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Influence of Crop Residue Management on Soil Physico-Chemical Properties and Available Nutrient Status of Maize Grown Saline Soils

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ABSTRACT

A green house experiment was conducted at Agricultural College, Bapatla during *kharif*, 2017 to study the effect of supplementation of 25 percent extra nitrogen through maize stover or its compost along with foliar spray of humic acid / proline / KNO_3 on properties of a maize grown saline soil. The experiment was conducted in CRD with thirteen treatments and three replications. The results revealed that soil pH and electrical conductivity were not influenced significantly by the imposed treatments at any stage of the crop growth. Integrated treatments recorded higher organic carbon content than only inorganics with the highest at all stages observed in the treatment supplied with maize stover. Addition of 25 per cent extra nitrogen either as maize stover or compost exhibited a significant influence on available nitrgen, phosphorus, potassium and sulphur at different stages of crop growth (knee high, tasseling and harvest) with the highest content observed in treatments supplied with compost. Foliar spray of humic acid / proline / KNO_3 did not show significant effect on soil properties at any stage of crop growth.

Key words: *Available nitrogen, KNO_3 foliar spray, Maize compost, Proline*

Soil salinization is one of the major causes of declining agricultural productivity in numerous arid and semiarid regions throughout the world (Qadir *et al*., 2000). The sustainability of crop production is primarily a function of various environmental stress factors, among them salinity associated problems are of major significance. Organic carbon content and nutrient availability have emerged as the most serious factors limiting plant growth and productivity in saline soils.. Organic amendments in association with micro flora enhance net mineralization, with a concomitant increase in CO_2 release and, consequently, soil aeration (Muhammad *et al*. 2007), presumably due to stimulation of enzymatic activities. Such an increase in mineralization helps to improve soil fertility and crop productivity in saline soils. Besides, application of foliar nutrients (humic acid) and osmoprotectants (KNO_3 and proline) can improve the performance of plants enabling them to survive under osmotic stress through osmoregulation, ion homeostasis, antioxidant and hormonal system (Mahajan and Tuteja, 2005).

MATERIAL AND METHODS

The experiment was conducted at Agricultural College, Bapatla using homogenous soil having an ECe of 6.2 dS m^{-1} obtained by mixing the transported soils of ECe 5.7 to 7.5 dS m^{-1} collected from salt affected areas identified through pilot survey prior to the south west monsoon in the month of May. The soil was clayey in texture and slightly alkaline in reaction. Maize stover was chopped into pieces and subjected to decomposition by mixing decomposing organisms and compost was prepared. The experiment was conducted in CRD with 13 treatments viz. 100 % RDFN (Recommended dose of fertilizer nitrogen) (T_1); 25 % extra nitrogen through inorganic fertilizers (T_2); 25% extra N through raw residue (T_3); 25% extra N through compost (T_4); and T_5-T_{13} treatments containing combination of T_2, T_3 and T_4 treatments with exogenous foliar sprays of humic acid / proline/ KNO_3. Required quantities of maize stover and compost were added to the pots considering their nitrogen content at 30 days and seven days, respectively prior to sowing. The maize variety Pioneer 3099 was used as test crop. The soil samples collected at various stages were analysed for physico-chemical properties and nutrient status following standard procedures. Soil pH and soluble salt content(EC) in soil were measured in 1:2.5 soil: water suspension using pH meter and EC bridge, respectively (Jackson, 1973) while, organic carbon(OC) was estimated using Walkley and Black's modified method (1943). Available nitrogen phosphorus, potassium and sulphur were estimated following by methods suggested by Subbiah and Asija, 1956, Olsen *et al*., 1954, Jackson, 1973 and Hesse, 1971, respectively.

