values in the same column for each trait followed by the same a lower case italic letter are not significantly different according to Duncan's multiple range test at $P \leq 0.05$.

[†] **Factor of study:** A = Salinity effects, B = Humic substances effects, C = Moringa leaf extract effects. HA = Humic Acid, FA = Falcic Acid, 1st = First cut, 2nd = Second cut and 3rd = Third cut

Table 4. Effect of humic substances and foliar spray of Moringa leaf extract on plant height, total chlorophyll and proline of Sudan grass plants grown under salinity stress.

Factor of study [†]			Plant height (cm)			Total chlorophyll (mg g ⁻¹ f wt)			Proline (mg g ⁻¹ d wt)		
			1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd
Effect of soil salinity (A)											
S1,(3.01 dSm ⁻¹)			158 <i>a</i>	144 <i>a</i>	79.67 <i>a</i>	1.84 <i>a</i>	1.58 <i>a</i>	1.17 <i>a</i>	17.67 <i>c</i>	14.06 <i>c</i>	11.18 <i>c</i>
S2,(6.12 dSm ⁻¹)			126 <i>b</i>	102 <i>b</i>	56.34 <i>b</i>	1.57 <i>b</i>	1.37 <i>b</i>	0.95 <i>b</i>	19.41 <i>b</i>	15.70 <i>b</i>	12.03 <i>b</i>
S3, (12.33 dSm ⁻¹)			86.56 <i>c</i>	60.8 <i>c</i>	26.67 <i>c</i>	1.44 <i>c</i>	1.12 <i>c</i>	0.61 <i>c</i>	24.42 <i>a</i>	19.3 <i>a</i>	12.67 <i>a</i>
Effect of humic substance (B)											
Untreated			108 <i>d</i>	89.64 <i>d</i>	40.77 <i>d</i>	1.53 <i>d</i>	1.26 <i>d</i>	0.64 <i>d</i>	19.07 <i>d</i>	14.07 <i>d</i>	6.64 <i>d</i>
HA			127 <i>b</i>	106 <i>b</i>	58.07 <i>b</i>	1.64 <i>b</i>	1.39 <i>b</i>	1.00 <i>b</i>	21.08 <i>b</i>	17.01 <i>b</i>	13.99 <i>bc</i>
FA			123 <i>c</i>	101 <i>c</i>	55.02 <i>c</i>	1.56 <i>c</i>	1.31 <i>c</i>	0.94 <i>c</i>	20.11 <i>c</i>	16.14 <i>c</i>	12.79 <i>c</i>
HA + FA			134 <i>a</i>	112 <i>a</i>	63.03 <i>a</i>	1.73 <i>a</i>	1.48 <i>a</i>	1.06 <i>a</i>	21.74 <i>a</i>	17.58 <i>a</i>	14.43 <i>a</i>
Effect of moringa leaf extract (C)											
Without			117 <i>b</i>	94.0 <i>b</i>	49.24 <i>b</i>	1.50 <i>b</i>	1.29 <i>b</i>	0.87 <i>b</i>	19.99 <i>b</i>	15.16 <i>b</i>	11.28 <i>b</i>
With			130 <i>a</i>	111 <i>a</i>	59.22 <i>a</i>	1.73 <i>a</i>	1.42 <i>a</i>	0.95 <i>a</i>	21.02 <i>a</i>	17.56 <i>a</i>	12.64 <i>a</i>
Effect the interaction (A*B*C)											
S1,(3.01 dSm ⁻¹)	Untreated	Without	141 <i>d</i>	124 <i>g</i>	68.36 <i>g</i>	1.65 <i>cdefg</i>	1.42 <i>bcdef</i>	1.02 <i>abcdefg</i>	16.18 <i>l</i>	11.1 <i>j</i>	8.19 <i>i</i>
