Effect of Fertilizers, Biochar and Humic acid on Seed Yield and Nutrient content of Maize (*Zea mays* L.) Grown on Alfisols of Telangana

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Abstract

A field study was carried out at college farm, College of Agriculture, Rajendranagar, Hyderabad, Andhra Pradesh during *Kharif* 2013 on an Alfisol to find out most efficient combination of biochar, humic acid and inorganic sources of nutrients to increase the productivity and nutrient content of maize. Soil had a pH of 7.72, EC of 0.217 dS m^{-1} with low organic carbon (0.49%) and available nitrogen (138.6 kg ha^{-1}), high available phosphorus (31.28 kg ha^{-1}) and potassium (629 kg ha^{-1}) and sufficient available sulphur (28 ppm). The experiment was laid out in a Randomized Block Design and replicated thrice with three factors comprised of factor-I (fertilizers- 100 % RDF and 75 % RDF), Factor-II (biochar levels- 0, 5 and 7.5 t ha^{-1}) and Factor-III (humic acid levels of 0 and 30 kg ha^{-1}). Recommended dose of NPK along with biochar at 7.5 t $ha^{-1}$and humic acid at 30 kg ha^{-1} was significant in increasing seed yield (60.71 q ha^{-1}). Though in the absence of biochar, 75% NPK put forth significantly lower yield (41.22 q ha^{-1}) than 100% NPK (52.10 q ha^{-1}), integration with biochar at the highest level of 7.5 t ha^{-1} and humic acid at 30 kg ha^{-1}, the yields from the two levels of fertilizers were at a par. Seed N content was higher in 100% NPK along with biochar @ 7.5 t ha^{-1} and humic acid 30 kg ha^{-1} (1.236 %) followed by 1.127% with 75% NPK along with biochar @ 5 t ha^{-1} and humic acid 30 kg ha^{-1}. In case of P and K, highest contents of 0.500 and 0.618 % was observed with 100% NPK and humic acid 30 kg ha^{-1} along with biochar @ 7.5 and 5 t ha^{-1} respectively.

Keywords: Maize, biochar, humic acid, seed yield, nutrient content

1. Introduction

Among cereals, maize (*Zea mays* L.) is an important food and feed crop which ranks third after wheat and rice in the world. It is a multipurpose crop that provides food for humans, feed for animals (especially poultry and livestock) and raw material for the industries. This crop has much higher grain protein content than our staple food rice. Maize is a heavy feeder of nutrients hence it is a very efficient converter of solar energy into dry matter. India is the fifth largest producer of maize in the world contributing 3 % of the global production (Arif et al., 2012).

Current concerns about global food security combined with the need to develop more sustainable agricultural systems and reduced greenhouse gas emissions necessiate many changes in agricultural management. Central to this tenet is the need for replenished soil organic matter reserves to sustain nutrient cycling; and improved WUE that help to mitigate climate change. Since excessive application of chemical fertilizers may affect soil health and sustainable productivity, it's imperative to search for possible alternate organic source that can sustain soil health and crop production (Jones et al., 2012). The application of biochar to agricultural land is receiving increasing attention as an intervention strategy for the sequestration of carbon and as a means of improving soil quality and nutrient cycling thereby aiming at reduced fertilizer use (Richard et al., 2012).

Climate change and global warming have worldwide adverse consequences. Biochar production and its use in agriculture can play a key role in climate change mitigation and help improve the quality and management of waste materials coming from agriculture and forestry. Biochar is a carbonaceous material obtained from thermal decomposition of residual biomass at relatively varying temperatures and under oxygen limited conditions (pyrolosis). Biochar is currently a subject of active research worldwide because it can constitute a viable option for sustainable agriculture due to its potential as a long term sink for carbon in soil and benefits for crops (Alburquerque et al., 2013). Studies suggest that biochar sequesters approximately 50% of the carbon available within the biomass feedstock being pyrolyzed (Kelsi

Bracmort, 2010). Humic substances are major components of organic matter, have both direct and indirect effects on plant growth (Sangeetha et al., 2006). Humic acid (HA) improves the physical chemical and biological properties of the soil and influences plant growth. Because of its molecular structure, it provides numerous benefits to crop production.

This present investigation is planned to integrate biochar with humic acid to evaluate its efficacy as a fertility amendment at varied fertiliser levels to increase the maize yield.

2. Materials and Methods

This experiment was conducted during *kharif*, 2013 at the College Farm, Acharya N.G Ranga Agricultural University, Rajendranagar, Hyderabad situated at 17°19′ N latitude, 78°23′ E longitude and at an altitude of 542.6 m above mean sea level falls under the Southern Telangana agro-climatic zone of Andhra Pradesh. The details of the material used and the methods adopted during the course of the present investigation are described under appropriate headings.

