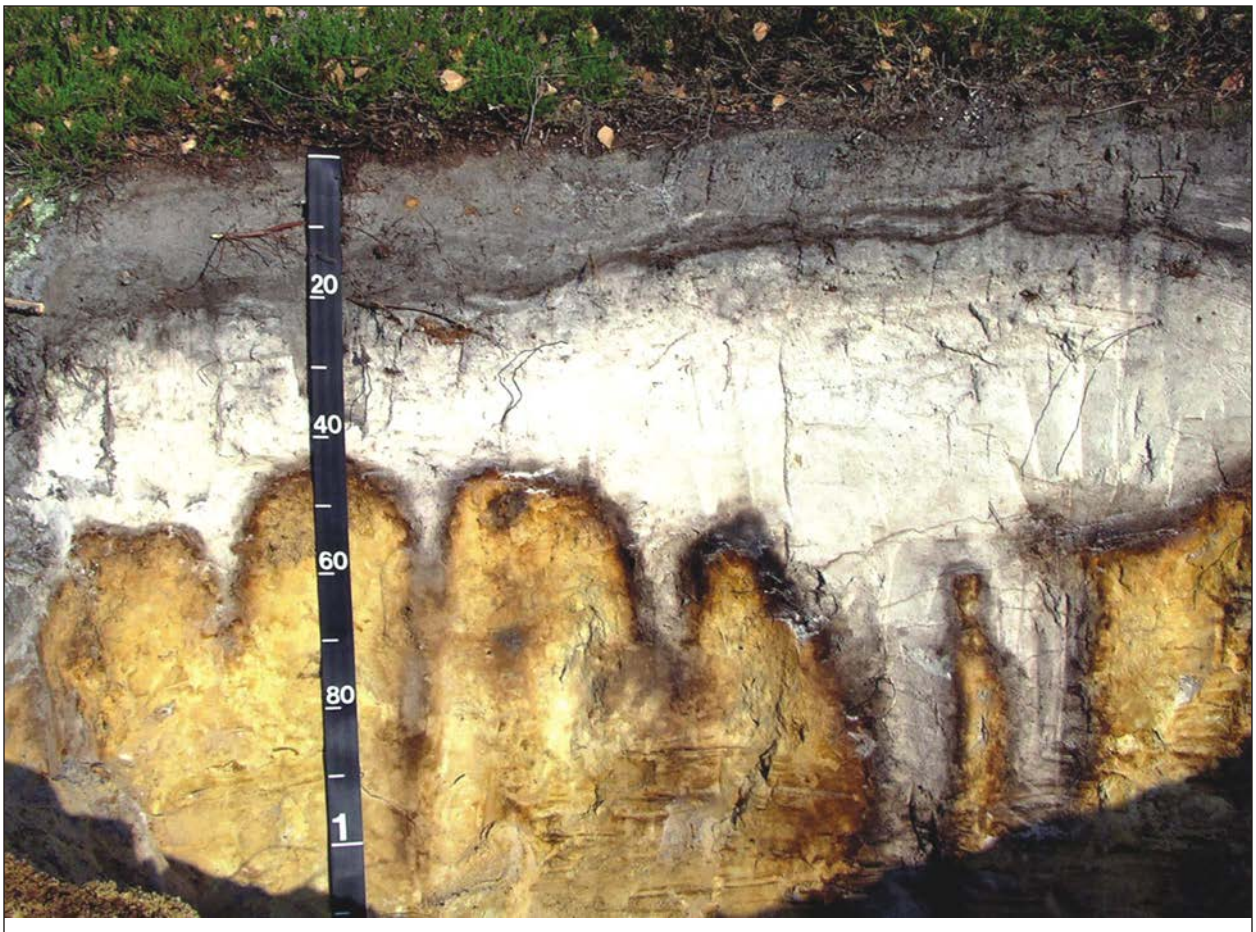

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Effect of Some Soil Amendments and Foliar Spray of Salicylic and Ascorbic Acids on Sorghum Under Saline Calcareous Soil Conditions

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ABSTRACT

A field experiment was conducted on a saline calcareous soil at El-Noubaria, near Alexandria, Egypt during the growth season of 2014 to study assess response to organic manure (chicken manure "ChM" and humic acid "HA") and foliar sprays with salicylic acid "SA" and ascorbic acid "AA" on sorghum (*Sorghum vulgare* var.) sudanense regarding yield and other attributes. Treatments inducted 12 combinations of 4 organic applications (none, ChM, HA and ChM+HA) and three sprays (none, SA and AA). Main effects of organic amendment show the following order: ChM+HA>ChM>HA>Non-amended. Main effects of sprays show AA>SA>none sprayed. Regarding combination between soil amendments and antioxidants effects, data reveal the superiority of ChM+HA+AA over other all treatments.