		With	150 <i>c</i>	133 <i>f</i>	81.32 <i>d</i>	1.79 <i>bcd</i>	1.55 <i>abcd</i>	1.10 <i>abcdef</i>	16.82 <i>kl</i>	13.12 <i>hij</i>	10.03 <i>gh</i>
	HA	Without	153 <i>c</i>	141 <i>d</i>	73.11 <i>f</i>	1.84 <i>bcd</i>	1.59 <i>abcd</i>	1.23 <i>abc</i>	18.52 <i>ghijk</i>	13.51 <i>hi</i>	11.31 <i>efgh</i>
		With	169 <i>a</i>	155 <i>b</i>	86.71 <i>b</i>	1.96 <i>ab</i>	1.66 <i>abc</i>	1.21 <i>abcd</i>	17.63 <i>jkl</i>	16.13 <i>efg</i>	12.88 <i>de</i>
	FA	Without	152 <i>c</i>	137 <i>e</i>	70.80 <i>f</i>	1.71 <i>bcdef</i>	1.43 <i>bcdef</i>	1.09 <i>abcdef</i>	17.66 <i>ijkl</i>	13.02 <i>ij</i>	9.86 <i>h</i>
		With	168 <i>a</i>	150 <i>c</i>	84.23 <i>c</i>	1.87 <i>bc</i>	1.57 <i>abcd</i>	1.14 <i>abcde</i>	17.02 <i>jkl</i>	14.69 <i>ghi</i>	11.61 <i>efg</i>
	HA +FA	Without	160 <i>b</i>	148 <i>c</i>	79.21 <i>e</i>	1.86 <i>bc</i>	1.67 <i>ab</i>	1.29 <i>ab</i>	18.28 <i>ghijk</i>	13.98 <i>hi</i>	11.98 <i>ef</i>
		With	170 <i>a</i>	161 <i>a</i>	92.63 <i>a</i>	1.99 <i>a</i>	1.80 <i>a</i>	1.32 <i>a</i>	18.61 <i>ghijk</i>	16.91 <i>ef</i>	13.63 <i>cd</i>
S2,(6.12 dSm ⁻¹)	Untreated	Without	103 <i>i</i>	86.4 <i>lk</i>	43.62 <i>l</i>	1.35 <i>ijk</i>	1.24 <i>dffgh</i>	0.83 <i>efg</i>	16.83 <i>kl</i>	13.63 <i>hi</i>	10.13 <i>gh</i>
		With	110 <i>h</i>	99.6 <i>j</i>	51.36 <i>j</i>	1.64 <i>cdefgh</i>	1.33 <i>bcdefgh</i>	0.93 <i>cdefg</i>	18.19 <i>hijk</i>	14.68 <i>ghi</i>	11.51 <i>efg</i>
	HA	Without	124 <i>g</i>	92.42 <i>k</i>	50.26 <i>j</i>	1.52 <i>efghij</i>	1.30 <i>bcdefgh</i>	0.94 <i>cdefg</i>	19.67 <i>fgh</i>	15.26 <i>fgh</i>	12.63 <i>def</i>
		With	136 <i>e</i>	116 <i>h</i>	66.31 <i>h</i>	1.73 <i>bcdef</i>	1.48 <i>abcdef</i>	1.03 <i>abcdefg</i>	20.98 <i>ef</i>	17.11 <i>ef</i>	12.91 <i>de</i>
	FA	Without	127 <i>g</i>	89.80 <i>k</i>	47.82 <i>k</i>	1.51 <i>efghijk</i>	1.29 <i>cdefgh</i>	0.86 <i>efg</i>	19.71 <i>fgh</i>	14.98 <i>fghi</i>	11.19 <i>fgh</i>
		With	130 <i>f</i>	109 <i>i</i>	58.26 <i>i</i>	1.69 <i>cdef</i>	1.41 <i>bcdef</i>	1.02 <i>abcdefg</i>	19.62 <i>fghi</i>	16.16 <i>efg</i>	11.96 <i>ef</i>
	HA + FA	Without	129 <i>f</i>	101 <i>j</i>	59.31 <i>i</i>	1.60 <i>defgh</i>	1.40 <i>bcdef</i>	0.96 <i>bcdefg</i>	20.18 <i>efg</i>	16.15 <i>efg</i>	12.85 <i>de</i>
		With	160 <i>b</i>	123 <i>g</i>	71.82 <i>f</i>	1.76 <i>bcde</i>	1.54 <i>abcde</i>	1.07 <i>abcdef</i>	21.63 <i>de</i>	17.68 <i>de</i>	12.98 <i>de</i>