RESULTS AND DISCUSSION

Soil physico-chemical properties

Soil pH and electrical conductivity were not influenced significantly while organic carbon content was significantly influenced by the imposed treatments

Table 1. Effect of exogenous compounds and crop residues on soil pH and Electrical conductivity at different stages of crop growth in maize

Treatment	pH (1: 2.5 soil water suspension)			EC (dSm^{-1}) (1: 2.5 soil water extract)		
	Knee high	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1 : 100% RDFN	8.14	8.14	8.14	2.68	2.65	2.63
T_2 : 125% RDFN	8.13	8.13	8.13	2.67	2.64	2.61
T_3 : 100% RDFN+25% RDN as raw residue	8.10	8.06	8.08	2.62	2.59	2.59
T_4 : 100%RDFN+25% RDN as maize compost	8.11	8.09	8.10	2.64	2.56	2.55
T_5 : T_2 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	8.11	8.12	8.12	2.66	2.64	2.62
T_6 : T_2 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	8.13	8.11	8.12	2.67	2.65	2.62
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	8.12	8.13	8.11	2.66	2.64	2.6
T_8 : T_3 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	8.08	8.07	8.09	2.63	2.59	2.58
T_9 : T_3 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	8.07	8.06	8.08	2.6	2.59	2.56
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	8.07	8.07	8.08	2.61	2.57	2.57
T_{11} : T_4 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	8.09	8.07	8.1	2.64	2.54	2.54
T_{12} : T_4 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	8.08	8.08	8.11	2.62	2.55	2.53
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	8.10	8.07	8.11	2.64	2.56	2.54
SEm±	0.05	0.05	0.05	0.05	0.04	0.05
CD (p= 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	1.01	1.07	1.01	3.07	2.81	3.08

at all stages of crop growth (Tables 1 and 2). Integrated treatments recorded relatively lower pH and greater reduction was observed at tasseling in raw residue treatments while higher values were recorded in inorganic treatment. Application of raw residue and compost resulted in lower EC than other treatments, with the lowest value (2.53 dSm^{-1}) found in the compost treatment T_{12} (compost+ proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS while the highest EC of 2.63 dS m^{-1} was recorded in T_1 (100% RDFN) at harvest. Application of organic amendments might increase CO_2 partial pressure and lower the pH values (Li and Keren, 2009). Similar non significant effect on EC of soil with maize residue compost than soil with inorganic fertilizer was reported by Azza *et al*. (2007).

Significant effect of different combinations of organics as source of extra nitrogen on soil organic carbon content was found during the course of experimentation. Critical observations on carbon content at knee high, tasseling and harvest revealed that, carbon content at all stages was comparable among all organic treatments with relatively higher values in raw residue incorporated treatments (T_3, T_8, T_9 and T_{10}). The higher values in raw residue incorporated treatments as compared to compost may be due to the high C: N ratio of the former. Similar

Table 2. Effect of exogenous compounds and crop residues on soil organic carbon ontent of soil at different stages of crop growth in maize

Treatment	Organic carbon (g kg^{-1})		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	5.88	5.93	5.50
T_2 : 125 % RDFN	5.70	5.84	5.53
T_3 : 100% RDFN +25% RDN as raw maize residue	7.14	7.33	6.49
T_4 : 100% RDFN +25% RDN as maize compost	6.94	7.07	6.40
T_5 : T_2 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	5.64	5.81	5.68
T_6 : T_2 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	5.60	5.76	5.63
T_7 : T_2 + KNO_3 foilar spray @ 10 g L^{-1} at 20 and 40 DAS	5.60	5.71	5.68
T_8 : T_3 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	7.12	7.29	6.50
T_9 : T_3 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	7.09	7.35	6.49
T_{10} : T_3 + KNO_3 foilar spray @ 10 g L^{-1} at 20 and 40 DAS	6.96	7.21	6.45
T_{11} : T_4 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	6.88	7.00	6.37
T_{12} : T_4 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	6.90	7.02	6.35
T_{13} : T_4 + KNO_3 foilar spray @ 10 g L^{-1} at 20 and 40 DAS	6.85	7.05	6.33
SEm $\pm$	0.11	0.17	0.16
CD (p= 0.05)	0.34	0.51	0.48
CV (%)	3.03	4.37	4.44

increase in OC was observed by Surekha *et al*. (2004). Application of organic manure or straw can increase OC content, at the same time, the application of inorganic fertilizer also can slightly increase the content of SOC, particularly with the balanced NPK applications (Wei *et al*., 2015).