Key words: Chicken manure, humic acid, salicylic acid, ascorbic acid, antioxidant, calcareous saline soil

INTRODUCTION

Calcareous soils have $CaCO_3$ in amount and forms that cause adverse effects to plant growth. Forms are including powders, nodules and crusts. According to FAO (1973), Tanganelli (2011), Leytem and Mikkelson (2005), calcareous soils are relatively widespread dry regions, their potential productivity is high where adequate water and nutrients can be supplied. High calcium saturation tends to keep them in well-aggregated form and favorable physical conditions. However, these soils may contain impermeable hard pans (petricalcic horizon which decreases the rhizosphere root zone of the soil. Breaking much pans by deep ploughing followed by establishment of an efficient drainage system id usually done to reclaim such soils. Furrow irrigation is usually preferred to basin irrigation for calcareous soils. On undulating lands, contour and sprinkler or drip irrigations are generally practiced. Calcareous soils generally have low organic matter content and lack nitrogen. Before planting up to application of nitrogen is done in split. Ammonium forms as well as urea should not be left on the surface of calcareous soils, since losses of ammonia through volatilization may occur, these such forms should be incorporated into the soil.

Humic acids are complex organic molecules that are formed by breakdown of organic matter. They improve soil fertility through contributions to soil stability and nutrient uptake. Humic acids are heterogeneous, ranging in colour from yellow to black, resistant to decay and may be used as a commercial products containing 44-58% C, 42-46% O, 6-8% H and 0.5-4% N as well as many other elements (Larcher, 2003). Humic substances are may be used to alleviate the negative effects

of chemical fertilizers on plant growth (Ghabbour and Davies, 2001). Chemical fertilizers are expensive and harmful effects on the environment (Adediran *et al*., 2005), therefore addition of organic matter are recommended (Oad *et al*., 2004) which ensures high crop production, continuous, increase roots development and soil microorganisms activity (El-Magd *et al*., 2006; Ayoola and Makinde, 2009). Spraying with humic acids increase plant growth, dry matter and yield (Akinci *et al*., 2009; El-Ghozoli, 2003; El-Bassiony *et al*., 2010).

Salicylic acid acts as a potential non-enzymatic antioxidant as well as a plant growth regulator some physiological processes including photosynthesis. El-Shraiy Adwi (2004) reported that acetyl salicylic acid promoted potato plant growth, plant height and the number of leaves. Hegazi and El-Shraiy (2007) found that foliar application of salicylic acid had a positive effect on yield and vegetative parameters (plant height, leaves number, shoots and roots fresh and dry weight) of bean. El-Hak *et al*. (2012) sprayed salicylic acid (200 mg L^{-1}) and humic acid at the rate of 1000 mg L^{-1} on cow peas with positive response.

Ascorbic acid regulates plant growth and owing to its effects on cell division and differentiation. Ahmed (1996) on lettuce, Tarraf *et al*. (1999) on lemongrass, found that foliar application of ascorbic acid positive effects on growth and that its plays a role in floral induction that it while Golan-Goldhirsh *et al*. (1995) indicated that foliar spray of soybean with ascorbic acid enhanced photosynthesis. Biacs *et al*. (1988) on tomato stated that sugar content increased by foliar spray of ascorbic acid.

The aim of the present study was to study the effect of humic acid and chicken manure applied through the soil and salicylic and ascorbic acids applied as foliar spray on photosynthetic pigments, nutrients uptake and other parameters on sorghum grown on calcareous saline soil.

MATERIALS AND METHODS

A field experiment was conducted on a saline calcareous soil at El-Noubaria, near Alexandria, Egypt during the growth season of 2014 to study assess response to organic manure (Chicken manure "ChM" and humic acid "HA") and foliar sprays with salicylic acid "SA" and ascorbic acids "AA" on some *Sorghum vulgare* var. sudanense regarding yield and other attributes. Table 1 shows some physical and chemical characteristics of the investigated soils. Soil was analyzed according to the methods described by USDA (1954).

Soil preparation for cultivation: The experimental site was ploughed and then followed by ridging up to 0.7 m between ridges which were oriented in a north-south direction. Individual plot size was 17 m^2 consisting of 6 ridges of 4 m in length.

