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RESEARCH ARTICLE :

Influence of biochar, phosphorus and mycorrhiza on nutrient content of baby corn (*Zea mays* L.)

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SUMMARY : A pot experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences B.H.U., Varanasi, India during *Kharif* season of 2015 to investigate the influence of biochar, phosphorus and mycorrhiza on performance of baby corn and soil quality. The treatments comprised of four levels of biochar *i.e.* No biochar, rice husk biochar, lantana biochar and parthenium biochar (each applied @ 4.545 g kg^{-1} soil, two levels of mycorrhiza (uninoculated and inoculated) and two levels of phosphorus *viz.*, no P and P @ 50% RDF along with full dose of nitrogen and potassium were applied. One of the important findings of the investigation showing beneficial effects of biochar could be exploited if it was applied along with mycorrhiza. Combined application of biochar (10 t ha^{-1} soil) along with mycorrhiza was produced significantly higher nutrients concentration in baby corn.

KEY WORDS :
Biochar, Mycorrhiza, Phosphorus

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BACKGROUND AND OBJECTIVES

Intensive cultivation and enhanced use of agrochemicals mainly fertilizers and pesticides cause remarkable increase in production of food grains during post green revolution era. However, it has ensued in decline in soil organic carbon and deterioration of soil quality at different places of India. Now a day's excessive deal of researchers how to obtain higher productivity of crops with organic sources of nutrients having low cost of inputs compare to inorganic sources of nutrients. Biochar application has been a sustainable technology to recover intensely weathered or degraded soils (Lehmann and Rondon, 2006). Biocharalso can improve growth of plants and physical, chemical and biological properties of soil. Presently, biochar has been used as a soil amendment in Europeans countries at large scale, still in India biochar has not been used due to some constraints like lack of research, miscellaneous effect of biochar on soil quality and crop productivity.

RESOURCES AND METHODS

Study area:

The experiment was conducted during *Kharif* season of 2015 in net house of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India in Factorial Completely Randomized Design with 16 treatment combinations replicated trice.

Experimental soil :

Bulk soil sample (0-15cm) was collected from Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University. Varanasi, India. After collecting, it was ground and passed through 5.0-mm sieve and 10 kg of soil filled in the each polythene lined pot. Soil in each pot was pulverized manually and 5 seeds of maize (variety Malviya Makka 2) were transplanted. After establishment, four plants were maintained. The pots were irrigated and 2 cm of standing water was maintained by daily addition of water. The soil used for experimentation was sandy loam with bulk density 1.63 Mgm^{-3}, pH (1:2.5) 7.6, E.C. 0.21 dsm^{-1}, CEC 11.63 $cmol(P^{+})$ kg^{-1}, organic carbon 0.34%, available N 135 kg ha^{-1}, available P 22.7 kg ha^{-1} and available K 183 kg ha^{-1}.

Source of biochar and arbuscularmycorrhiza:

Biochar and arbuscularmycorrhiza was obtained from the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. (India).

Fertilizers application methods:

Two levels of phosphorus those were no P and P @ 50% RDF along with full dose of nitrogen and potassium were applied. Required quantities of fertilizers for each pot (10 kg soil) were calculated and applied in solution form using urea, KH_2PO_4 and KCl as source of N, P, and K, respectively. So rate of N, P and K were 150, 30 and 40 kg ha^{-1} and for each pot (10 kg soil) those became 0.66 g, 0.13 g and 0.17 g, respectively. Half the dose of N applied as basal and left over dose of nitrogen was added at 30 and 45 days after sowing. Full dose of P_2O_5 was applied as KH_2PO_4 among the 24 pots and it meets the K_2O requirement of the crop as it contained 35% K_2O.

Biochar application methods :

Three types of biochar *viz.*, rice husk biochar, lantana biochar and partheniumbiochar were applied corresponding to 10 t ha^{-1}. Required quantities of biochar for 10 kg soil were calculated and the full dose was applied as soil application before sowing the maize seeds.

Arbuscularmycorrhiza application methods:

Mycorrhizal treatment has two levels *i.e.* with mycorrhiza and without mycorrhiza and mycorrhizal consortia was applied @ 5 g pot^{-1}. Mycorrhizal consortia were equally spared on the moist top soil of the pots followed by covering with thin 2-3 cm soil layer.