S3, (12.33 dSm ⁻¹)	Untreated	Without	69.11 <i>m</i>	43.7 <i>r</i>	0.00 <i>r</i>	1.27 <i>k</i>	1.00 <i>h</i>	0.00 <i>h</i>	21.87 <i>de</i>	16.27 <i>efg</i>	0.00 <i>j</i>
		With	75.24 <i>l</i>	51.3 <i>q</i>	0.000 <i>r</i>	1.33 <i>ijk</i>	1.02 <i>g</i>	0.00 <i>h</i>	23.10 <i>cd</i>	19.36 <i>cd</i>	0.00 <i>j</i>
	HA	Without	83.61 <i>k</i>	55.3 <i>p</i>	31.82 <i>pq</i>	1.39 <i>ghijk</i>	1.11 <i>gh</i>	0.78 <i>fg</i>	23.74 <i>bc</i>	18.07 <i>de</i>	16.11 <i>b</i>
		With	98.39 <i>i</i>	76.2 <i>m</i>	39.268 <i>n</i>	1.55 <i>defghi</i>	1.22 <i>defgh</i>	0.87 <i>defg</i>	25.96 <i>a</i>	21.98 <i>ab</i>	18.10 <i>a</i>
	FA	Without	80.36 <i>kl</i>	49.7 <i>q</i>	30.91 <i>q</i>	1.29 <i>jk</i>	1.026 <i>gh</i>	0.72 <i>g</i>	23.17 <i>cd</i>	17.69 <i>de</i>	14.61 <i>c</i>
		With	93.26 <i>j</i>	71.4 <i>n</i>	36.11 <i>o</i>	1.51 <i>efghijk</i>	1.18 <i>efgh</i>	0.82 <i>efg</i>	24.99 <i>abc</i>	20.36 <i>bc</i>	17.55 <i>ab</i>
	HA + FA	Without	92.47 <i>j</i>	60.4 <i>o</i>	33.69 <i>p</i>	1.53 <i>efghij</i>	1.16 <i>fgh</i>	0.83 <i>efg</i>	25.68 <i>ab</i>	18.18 <i>de</i>	16.38 <i>b</i>
		With	99.8 <i>i</i>	79.2 <i>m</i>	41.63 <i>m</i>	1.61 <i>defgh</i>	1.30 <i>bcdefgh</i>	0.90 <i>cdefg</i>	25.88 <i>a</i>	22.61 <i>a</i>	18.63 <i>a</i>
Effect of the interaction (B*C)											
Untreated	Without	104 <i>h</i>	84.57 <i>g</i>	37.33 <i>h</i>	1.42 <i>d</i>	1.22 <i>c</i>	0.62 <i>c</i>	18.30 <i>d</i>	13.69 <i>d</i>	6.11 <i>f</i>	
	With	112 <i>g</i>	94.72 <i>e</i>	44.23 <i>g</i>	1.59 <i>bc</i>	1.30 <i>bc</i>	0.68 <i>c</i>	19.37 <i>c</i>	15.72 <i>c</i>	7.18 <i>g</i>	
HA	Without	120 <i>e</i>	96.33 <i>e</i>	52.06 <i>e</i>	1.59 <i>bc</i>	1.33 <i>bc</i>	0.98 <i>ab</i>	20.65 <i>bc</i>	15.61 <i>c</i>	13.35 <i>d</i>	
	With	134 <i>b</i>	116 <i>b</i>	64.09 <i>b</i>	1.74 <i>ab</i>	1.45 <i>ab</i>	1.04 <i>ab</i>	21.52 <i>ab</i>	18.41 <i>a</i>	14.63 <i>b</i>	
FA	Without	119 <i>f</i>	92.1 <i>f</i>	50.18 <i>e</i>	1.51 <i>cd</i>	1.23 <i>c</i>	0.89 <i>b</i>	20.19 <i>c</i>	15.23 <i>c</i>	11.89 <i>e</i>	
	With	130 <i>c</i>	110 <i>c</i>	59.87 <i>c</i>	1.69 <i>b</i>	1.38 <i>abc</i>	0.99 <i>ab</i>	20.54 <i>bc</i>	17.07 <i>b</i>	13.71 <i>c</i>	
HA + FA	Without	127 <i>d</i>	103 <i>d</i>	57.40 <i>d</i>	1.67 <i>bc</i>	1.41 <i>abc</i>	1.02 <i>ab</i>	21.50 <i>ab</i>	16.1 <i>bc</i>	13.78 <i>c</i>	
	With	142 <i>a</i>	121 <i>a</i>	68.69 <i>a</i>	1.79 <i>a</i>	1.55 <i>a</i>	1.10 <i>a</i>	21.93 <i>a</i>	19.07 <i>a</i>	15.08 <i>a</i>	