Fertilization: All plots were supplied with N, P and K. 677 kg ha^{-1} Nitrogen fertilizer was added in 3 equal splits (at germination, after 1st cut and 2nd cut) as ammonium sulfate (210 g N kg^{-1}) at 476 kg N ha^{-1}. The P and K fertilizers were added to the soil as ordinary super phosphate (65.5 g P kg^{-1}) at 31 kg P ha^{-1} and potassium sulphate (410 g K kg^{-1}) at 100 kg K ha^{-1} along with manures during soil preparation for cultivation.

Treatments and design: Humic Acid (HA) and chicken manure (ChM) were applied through the soil while Salicylic Acid (SA) and Ascorbic Acid (AA) were applied as foliar sprays. The experiment includes 12 representing the different combinations of four organic application (none, ChM, HA and ChM+HA) and 3 sprays (none, SA and AA). The design was a factorial randomized complete

Table 1: Properties of studied soil and chicken manure (ChM)

Property	Soil	ChM
Texture class	Sandy loam	-
Organic matter (g kg^{-1})	7.1	24.32
$CaCO_3$ (g kg^{-1})	196.0	-
Soluble ions, EC and pH		
EC (mS cm^{-1}) (Paste extract)	7.43	2.11
pH (suspension 1:2.5)	8.15	7.68
Soluble ions ($mmol_c$ L^{-1})		
Na^+	39.8	-
K^+	5.70	-
Ca^{++}	14.8	-
Mg^{++}	12.3	-
Cl^-	46.4	-
HCO_3^-	11.8	-
SO_4^{-2}	14.4	-
SAR	10.82	-
Available and total NPK (mg kg^{-1})		
Available nitrogen (N)	95.4	-
Total nitrogen (N)	-	3.75
Available phosphors (P)	6.20	-
Total phosphors (P)	-	6.44
Available potassium (K)	246.0	-
Total potassium (K)	-	0.52
C/N ratio	-	3.72

-: Mark refer to undetermined

block with three replicates. Application of organic manures was 35.8 mg ha^{-1} for ChM and 7 kg ha^{-1} for HA. Characteristics of ChM shown in Table 1. Each of antioxidants of SA and AA sprayed by solutions of 2000 mg L^{-1} (1200 L ha^{-1}) in each of 2 occasions (20 and 40 days) at germination, after 1st and 2nd cut.

Character studies: Three cuts were taken from the sorghum. Each cut was taken after 60 day. The following parameters were measured: Plant height, fresh weight, dry matter, nutrient uptake and photosynthetic pigments (chlorophyll a and b, carotenoids) of sorghum were conducted. Plant samples taken at three different cuts and dried at 70°C until constant weight and wet digested using a mixture of $HClO_4$ and H_2SO_4 for determining nutrients (Piper, 1950).

RESULTS AND DISCUSSION

Fresh weight, dry weight and plant height: Data in Table 2 show that application of organic manures or foliar sprays with SA or AA increased of fresh weight as well as dry weight and plant height of sorghum in the three cuts. ChM+HA treatment was superior to other addition treatments. Treatments could be arranged in the following order regarding the main effects ChM+HA>ChM>HA. Superiority of ChM+HA and HA was 22.86, 13.48 and 6.53% for fresh weight and dry weight and 19.85, 14.71 and 8.10% for plant height. The main effect regarding response to foliar spray was 6.5 and 37.0% for SA and AA, respectively for dry weight. Response to fresh weight and plant height followed a similar pattern as that of the dry weight. Superiority of ChM+HA combined with AA over other all treatments occurred with all parameters.

Table 2: Effect of soil amendments and antioxidant on fresh weight, dry weight and plant height