Some physical and chemical properties of the soil were analysed. Its texture was determined by Bouyoucos hydrometer method (Piper, 1966). The pH and Electrical conductivity of the soil samples were determined in soil: water (1:2) suspension using a glass electrode pH meter and conductivity meter, respectively. Organic carbon percentage in soil sample was determined by wet digestion method (Walkley and Black, 1934). Available nitrogen in soil sample was estimated by alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus in soil sample was extracted with $NaHCO_3$ (0.5M) and the phosphorus in the extract was estimated by colorimetric method using ascorbic acid as the reductant; the intensity of blue colour developed was read in spectrophotometer at 680 nm (Watanabe and Olsen, 1965). Available potassium in the soils was extracted by employing Ammonium Acetate (NN) and determined by aspirating the extract to the ELICO Flame photometer (Jackson, 1973). Available sulphur in soil samples was extracted with calcium chloride (0.15%) solution (Williams and Steinbergs, 1961) and sulphur in the extract was estimated by turbidimetric method on UV-Visible spectrophotometer at 410 nm (Chesnin and Yien, 1963).

3. Results and Discussion

3.1. Seed yield

The two levels of inorganic NPK were significantly the seeds yields being 55.6 and 49.33 q ha^{-1} respectively. Biochar application across the fertilisers and humic acid levels showed a significant increase to 57.04 q ha^{-1} as against 48.35 q ha^{-1} in the control. Individual application of humic acid also had a significant positive effect on the seed yield of maize.

Integrated application of recommended dose of NPK, biochar at 7.5 t ha^{-1} and humic acid at 30 kg ha^{-1} was significant in increasing seed yield. Though in the absence of biochar, 75% NPK put forth significantly lower yield to that of 100% NPK, integration at the highest level of 7.5 t ha^{-1} the yields from the two levels of fertilisers were on a par with the corresponding yields of 58.52 and 55.56 q ha^{-1} (Table 1). It may be inferred that the use of biochar as a soil amendment may reduce fertilizer use while at the same time maintaining high crop yield, even though an increase in crop yield did not occur with increasing fertilizer application rates in the absence of biochar in this study. Similar synergetic effects have also been reported in previous field study (Yamato et al., 2006; Arif et al., 2012).

Table 1: Seed yield (q ha^{-1}) of maize as influenced by fertiliser, biochar and humic acid levels and their interaction

Treatments	BC @ 0 t ha^{-1}			BC @ 5. 0 t ha^{-1}			BC @ 7.5 t ha^{-1}			Fertiliser mean
Fertiliser levels	HA_1	HA_2	Mean	HA_1	HA_2	Mean	HA_1	HA_2	Mean	
100% NPK	52.10	54.43	53.27	56.04	54.01	55.02	56.32	60.71	58.51	55.60
75% NPK	41.22	45.63	43.43	48.17	49.85	49.01	54.43	56.68	55.55	49.33
Mean	46.66	50.03	48.35	52.10	51.92	52.02	55.37	58.69	57.04	52.47
CV (%)	5.22									
CD (p=0.05)	Fert. =1.89; Biochar =2.32; Humic acid =1.89						Fert.xbiochar=3.28; Fert.xhumic acid=N.S; Biocharxhumic acid=N.S; Fert.xbiocharxhumicxacid=N.S			

3.2. Nutrient content

Seed contained significantly higher mean N of 1.074% when the crop was fed with the recommended dose of NPK as compared to 1.002% when fertiliser level was reduced to 75%. The increased N content of plant with the application of recommended NPK is due to higher additions into available N pool of the soil. Similar results were reported by Kalhapure et al., 2013). The interaction between fertilisers and biochar significantly increased the N content of seed from 0.98% with 75% NPK alone to 1.14 % with recommended NPK when applied in combination with 7.5 t ha^{-1}of biochar. Even at the reduced level of fertilisers, the integration with biochar at 5 t ha^{-1} was on par with the N content when recommended NPK alone was applied (Table 2). Lehmann et al. (2003) found that the NH_4^+ adsorbed by biochar reduces the rate of nitrification thus preventing leaching losses and makes it available to the crop at stages of its requirement with concomitant increase

Table 2: Nitrogen content (%) of maize seed as influenced by fertiliser, biochar and humic acid levels and their interaction										
Treatments	BC @ 0 t ha^{-1}			BC @ 5. 0 t ha^{-1}			BC @ 7.5 t ha^{-1}			Fertiliser mean
Fertiliser levels	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	
100% NPK	0.953	1.065	1.009	1.109	1.038	1.073	1.047	1.236	1.141	1.074
75% NPK	0.844	1.115	0.979	0.971	1.127	1.049	0.939	1.015	0.977	1.002
Mean	0.899	1.090	0.994	1.040	1.082	1.061	0.993	1.125	1.059	1.038
CV (%)	8.36									
CD (p=0.05)	Fert.=0.060; Biochar=N.S; Humic acid=N.S						Fert. x biochar=0.104; Fert x humic acid=N.S; Biocharx-humic acid=N.S; Fert x biocharxhumic x acid=N.S			

in N uptake by the crop.