Note: Mean values in the same column for each trait followed by the same a lower case italic letter are not significantly different according to Duncan's multiple range test at $P \leq 0.05$.

[†] **Factor of study:** A = Salinity effects, B = Humic substances effects, C= Moringa leaf extract effects.

HA = Humic Acid, FA = Falcic Acid, 1st = First cut, 2nd = Second cut and 3rd = Third cut

Table 5. Effect of humic substances and foliar spray of Moringa leaf extract on N, P and K-uptake by Sudan grass plants grown under salinity stress

Factor of study†			N-uptake(mg pot ⁻¹)			P-uptake (mg pot ⁻¹)			K-uptake (mg pot ⁻¹)		
			1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd
Effect of soil salinity (A)											
	S1,(3.01 dSm ⁻¹)		3200 <i>a</i>	2958 <i>a</i>	1942 <i>a</i>	302 <i>a</i>	281 <i>a</i>	184 <i>a</i>	1946 <i>a</i>	1818 <i>a</i>	1237 <i>a</i>
	S2,(6.12 dSm ⁻¹)		2689 <i>b</i>	2439 <i>b</i>	1399 <i>b</i>	204 <i>b</i>	187 <i>b</i>	122 <i>b</i>	1525 <i>b</i>	1399 <i>b</i>	957 <i>b</i>
	S3,(12.33 dSm ⁻¹)		1943 <i>c</i>	1761 <i>c</i>	543 <i>c</i>	156 <i>c</i>	140 <i>c</i>	62.20 <i>c</i>	1020 <i>c</i>	905 <i>c</i>	315 <i>c</i>
Effect of humic substance (B)											
	Untreated		2120 <i>d</i>	1899 <i>d</i>	893 <i>d</i>	154 <i>d</i>	135 <i>d</i>	63.88 <i>d</i>	1162 <i>d</i>	1048 <i>d</i>	521 <i>d</i>
	HA		2398 <i>c</i>	2195 <i>c</i>	1266 <i>c</i>	192 <i>c</i>	176 <i>c</i>	127 <i>c</i>	1354 <i>c</i>	1253 <i>c</i>	763 <i>c</i>
	FA		2748 <i>b</i>	2525 <i>b</i>	1377 <i>b</i>	235 <i>b</i>	217 <i>b</i>	129 <i>b</i>	1537 <i>b</i>	1428 <i>b</i>	907 <i>b</i>
	HA + FA		3177 <i>a</i>	2925 <i>a</i>	1643 <i>a</i>	303 <i>a</i>	283 <i>a</i>	172 <i>a</i>	1935 <i>a</i>	1767 <i>a</i>	1156 <i>a</i>
Effect of moringa leaf extract (C)											
	Without		2500 <i>b</i>	2293 <i>b</i>	1229 <i>b</i>	207 <i>b</i>	189 <i>b</i>	118 <i>b</i>	1417 <i>b</i>	1300 <i>b</i>	778 <i>b</i>
	With		2721 <i>a</i>	2480 <i>a</i>	1360 <i>a</i>	235 <i>a</i>	216 <i>a</i>	128 <i>a</i>	1576 <i>a</i>	1449 <i>a</i>	896 <i>a</i>
Effect the interaction (A*B*C)											
S1,(3.01 dSm ⁻¹)	Untreat	Without	2517 <i>i</i>	2221 <i>jk</i>	1549 <i>h</i>	198 <i>i</i>	168 <i>i</i>	103 <i>efgh</i>	1518 <i>g</i>	1369 <i>j</i>	672 <i>hij</i>
	d	With	2791 <i>g</i>	2490 <i>gh</i>	1708 <i>g</i>	235 <i>g</i>	213 <i>g</i>	131 <i>cdefg</i>	1675 <i>f</i>	1545 <i>hi</i>	1040 <i>ef</i>
		Without	2816 <i>g</i>	2621 <i>fg</i>	1830 <i>f</i>	245 <i>f</i>	229 <i>f</i>	156 <i>bcdef</i>	1686 <i>f</i>	1611 <i>gh</i>	1172 <i>de</i>