	Fresh weight (Mg ha^{-1})				Dry weight (Mg ha^{-1})				Plant height (cm)			
A×B effects	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
Untreated soil												
Water	79.67	84.91	69.67	78.08	13.28	14.15	11.61	13.01	127	131	128	129
SA	90.19	94.05	74.10	86.11	15.03	15.67	12.35	14.35	138	141	133	137
AA	94.43	452.01	85.00	210.48	15.74	75.33	14.17	35.08	147	148	134	143
Mean	88.10	210.32	76.26	124.89	14.68	35.05	12.71	20.81	137	140	132	136
Chicken manure												
Water	121.38	150.96	128.43	133.59	20.23	25.16	21.41	22.27	147	150	142	146
SA	130.19	156.19	137.34	141.24	21.70	26.03	22.89	23.54	164	165	148	159
AA	149.00	160.77	141.29	150.35	24.83	26.79	23.55	25.06	167	169	156	164
Mean	133.53	155.97	135.69	141.73	22.25	26.00	22.61	23.62	159	161	149	156
Humic acid												
Water	114.34	135.15	119.24	122.91	19.06	22.52	19.87	20.48	140	141	139	140
SA	134.86	139.24	129.34	134.48	22.48	23.21	21.56	22.42	148	150	146	148
AA	141.86	148.38	135.05	141.76	23.64	24.73	22.51	23.63	158	159	150	156
Mean	130.35	140.92	127.88	133.05	21.73	23.49	21.31	22.18	149	150	145	148
Chicken manure+Humic acid												
Water	156.48	152.72	132.29	147.16	26.08	25.45	22.05	24.53	158	161	146	155
SA	151.34	159.72	142.48	151.18	25.22	26.62	23.75	25.20	164	170	152	162
AA	166.53	171.00	148.43	161.99	27.75	28.50	24.74	27.00	173	178	162	171
Mean	158.11	161.15	141.07	153.44	26.35	26.86	23.51	25.57	165	170	154	163
B effects												
Water	117.97	130.93	112.41	120.44	19.66	21.82	18.73	20.07	143	146	139	143
SA	126.65	137.30	120.81	128.25	21.11	22.88	20.14	21.38	154	156	145	152
AA	137.96	233.04	127.44	166.15	22.99	38.84	21.24	27.69	161	164	151	159
Grand mean	127.52	167.09	120.22	138.28	21.25	27.85	20.04	23.05	153	155	145	151
$LSD_{0.05}$												
A	6.11	ns	2.58		1.02	ns	0.43		2.50	1.79	2.09	
B	5.29	ns	2.24		0.88	ns	0.37		2.17	1.55	1.81	
AB	10.58	ns	ns		1.76	ns	ns		4.34	ns	3.61	

SA: Salicylic acid, AA: Ascorbic acid, A: Amendment effects, B: Antioxidant effects, 1st: First cut, 2nd: Second cut and 3rd: Third cut

Photosynthetic pigments of sorghum (Chlorophyll a, Chlorophyll b and Carotenoids): Data in Table 3 show effect of soil amendments, ChM and HA with or without antioxidants, SA and AA on photosynthetic pigments of sorghum. Data indicated that the photosynthetic pigments followed a rather similar pattern as that of the growth parameters. All soil amendments increased Chlorophyll a, Chlorophyll b and Carotenoids of sorghum compared with untreated one. Treatments could be arranged as following order ChM+HA>ChM>HA. Spray with AA was superior to that of SA. The treatment which gave the highest response was that of ChM+HA combined with a foliar spray with AA.

NPK uptake by sorghum plant: Data in Table 4 show effect of ChM and HA combined with or without SA and AA on NPK uptake by sorghum. All treatments receiving any or more combinations of the added material showed higher uptake of N, P and K. effect of ChM showed average uptake greater than HA. The mixture of ChM+HA gave higher uptake than each individually. The main effect of treatments of ChM and HA show the following order: ChM+HA>ChM>HA. Respective increases were as follows: 54.3, 36.6 and 15.9% for N uptake;

Table 3: Effect of soil amendments and antioxidant on some photosynthetic pigments of sorghum

