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Effect of Fertilizers, Biochar and Humic acid on Seed, Stover Yield, Harvest index and Economics of Maize (*Zea mays* L.) Grown on Alfisols

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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 economics 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 recorded significantly highest seed (60.71 q ha^{-1}) and stover yield (91.43 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. Highest harvest index (0.447) was obtained in 100 percent NPK alone, was on par with treatment receiving 100 percent NPK along with biochar @ 5.0 t ha^{-1}. Highest B: C ratio (3.84) was obtained in treatment receiving 75 percent NPK with biochar @ 7.5 t ha^{-1}.

Key words: *Maize, Biochar, Humic acid, Seed yield, Stover yield, Harvest index, Economics.*

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 per cent of the global production[2].

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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[4]. 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[8].

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. It 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[1]. Studies suggest that biochar sequesters approximately 50% of the carbon available within the biomass feedstock being pyrolyzed[5]. Humic substances are major components of organic matter, have both direct and indirect effects on plant growth[9]. 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 productivity and economics.

MATERIAL AND METHODS

This experiment was conducted during *kharif*, 2013 at the College Farm, Acharya N.G Ranga Agricultural University, Rajendranagar, Hyderabad situated falls under the Southern Telangana agro-climatic zone of Andhra Pradesh. For seed yield the matured cobs were harvested from net plot area and dried. After drying, shelling was done by maize sheller and again the grain was dried and weights were recorded as per the treatments and expressed in q ha^{-1}. After the harvest of cobs, the left over plants were cut off and sun dried to a constant weight. The stover yield of the net plot was recorded for individual treatments and expressed in q ha^{-1}.The cost of cultivation for each treatment was worked out. Similarly, gross returns were calculated based on current market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. Later, the benefit cost ratio was worked out by using the formula:

B: C =Gross returns / Cost of cultivation

Nutrient Index was calculated by using this formula: Economic yield/ Biological yield

The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design as suggested by Panse and Sukhatme[7]. The statistical significance was tested by F-test at 5 per cent level of probability and wherever the “F” value was found significant, critical difference (CD) was worked out to test the significance.

RESULTS AND DISCUSSION

Seed yield

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 the mean seed yields of 55.60, 57.04 and 53.55 q ha^{-1}. The per cent decline in the seed yield due to withholding 25 per cent fertiliser dose narrowed down from 18.50 to 8.0 when conjunctively applied with biochar at 5.0 t ha^{-1}. While, in combination with 7.5 t ha^{-1} of biochar, there was a 4.3 per cent higher yield over 100 % NPK. 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}.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 (Table 1). Similar synergetic effects have alsobeen reported in previous field studies[2,11].

Stover yield

Application of recommended dose of fertiliser, the mean stover yield of maize was 75.31 q ha^{-1}, which was significantly higher to the yield of 71.70 q ha^{-1} obtained when the fertiliser was reduced to 75 percent. Application of 7.5 t ha^{-1} of biochar across the fertilisers and humic acid brought about a significant increase in the mean stover yield to 83.20 q ha^{-1} as against 72.13 and 65.17 q $ha^{-1}$when applied at 5 t ha^{-1} and without its application respectively. The results are in consonance with the findings of Baronti *et al.*[3], Lehman *et al.*[6] and Widowati *et al*[10]. Stover yield significantly increased from 63.61 q ha^{-1} when a reduced level of fertilisers alone was applied to a significantly higher stover yield of 85.76 q ha^{-1} with the application recommended fertilisers along with 7.5 t ha^{-1} of biochar. At the recommended level of fertilisers, biochar had more pronounced influence even at the highest level (Table 2).

Harvest Index

Treatment receiving 100 percent NPK shown highest harvest index (0.447), was on par with 100 percent NPK along with biochar @ 5.0 t ha^{-1}. Lowest was recorded with 75 percent NPK alone. In case of reduced fertilizer application i.e. 75 percent NPK with biochar @ 7.5 t ha^{-1} showed highest Harvest index was on par with 75 percent NPK with humic acid @ 30 kg ha^{-1} (Fig.1).

Economics

Data presented in table 3.3 indicates that highest B: C ratio (3.84) was obtained in treatment receiving 75 percent NPK with biochar @ 7.5 t ha^{-1} followed by 75 percent NPK with biochar @ 7.5 t ha^{-1} and humic acid @ 30 kg ha^{-1} (3.77), while recommended NPK alone realized a B: C ratio of 3.66. Treatment receiving 75 percent NPK alone shows lowest (3.30) B: C ratio (Table 3).