	HA	With	3139 <i>ef</i>	2816 <i>ef</i>	1943 <i>d</i>	271 <i>e</i>	252 <i>e</i>	185 <i>bcd</i>	1814 <i>e</i>	1708 <i>ef</i>	1029 <i>ef</i>
		Without	3181 <i>e</i>	2961 <i>de</i>	1892 <i>e</i>	290 <i>d</i>	274 <i>d</i>	187 <i>bcd</i>	1822 <i>e</i>	1743 <i>e</i>	1269 <i>cd</i>
	FA	With	3485 <i>c</i>	3283 <i>c</i>	2024 <i>c</i>	351 <i>c</i>	329 <i>c</i>	202 <i>abc</i>	2070 <i>c</i>	1957 <i>c</i>	1386 <i>bc</i>
S2,(6.12 dSm ⁻¹)	HA +	Without	3668 <i>b</i>	3501 <i>b</i>	2142 <i>b</i>	394 <i>b</i>	372 <i>b</i>	233 <i>ab</i>	2342 <i>b</i>	2177 <i>b</i>	1543 <i>b</i>
	FA	With	3864 <i>a</i>	3775 <i>a</i>	2449 <i>a</i>	416 <i>a</i>	409 <i>a</i>	275 <i>a</i>	2554 <i>a</i>	2434 <i>a</i>	1791 <i>a</i>
	Untreat	Without	2005 <i>m</i>	1780 <i>no</i>	997 <i>m</i>	138 <i>no</i>	119 <i>k</i>	63.2 <i>ghi</i>	1092 <i>jk</i>	972 <i>m</i>	617 <i>ijk</i>
	d	With	2184 <i>k</i>	1992 <i>m</i>	1104 <i>l</i>	153 <i>m</i>	138 <i>j</i>	86.4 <i>efgh</i>	1277 <i>i</i>	1150 <i>l</i>	799 <i>ghi</i>
		Without	2340 <i>j</i>	2181 <i>jkl</i>	1205 <i>k</i>	170 <i>k</i>	157 <i>i</i>	96.2 <i>efgh</i>	1395 <i>h</i>	1269 <i>k</i>	850 <i>fgh</i>
	HA	With	2546 <i>i</i>	2372 <i>hij</i>	1323 <i>j</i>	186 <i>j</i>	169 <i>i</i>	115 <i>defgh</i>	1515 <i>g</i>	1391 <i>j</i>	966 <i>efg</i>
S3,(12.33 dSm ⁻¹)	FA	Without	2638 <i>h</i>	2474 <i>ghi</i>	1392 <i>i</i>	199 <i>hi</i>	187 <i>h</i>	124 <i>cdefgh</i>	1531 <i>g</i>	1436 <i>j</i>	951 <i>efg</i>
		With	3084 <i>f</i>	2762 <i>ef</i>	1560 <i>h</i>	227 <i>g</i>	206 <i>g</i>	140 <i>cdefg</i>	1645 <i>f</i>	1522 <i>i</i>	1045 <i>ef</i>
	HA +	Without	3251 <i>d</i>	2903 <i>de</i>	1692 <i>g</i>	265 <i>e</i>	247 <i>e</i>	165 <i>bcde</i>	1778 <i>e</i>	1665 <i>fg</i>	1135 <i>de</i>
	FA	With	3429 <i>c</i>	3055 <i>d</i>	1922 <i>e</i>	294 <i>d</i>	272 <i>d</i>	186 <i>bcd</i>	1952 <i>d</i>	1789 <i>d</i>	1295 <i>cd</i>
	Untreat	Without	1579 <i>p</i>	1401 <i>q</i>	0.00 <i>s</i>	90.01 <i>q</i>	76.2 <i>m</i>	0.00 <i>i</i>	679 <i>n</i>	596 <i>q</i>	000 <i>r</i>
	d	With	1620 <i>op</i>	1512 <i>pq</i>	0.00 <i>s</i>	103 <i>p</i>	98.3 <i>l</i>	0.00 <i>i</i>	707 <i>mn</i>	662 <i>pq</i>	000 <i>r</i>
S3,(12.33 dSm ⁻¹)	HA	Without	1709 <i>o</i>	1527 <i>pq</i>	612 <i>r</i>	147 <i>mn</i>	134 <i>j</i>	49.90 <i>hi</i>	800 <i>m</i>	712 <i>p</i>	256 <i>m</i>
		With	1802 <i>n</i>	1659 <i>op</i>	684 <i>pq</i>	130 <i>o</i>	115 <i>k</i>	56.20 <i>i</i>	921 <i>l</i>	825 <i>o</i>	311 <i>m</i>
	FA	Without	1954 <i>m</i>	1751 <i>no</i>	667 <i>q</i>	161 <i>kl</i>	140 <i>j</i>	55.9 <i>hi</i>	1019 <i>k</i>	895 <i>n</i>	344 <i>lm</i>