Sampling and analysis:

Plant samples were dried at 65-70°C and nitrogen, phosphorus and potassium were analysed following suitable methods as mention in the practical manual of Tandon (2001).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Macro-nutrient concentration of baby corn as affected by different levels of phosphorus, biochar and AM :

Nitrogen content in baby corn and straw:

A critical observation of the data given in Table 1, makes it clear that application of P increased nitrogen content in baby corn and straw significantly by 2.97 % and 2.09 %, respectively over no P. Application of AM1 showed significantly higher nitrogen content in baby corn and straw and the increment were 7.76% and 0.83%, respectively over the treatment AM0. Application of biochar was found to be significantly decreasing nitrogen content of corn and statistically non-significant in case of straw. Significant interaction among phosphorus, biochar and AM was observed for nitrogen content in corn and straw (Table 2). The highest nitrogen content (1.46%) in corn was obtained in the treatment of LBAMIP2, while the lowest nitrogen content (1.39%) was recorded in the treatment NBAM0P1. Highest nitrogen content (0.97%) in straw was obtained with the combined application of biochar and AM.By increasing ammonia (NH_3) and ammonium (NH_4+) retention and reducing nitrous oxide (N_2O) emission and nitrate (NO_3-) leaching, biochar has the ability to retain nitrogen in soils (Clough and Condron, 2010).

Phosphorus content in baby corn and straw:

Data pertaining to P content in corn and straw of maize as affected by different levels of phosphorus, biochar and AM have been presented in Table 1. Upon going through the data, it becomes clear that application of P2 in soil significantly increased phosphorus content in corn and straw and the recorded increment were of the order of 11.11% and 20.09%, respectively over P1. Application of LB significantly increased the phosphorus content in corn by 8.53% over control. The inoculation with AM significantly increased the phosphorus content in corn and straw increments being 22.2% and 10.3%, respectively, over no AM. Various mechanisms of mycorrhiza for phosphorus uptake are 1. physical exploration of soil by mycorrhiza 2. diffusion zone 3. increased absorption surface 4. high affinity to phosphorus 5. threshold concentration and 6. direct modification of root environment. Recent researches have highlighted the importance of root foraging to plant P nutrition (Ramaekers *et al*., 2010 and Richardson *et al*., 2011). Increased root hair elongation, top soil lateral branching, high root:shoot ratio, root exudation, increased root P uptake kinetics and mycorrhizal symbiosis are all found to be strategies that favour P acquisition (Lynch, 2011). The highest phosphorus content in corn (0.46%) was recorded with integrated application of phosphorus, AM and biochar over control (0.30%). Significant interaction between phosphorus and AM was observed for phosphorus content in corn and straw (Table 4 and 6).

Table 1: Macronutrient content of baby corn and straw as affected by different levels of phosphorus, biochar and AM

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Baby corn	Straw	Baby corn	Straw	Baby corn	Straw
P1	1.417	0.953	0.360	0.204	0.500	1.213
P2	1.438	0.975	0.400	0.245	0.512	1.226
S.E.±	0.002	0.001	0.002	0.002	0.002	0.002
C.D. (P=0.05)	0.007	0.003	0.005	0.005	0.005	0.005
NB	1.433	0.963	0.363	0.217	0.502	1.214
RHB	1.422	0.962	0.376	0.223	0.500	1.217
PB	1.425	0.964	0.387	0.225	0.508	1.220
LB	1.431	0.965	0.394	0.232	0.515	1.226
S.E.±	0.003	0.002	0.002	0.002	0.002	0.003
C.D. (P=0.05)	0.010	0.005	0.007	0.007	0.006	0.008
AM0	1.408	0.960	0.342	0.213	0.494	1.208
AM1	1.447	0.968	0.418	0.235	0.518	1.231
S.E.±	0.002	0.001	0.002	0.002	0.002	0.002
C.D. (P=0.05)	0.007	0.003	0.005	0.005	0.005	0.005
Interaction						
P × B	NS	NS	NS	NS	NS	NS
P × AM	NS	NS	S	S	S	S
B × AM	NS	S	NS	NS	NS	NS
P × B × AM	S	NS	S	NS	NS	NS

P1 and P2 means phosphorus @ 0 and 50% RDF, respectively; NB, RHB, LB and PB means no biochar, rice husk biochar, lantana biochar and partheniumbiochar @ 10 t ha^{-1}, respectively; AM0 and AM1 means mycorrhiza @ 0 and 5 g pot^{-1} respectively. P × B means phosphorus and biochar interaction, P × AM means phosphorus and mycorrhiza interaction, B × AM means biochar and mycorrhiza interaction, P × B × AM means phosphorus, biochar and mycorrhiza interaction. S means significance and NS means non-significanc.