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 at 5% level	Fert. =1.89 Biochar =2.32 Humic acid =1.89				Fert. x biochar = 3.28 Fert. x humic acid = N.S Biochar x humic acid = N.S Fert. x biochar x humic x acid = N.S					

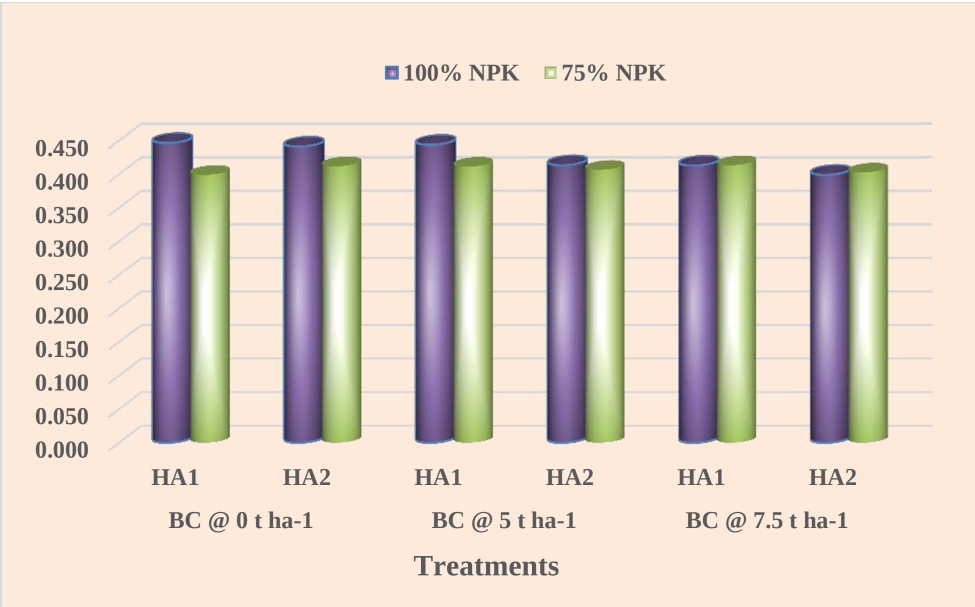
Table 2: Stover yield (q ha^{-1}) of maize as influenced by fertiliser, biochar and humic acid levels and their interaction

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	64.56	68.92	**66.74**	70.2	76.65	**73.43**	80.09	91.43	**85.76**	**75.31**
75% NPK	62.06	65.15	**63.61**	68.91	72.76	**70.84**	77.2	84.09	**80.64**	**71.70**
Mean	63.31	67.03	**65.17**	69.55	74.70	**72.13**	78.64	87.76	**83.20**	**73.50**
CV (%)	5.66									
CD at 5% level	Fert. = 2.87 Biochar = 3.52 Humic acid = N.S			Fert x biochar = 4.98 Fert x humic acid = N.S Biochar x humic acid = N.S Fert x biochar x humic x acid = N.S						

Table 3: Economics of maize

	100% NPK						75% NPK					
	B$_1$		**B$_2$**		**B$_3$**		**B$_1$**		**B$_2$**		**B$_3$**	
	HA$_1$	**HA$_2$**	**HA$_1$**	**HA$_2$**	**HA$_1$**	**HA$_2$**	**HA$_1$**	**HA$_2$**	**HA$_1$**	**HA$_2$**	**HA$_1$**	**HA$_2$**
Cost of cultivation	18655	19765	20265	21375	20890	22000	16345	17455	17955	19065	18580	19690
Gross returns	68251	71264	73412	70740	73779	79530	53998	59775	63102	65303	71303	74250
Net returns	49596	51499	51897	48115	51014	55655	37653	42320	43897	44988	50848	52685
B: C ratio	3.66	3.61	3.62	3.31	3.53	3.62	3.30	3.42	3.51	3.43	3.84	3.77

Fig. 1: Harvest Index of maize as influenced by fertiliser, biochar and humic acid levels and their interaction



CONCLUSION

Recommended level of NPK though has a significant influence on seed and stover yield as against the reduced level, the conjunctive use of fertilisers even at 75% NPK level with biochar and humic acid could improve the soil health while maintaining the crop yields as well as highest B: C ratio.

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