		With	2110 <i>l</i>	1920 <i>mn</i>	726 <i>p</i>	184 <i>j</i>	165 <i>i</i>	65.58 <i>ghi</i>	1122 <i>j</i>	1014 <i>m</i>	448 <i>klm</i>
	HA +	Without	2212 <i>k</i>	2044 <i>klm</i>	776 <i>o</i>	203 <i>h</i>	187 <i>h</i>	76.09 <i>fghi</i>	1265 <i>hi</i>	1148 <i>l</i>	527 <i>jkl</i>
	FA	With	2477 <i>i</i>	2278 <i>ij</i>	883 <i>n</i>	232 <i>g</i>	209 <i>g</i>	93.50 <i>efgh</i>	1556 <i>g</i>	1385 <i>j</i>	642 <i>hijk</i>
Effect of the interaction (B*C)											
	Untreated	Without	2034 <i>h</i>	1800 <i>f</i>	849 <i>g</i>	142 <i>h</i>	121 <i>h</i>	55.26 <i>c</i>	1096 <i>h</i>	979 <i>h</i>	430 <i>f</i>
		With	2199 <i>g</i>	1998 <i>e</i>	937 <i>f</i>	164 <i>g</i>	150 <i>g</i>	72.52 <i>c</i>	1220 <i>g</i>	1119 <i>g</i>	613 <i>e</i>
	HA	Without	2288 <i>f</i>	2110 <i>e</i>	1216 <i>e</i>	181 <i>f</i>	167 <i>f</i>	136 <i>b</i>	1294 <i>f</i>	1198 <i>f</i>	759 <i>d</i>
		With	2496 <i>e</i>	2282 <i>d</i>	1316 <i>d</i>	202 <i>e</i>	185 <i>e</i>	117 <i>b</i>	1417 <i>e</i>	1308 <i>e</i>	768 <i>d</i>
	FA	Without	2591 <i>d</i>	2395 <i>d</i>	1317 <i>d</i>	216 <i>d</i>	200 <i>d</i>	122 <i>b</i>	1457 <i>d</i>	1358 <i>d</i>	855 <i>cd</i>
		With	2893 <i>c</i>	2655 <i>c</i>	1437 <i>c</i>	254 <i>c</i>	233 <i>c</i>	135 <i>b</i>	1612 <i>c</i>	1498 <i>c</i>	960 <i>bc</i>
	HA + FA	Without	3043 <i>b</i>	2867 <i>b</i>	1536 <i>b</i>	287 <i>b</i>	268 <i>b</i>	158 <i>ab</i>	1795 <i>b</i>	1664 <i>b</i>	1068 <i>b</i>
		With	3257 <i>a</i>	2985 <i>a</i>	1751 <i>a</i>	314 <i>a</i>	297 <i>a</i>	185 <i>a</i>	2021 <i>a</i>	1869 <i>a</i>	1243 <i>a</i>

Note: Mean values in the same column for each trait followed by the same a lower case italic letter are not significantly different according to Duncan's multiple range test at $P \leq 0.05$.

† **Factor of study:** A = Salinity effects, B = Humic substances effects, C= Moringa leaf extract effects. HA = Humic Acid, FA = Folic Acid, 1st = First cut, 2nd = Second cut and 3rd = Third cut

Figure 1. Effect of humic substances and foliar spray of Moringa leaf extract on a) soil pH and b) available nitrogen under salinity stress. Error bars represent standard deviation.

Figure 2. Effect of humic substances and foliar spray of Moringa leaf extract on a) available phosphorus and b) potassium under salinity stress. Error bars represent standard deviation.

Figure 3. Relationship between K and Na concentration at different cuts as affected by soil salinity and humic substances and Moringa leaf extract.