	Chlorophyll a (mg/g fresh weight)				Chlorophyll b (mg/g fresh weight)				Carotenoids (mg/g fresh weight)			
A×B effects	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
Untreated soil												
Water	1.18	1.21	1.08	1.16	0.33	0.34	0.33	0.33	0.32	0.30	0.28	0.30
SA	1.28	1.30	1.23	1.27	0.38	0.40	0.39	0.39	0.37	0.38	0.32	0.36
AA	1.38	1.40	1.34	1.37	0.43	0.45	0.45	0.44	0.44	0.46	0.45	0.45
Mean	1.28	1.30	1.22	1.27	0.38	0.40	0.39	0.39	0.38	0.38	0.35	0.37
Chicken manure												
Water	1.49	1.51	1.43	1.48	0.50	0.52	0.50	0.51	0.49	0.49	0.48	0.49
SA	1.58	1.60	1.49	1.56	0.57	0.58	0.57	0.57	0.52	0.53	0.53	0.53
AA	1.65	1.67	1.62	1.65	0.60	0.63	0.63	0.62	0.56	0.56	0.57	0.56
Mean	1.57	1.59	1.51	1.56	0.56	0.58	0.57	0.57	0.52	0.53	0.53	0.53
Humic acid												
Water	1.41	1.43	1.40	1.41	0.46	0.47	0.47	0.47	0.45	0.45	0.44	0.45
SA	1.58	1.60	1.54	1.57	0.58	0.58	0.57	0.58	0.49	0.50	0.49	0.49
AA	1.61	1.66	1.60	1.62	0.56	0.62	0.60	0.59	0.54	0.55	0.55	0.55
Mean	1.53	1.56	1.51	1.53	0.53	0.55	0.55	0.54	0.49	0.50	0.49	0.49
Chicken manure+Humic acid												
Water	1.56	1.61	1.59	1.59	0.59	0.57	0.56	0.57	0.54	0.54	0.55	0.54
SA	1.69	1.72	1.62	1.68	20.41	21.10	0.63	14.05	0.59	0.60	0.60	0.60
AA	1.78	1.82	1.71	1.77	0.68	0.70	0.68	0.69	0.64	0.65	0.65	0.65
Mean	1.68	1.72	1.64	1.68	7.23	7.45	0.62	5.10	0.59	0.60	0.60	0.60
B effects												
Water	1.41	1.44	1.38	1.41	0.47	0.48	0.47	0.47	0.45	0.45	0.44	0.45
SA	1.53	1.55	1.47	1.52	5.49	5.66	0.54	3.90	0.49	0.50	0.48	0.49
AA	1.60	1.64	1.57	1.60	0.57	0.60	0.59	0.59	0.55	0.56	0.56	0.56
Grand mean	1.52	1.54	1.47	1.51	2.17	2.25	0.53	1.65	0.50	0.50	0.49	0.50
$LSD_{0.05}$												
A	0.03	0.02	0.02		ns	ns	ns		0.02	0.02	0.02	
B	0.03	0.02	0.02		ns	ns	ns		0.01	0.02	0.02	
AB	Ns	ns	0.04		ns	ns	ns		ns	ns	0.03	

SA: Salicylic acid, AA: Ascorbic acid, A: Amendment effects, B: Antioxidant effects, 1st: First cut, 2nd: Second cut, 3rd: Third cut

65.4, 36.0 and 13.4% for P uptake and 65.7, 52.9 and 24.3% for K uptake. The main effect of foliar spray was AA>AS>non-sprayed. Increases due to AA and SA averaged 66.2 and 20.1%, respectively for N uptake. Relative increases for P uptake were 59.2 and 11.1%; increases for K uptake were 83.6 and 27.5%. Highest uptake obtained by the treatment of ChM+HA combined with AA spray.

Previous results can be explained as follows: Chicken manure treatments gave the highest response and increasing the yield of fresh and dry matter compared to the control. These responses may refer to its high content of nitrogen, phosphorus and potassium (Schlegel, 1992). Another explanation may be due to the effect of chicken manure on soil fertility. This is in agreement with that of Mullins *et al.* (2002) who reported that potential uses for poultry manure as a fertilizer and soil amendment. On the other hand, Mullins *et al.* (2002) reported that poultry litter contains, a considerable amount of organic matter, hence have an impact on soil pH and liming due to varying amount of calcium carbonate in poultry feed. Ahmed and Mahmoud (2010) found that organic matter decomposition improved the physical and chemical proprieties of the soil. Regarding humic acid, humic acid and humic substances increase cation exchange capacity and enhances soil

Table 4: Effect of soil amendments and antioxidant on nitrogen, phosphor and potassium uptake by sorghum