Significantly higher P content of 0.484% was obtained with the application of recommended NPK against 0.427% with 75% NPK. Application of biochar levels and humic acid levels were not significant for P content for maize seed. The interaction between fertilisers and biochar resulted significantly increased P content from 0.422% when 75% NPK along with biochar @ 5 t ha^{-1} to 0.498% with recommended NPK along with biochar @ 7.5 t ha^{-1}. These results were on par with treatment receiving recommended NPK alone (Table 3).

Individual application of fertilisers, biochar and humic acid showed a significant influence on K content of maize seed, while integrated effect was not exerted. Recommended NPK resulted in a significantly higher K content of 0.586% against 0.475% with a reduced level (NPK) of fertilisers. Graded levels of biochar application showed a significant increase in K content from 0.520 to 0.590% when applied at 7.5 t ha^{-1}. This might be due to the release of adsorbed K from biochar resulting in higher absorption. Seed K content showed an increase from 0.520 to 0.538% with the application of humic

Table 3: Phosphorus content (%) of maize seed as influenced by fertiliser, biochar and humic acid levels and their interaction										
Treatments	BC @ 0 t ha^{-1}			BC @ 5. 0 t ha^{-1}			BC @ 7.5 t ha^{-1}			Fertiliser mean
Fertiliser levels	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	
100% NPK	0.464	0.489	0.480	0.468	0.481	0.474	0.496	0.500	0.498	0.484
75% NPK	0.422	0.43	0.430	0.404	0.44	0.422	0.417	0.446	0.431	0.427
Mean	0.443	0.459	0.451	0.436	0.460	0.450	0.456	0.473	0.464	0.455
CV (%)	4.94									
CD (p=0.05)	Fert.=0.016; Biochar=N.S; Humic acid=N.S						Fert.×biochar=0.027; Fert.×humic acid=N.S; Biochar×humic acid=N.S; Fert.×biocharxhumic×acid=N.S			

acid at 30 kg ha^{-1} across the fertilisers and biochar (Table 4).

Sulphur content of maize seed was influenced significantly by fertiliser levels alone across biochar and humic acid. Significantly higher mean S % of 0.336 was obtained with the application of recommended NPK as against 0.322 with 75% NPK (Table 5). Increased sulphur content with higher NPK level could be due to the synergistic interaction between P and S that enabled enhanced root activity and more absorption of S from the soil.

Table 4: Potassium content (%) of maize seed as influenced by fertiliser, biochar and humic acid levels and their interaction										
Treatments	BC @ 0 t ha^{-1}			BC @ 5. 0 t ha^{-1}			BC @ 7.5 t ha^{-1}			Fertiliser mean
Fertiliser levels	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	HA$_1$	HA$_2$	Mean	
100% NPK	0.563	0.574	0.569	0.585	0.566	0.580	0.598	0.618	0.608	0.586
75% NPK	0.469	0.474	0.472	0.352	0.415	0.380	0.557	0.587	0.572	0.475
Mean	0.516	0.524	0.520	0.468	0.490	0.480	0.577	0.602	0.590	0.528
CV (%)	7.04									
CD (p=0.05)	Fert. = 0.026 Biochar = 0.032 Humic acid =0.026						Fert. x biochar = N.S Fert. x humic acid = N.S Biochar x humic acid = N.S Fert. x biochar x humic x acid = N.S			

Table 5: Sulphur content (%) of maize seed as influenced by fertiliser, biochar and humic acid levels and their interaction

Treatments	BC @ 0 t ha^{-1}			BC @ 5. 0 t ha^{-1}			BC @ 7.5 t ha^{-1}			Fertiliser mean
Fertiliser levels	HA_1	HA_2	Mean	HA_1	HA_2	Mean	HA_1	HA_2	Mean	
100% NPK	0.321	0.310	0.316	0.35	0.333	0.342	0.344	0.353	0.349	0.336
75% NPK	0.337	0.305	0.321	0.308	0.328	0.318	0.327	0.325	0.326	0.322
Mean	0.329	0.307	0.320	0.329	0.330	0.330	0.335	0.339	0.337	0.330
CV (%)	5.64									
CD (*p*=0.05)	Fert. = 0.013; Biochar = N.S; Humic acid = N.S				Fert.×biochar=N.S; Fert.×humic acid=N.S; Biochar× humic acid=N.S; Fert.×biochar×humic×acid=N.S					

4. Conclusion

Application of recommended dose of NPK, biochar at 7.5 t ha^{-1} and humic acid at 30 kg ha^{-1} were significant and resulted in higher mean seed yield. Integration of biochar at 7.5 t ha^{-1} and humic acid with reduced fertiliser dose could result in comparable yield as that of recommended level. The nutrient contents resulted with 75% NPK could be on par with 100% NPK when applied conjunctively with biochar at 5 t ha^{-1} and humic acid.

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