Table 2: Interaction effect among phosphorus, biochar and AM on nitrogen (%) of baby corn

P/BAM	NBAM0	NBAM1	RHBAM0	RHBAM1	PBAM0	PBAM1	LBAM0	LBAM1
P1	1.39	1.44	1.38	1.45	1.40	1.43	1.4	1.43
P2	1.44	1.46	1.41	1.45	1.41	1.46	1.43	1.46
S.E.±				0.009				
C.D. (P=0.05)				0.019				

Table 3 : Interaction effect between AM and biochar on nitrogen (%) of straw

AM × B	NB	RHB	PB	LB
AM0	0.96	0.96	0.96	0.97
AM1	0.95	0.97	0.95	0.97
S.E.±		0.003		
C.D. (P=0.05)		0.006		

Table 4 : Interaction effect between phosphorus and AM on phosphorus (%) of baby corn

P × AM	AM0	AM1
P1	0.33	0.40
P2	0.36	0.44
S.E.±	0.003	
C.D. (P=0.05)	0.006	

The phosphorus content (0.44%) in corn was obtained with the combined application of AM1 and P2, while the lowest phosphorus content (0.33%) was recorded in the treatment P1AM0. Highest phosphorus content (0.25%) in straw was obtained with the combined application of AM1 and P2.There was increased P uptake by plants when biochar was applied to the soils (Nelson *et al.*, 2011). Availability of P to plants can be changed by using biochar through process of anion and cation exchange that interact with P and can also be influenced by addition of biochar in to soil (Liang *et al.*, 2006).

Potassium content in baby corn and straw:

From the data given in Table 1, it has been found that application of AM1 recorded the highest potassium

Table 5 : Interaction effect among phosphorus, biochar and AM on phosphorus (%) of baby corn

P/BAM	NBAM0	NBAM1	RHBAM0	RHBAM1	PBAM0	PBAM1	LBAM0	LBAM1
P1	0.30	0.38	0.32	0.39	0.33	0.40	0.34	0.41
P2	0.35	0.42	0.36	0.44	0.36	0.45	0.36	0.46
S.E.±				0.006				
C.D. (P=0.05)				0.013				

Table 6: Interaction effect between phosphorus and AM on phosphorus (%) of straw

P × AM	AM0		AM1
P1	0.19		0.22
P2	0.23		0.25
S.E.±		0.003	
C.D. (0.05)		0.006	

Table 7 : Interaction effect between phosphorus and AM on potassium % of straw

P × AM	AM0		AM1
P1	0.49		0.51
P2	0.50		0.53
S.E.±		0.003	
C.D. (P=0.05)		0.006	

Table 8: Interaction effect between phosphorus and AM on potassium % of straw

P × AM	AM0		AM1
P1	1.2		1.23
P2	1.22		1.23
S.E.±		0.003	
C.D. (P=0.05)		0.007	

content in corn and straw (0.518% and 1.231%, respectively). Effect of application of biochar was significant in increasing the potassium content of corn and straw. Application of LB showed significantly higher potassium content in corn (2.58%) and straw (0.98%) compared to NB. The increased concentration of potassium in baby corn and straw due the biochar is a rich source of potassium. Rondon *et al*. (2007) have reported potassium concentration in plant significantly increased with biochar applications.Significant interaction between phosphorus and AM was observed for potassium content in corn and straw (Table 7 and 8). The highest potassium content (0.53%) in corn was obtained in P2AM1, while the lowest potassium content (0.49%) was recorded in the treatment P1AM0. Highest potassium content (1.23%) in straw was obtained with the combined application of phosphorus and AM.

Conclusion:

Based on the results of present investigation, following conclusions could be drawn, a significant increase in phosphorus and potassium concentration of baby corn and straw could be achieved by sole application of AM. Sole application of biochar has no significant effect on nitrogen content, but it increase phosphorus and potassium concentration of baby corn yield in alluvial soils of Varanasi. However, when combined with phosphorus and AM, biochar application resulted in significant nutrient enhancement of baby corn.

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