Nutrient status of soil

Available N and P (kg ha^{-1})

Perusal of the data reported in Table 3, showed that organic amendments treatments (T_3 and T_4) and its combination treatments (T_8 –T_{13}) had significant influence on available nitrogen and phosphorus contents at all stages with relatively higher content recorded in compost treatments and were significantly superior to inorganic treatments. At knee high stage, T_{11} (25% extra nitrogen through compost + humic acid foliar spray @ 0.2 % at 20 and 40 DAS) recorded the highest value (59.22 kg ha^{-1}) of available phosphorus followed by T_{13}, T_4 and T_{12}, which were comparable and significantly superior to all inorganic treatments. The highest available nitrogen was noticed in treatment T_{13} supplied with 25 % extra nitrogen through compost+KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS(258 kg ha^{-1}), which was on par with all treatments received compost (T_{12},T_4,T_{11}) and treatment supplied with raw residue + foliar spray of humic acid (0.2%), proline (50mM L^{-1}) and KNO_3 (10 g L^{-1}) (T_8,T_9,T_{10}) and significantly superior to remaining treatments.

At tasseling stage, the highest nitrogen content (286 kg ha^{-1}) was observed in the treatment T_{13} which was on par with other compost treatments (T_4, T_{11} and T_{12}). Similarily, higher values of P were recorded in compost treatments (T_4, T_{11}, T_{12}, T_{13}), at tasseling which were statistically superior to respective raw residue treatments (T_3, T_8, T_9, T_{10}) and lower values were recorded in all inorganic treatments. At harvest, all treatments supplied with compost were comparable with raw residue and significantly superior to the remaining inorganic treatments (T_1, T_2, T_5, T_6 and T_7). Statistically comparable values of available phosphorus were observed at harvest among the organic treatments. The highest phosphorus content (53.80 kg ha^{-1}) was sustained in compost supplied pots (T_4). Exogenous compounds alone did not show significant effect on available nitrogen and phosphorus at any stage.

The release rate of bioavailable form of N from organic amendments was about three times faster when compared to chemical fertilizers (Claassen and Carey, 2007). Increase in available P content in soil observed after retaining crop residue was ascribed to the role of organic ligands, which were released after

Table 3. Effects of exogenous compounds and crop residues on available nitrogen and phosphorus content of soil at different stages of crop growth in maize

Treatment	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})		
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	226	245	218	41.44	43.41	40.83
T_2 : 125% RDFN	238	258	230	42.68	44.91	41.23
T_3 : 100% RDFN+25% RDN as raw residue	245	265	236	51.68	56.42	52.76
T_4 : 100%RDFN+25% RDN as maize compost	257	283	243	57.28	64.12	53.8
T_5 : T_2 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	240	258	231	44.22	45.33	42.74
T_6 : T_2 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	238	260	230	42.38	47.64	41.63
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	238	258	232	43.96	46.64	41.22
T_8 : T_3 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	247	268	239	51.65	57.12	52.53
T_9 : T_3 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	248	267	237	51.99	56.83	52.17
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	247	267	238	49.76	55.69	51.55
T_{11} : T_4 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	255	283	246	59.22	64.52	53.53
T_{12} : T_4 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	255	282	245	55.57	63.01	53.49
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	258	286	244	57.90	64.68	53.12
SEm±	3.46	4.54	3.38	1.34	1.46	1.36
CD (p= 0.05)	11	14	10	4.06	4.44	4.14
CV (%)	2.44	2.94	2.46	4.64	4.64	4.86

degradation of crop residues (Yaduvanshi and Sharma, 2007). Higher activities of soil microbes in the presence of organics might be responsible for conversion of organically bound nutrients into their bioavailable form (Pathak and Rao., 1998).