	N-uptake (kg ha^{-1})				P-uptake (kg ha^{-1})				K-uptake (kg ha^{-1})			
A×B effects	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
Untreated soil												
Water	296.06	307.27	181.95	261.76	25.09	25.62	68.79	39.83	260.45	250.60	178.15	229.73
SA	390.68	412.67	230.06	344.47	35.58	34.59	22.26	30.81	339.94	407.64	217.67	321.75
AA	440.64	2180.08	325.09	981.94	210.85	41.97	30.15	94.32	393.68	2259.20	296.66	983.18
Mean	375.80	966.67	245.70	529.39	90.51	34.06	40.40	54.99	331.36	972.48	230.83	511.56
Chicken manure												
Water	606.14	746.26	513.36	621.92	75.48	65.37	51.34	64.06	640.81	855.45	535.19	677.15
SA	708.90	858.91	602.79	723.53	87.63	73.07	61.03	73.91	737.71	954.22	617.79	769.91
AA	857.59	928.91	690.74	825.75	109.82	91.88	57.35	86.35	894.12	1107.48	698.66	900.09
Mean	724.21	844.69	602.30	723.73	90.98	76.77	56.57	74.77	757.55	972.38	617.21	782.38
Humic acid												
Water	527.29	615.64	390.83	511.25	60.74	47.48	36.37	48.20	552.93	607.42	377.16	512.50
SA	697.39	688.56	488.18	624.71	71.95	70.38	44.56	62.30	719.28	719.25	488.18	642.24
AA	764.35	765.99	585.45	705.26	88.95	84.33	56.26	76.51	796.35	856.86	607.27	753.49
mean	663.01	690.06	488.15	613.74	73.88	67.40	45.73	62.34	689.52	727.85	490.87	636.08
Chicken manure+Humic acid												
Water	816.04	755.23	500.04	690.44	89.08	97.16	44.84	77.03	578.87	789.20	455.72	607.93
SA	877.68	886.95	672.70	812.44	102.05	101.73	60.94	88.24	899.78	1064.55	585.70	850.01
AA	1026.69	1054.65	766.85	949.40	124.46	126.57	71.77	107.60	1165.88	1282.94	808.76	1085.86
Mean	906.80	898.94	646.53	817.42	105.20	108.49	59.18	90.96	881.51	1045.56	616.73	847.93
B effects												
Water	561.38	606.10	396.54	521.34	62.60	58.91	50.33	57.28	508.27	625.67	386.55	506.83
SA	668.66	711.77	498.43	626.29	74.30	69.94	47.20	63.81	674.17	786.42	477.34	645.98
AA	772.32	1232.41	592.03	865.59	133.52	86.19	53.88	91.20	812.51	1376.62	602.84	930.66
Grand mean	667.45	850.09	495.67	671.07	671.07	71.68	50.47	1.65	664.98	929.57	488.91	694.49
$LSD_{0.05}$												
A	31.46	ns	27.49		4.82	ns	ns		130.54	ns	24.82	
B	27.25	ns	23.81		4.17	ns	ns		113.05	ns	21.49	
AB	54.49	ns	47.62		8.34	ns	ns		ns	ns	42.98	

SA: Salicylic Acid, AA: Ascorbic Acid, A: Amendment effects, B: Antioxidant effects, 1st: First cut, 2nd: Second cut and 3rd: Third cut

fertility, converting the mineral elements into forms available to plants (Yilmaz, 2007; Tipping, 2002; Kulikova *et al*., 2005; Stevenson, 1994). Humic acids show a sponge-like tampon character affecting pH levels in soil causing many micronutrients become available to plant (Yilmaz, 2007). They can break the bonds between phosphate and iron ions in acid soils and in calcium and iron ions in alkaline soils (Stevenson, 1994).

Amutha *et al*. (2007) reported that foliar spray of salicylic acid at 0.1% on sunflower increased yield of seeds on head diameter and work by Shehata *et al*. (2001), El-Wahed *et al*. (2006), Shakirova *et al*. (2003) and Iqbal and Ashraf (2006) indicated positive effects by salicylic acid foliar spray on maize and wheat. Salicylic acid plays a role in plant defense mechanisms to pathogen attack by inhibition of catalase, resulting in elevated levels of H_2O_2, thus activating defense related genes and ascorbate peroxidase enzyme for scavenging H_2O_2 (Durner and Klessig, 1995). Singh *et al*. (2006) on cassia august (Talaat, 2003) on sweet pepper reported that foliar spray with ascorbic acid increased NPK uptake. Other investigators recorded similar effects of vitamin C on potato (El-Banna *et al*., 2006), pepper (Shehata *et al*., 2002) and on pea plants (Helal *et al*., 2005).

CONCLUSION

A field experiment was conducted on a saline calcareous soil to study assess response to organic manure (chicken manure "ChM" and humic acid "HA") and foliar sprays with salicylic acid "SA" and ascorbic acids "AA" on pant growth, photosynthetic pigments and NPK uptake of *Sorghum vulgare* var. sudanense. Efficiency of amendment showed the following average response ChM+HA>ChM>HA. The average efficiency regarding foliar spray was AA>SA. Highest treatment combination was ChM+HA combined with AA.

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