Available K and S

The highest potassium (478, 486 and 449 kg ha-1) and sulphur content of (77.08 and 80.17 mg kg-1) at knee high, tasseling and harvest stages and except at harvest for S was observed in $T_{13,}$ which was supplied with extra 25 % nitrogen through compost + foliar spray of potassium nitrate 10 g L^{-1}at 20 and 40 DAS as shown in Table 4. At all three stages, compost treatments exhibited higher values, which were comparable with raw residue except, T_3 at knee high, T_3 and T_8 at tasseling and superior to inorganic treatments. At harvest irrespective of source of extra nitrogen potassium content was found to be non significant. Foliar sprays treatment did not show significant influence in any combination.

At knee high stage, higher and comparable sulphur content was recorded in treatments supplied with extra 25% nitrogen through organics except T_3, and were superior to no residue treatments ($T_{1,}$ T_2, T_5 to T_7). At tasseling the highest available sulphur content (80.17mg kg^{-1}) was recorded in T_{13} and it was on par with all organic treatments except T_3 (25% extra nitrogen through raw crop residue) and T_8 (25% extra nitrogen through raw residue + humic acid foliar spray@0.2% at 20 and 40 DAS). At harvest, all integrated treatments showed comparable values of

Table 4. Effect of exogenous compounds and crop residues on available potassium and sulphur content of soil at different stages of crop growth in maize

Treatment	Available potassium (kg ha^{-1})			Available sulphur (mg kg^{-1})		
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	448	453	436	63.08	60.88	55.17
T_2 : 125% RDFN	449	454	437	64.5	62.08	56.83
T_3 : 100% RDFN+25% RDN as raw residue	463	470	441	69.83	73.17	68.08
T_4 : 100%RDFN+25% RDN as maize compost	477	482	445	74.25	79.08	73.25
T_5 : T_2 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	451	458	439	64.53	63	59.42
T_6 : T_2 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	452	457	440	64.88	63.42	60.92
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	450	458	442	68.29	64.75	62.17
T_8 : T_3 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	467	473	443	72.83	73.29	67.75
T_9 : T_3 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	466	476	445	72.25	75.83	68.92
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	467	472	448	72.29	74.17	65.33
T_{11} : T_4 + humic acid foliar spray @ 0.2% at 20 and 40 DAS	475	483	446	74.42	78.67	72.75
T_{12} : T_4 + proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	477	485	448	74.33	79.92	72.08
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	478	486	449	77.08	80.17	72.33
SEm±	7.36	9.27	11.88	1.86	2.04	1.85
CD (p= 0.05)	22	28	NS	5.63	6.19	5.6
CV (%)	2.75	3.42	4.65	4.58	4.95	4.87

available sulphur content, except T_{10}, with the highest sulphur content (73.25 mg kg-[1]) recorded in treatment supplied with 25% extra nitrogen through compost (T_4).The lowest k content of 448, 453 and 436 kg ha^{-1} and S content of 63.08, 60.88 and 55.17 mg kg^{-1} was recorded in T_1 (100% RDFN).

Production of hydrogen ions during decomposition of organic materials would have helped the release of K from exchange sites or from the fixed pool (Sarwar *et al*., 2009). High potassium content in compost amended soil can be ascribed to their capacity to bind with clay minerals and organic matter (Abdelbasset *et al*., 2009). Rapid S mineralization after incorporation of plant residues is assumed to be partly due to solubilization of SO_4^{2-} in the residue (Janzen and Ellert, 1998). During decomposition of organic matter, organic sulphur compounds are transformed or oxidized to sulphates (Sekhon *et al.*, 2002).

CONCLUSION

The integrated use of crop residues and inorganic fertilizers did not influence soil pH and EC but, organic carbon and available nutrients status of soil significantly. Irrespective of source of extra nitrogen *(*inorganic / crop residues), application of exogenous foliar sprays did not show any significant

influence at any stage of crop growth though, comparatively higher nutrient content was recorded in combination treatments.

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