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Effect of organic resources and Subabul (*Leucaena leucocephala*) biochar on competitive ability of barley crop in acidic soil

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Abstract
Soil amendment with organic resources is currently proposed as a management strategy to improve soil quality and enhance crop productivity. The objective of this study was to evaluate the effect of organic resources, farmyard manure (FYM) and Subabul (*Leucaena Leucocephala*) biochar along with inorganic fertilizers on the competitive ability of barley (*Hordeum vulgare* L.) biomass production. The treatments included thirteen selected combination of organic, inorganic and biochar. The experiment was led out in a completely randomized design with three replications in *Alfisols*. Results revealed that barley biomass yield and some yield components significantly responded to the FYM and biochar applications. The highest total fresh biomass yield (32.6 g pot^{-1}) and dry biomass yield (6.18 g pot^{-1}) were obtained from application of soil + NPK + FYM 1% + Biochar 3% (T_{13}) as compared to control (17.5 g pot^{-1}) T_1. The treatments T_{11} (31.3 g pot^{-1}) and T_{12} (32.4 g pot^{-1}) both were recorded significantly at par to each other and significantly higher over control (T_1). We conclude that application of organic amendments optimizes biomass of barley plants.

Keywords: *Leucaena leucocephala*, barley crop, acidic soil, soil quality

Introduction

Soil acidity is a serious problem for crop production in many regions of India. Agriculture land affected by acidity is estimated at 4 billion ha, representing 30% of the total ice-free land area of the world (Sumner and Noble, 2003) [12]. Soil acidity affects nearly 50 percent of the world's potentially arable land, particularly in humid tropics regions (Von Uexkull and Mutert, 1995) [15]. Liming is the conventional practices, yet lime is costly and may not be available in some places. Biochar derived from natural organic materials (woody debris, corn stalks, macadamia shell etc.) is a stable form of charcoal produced in a high temperature, low oxygen process, such as control pyrolysis of organic materials (Berek *et al.*, 2011) [3].

Barley (*Hordeum vulgare* L.) a member of the grassy family, is a major cereal grain grown in temperate climates globally. It was one of the first cultivated grains, particularly in Eurasia as early as 10,000 years ago. Barley grains are commonly made into malt in a traditional and ancient method of preparation. In 2014, barley was ranked fourth among grains in quantity produced (144 million tonnes) behind maize, rice and wheat. Barley is more tolerant of soil salinity than wheat. The major production states of Barley in India are Rajasthan, UP, MP, Haryana, Punjab, West Bengal, and Jammu & Kashmir. It can be grown on wide range of soils including saline, sodic and lighter soils. Acidic soils are not suitable for barley cultivation. Our research showed that organic resources could replace lime and cultivate barley crop. Therefore increasing productivity of this crop could be achieved by ameliorating the soil conditions and improving the fertility of soils. Leaching of nutrients from agricultural soils depletes soil fertility and accelerates soil acidification that aggravates crop yield reduction. Nutrient leaching varies substantially with rainfall intensity and soil properties (Juo and Manu, 1996) [2].

Recent research has shown that additions of composts, green, or animal manures reduce Al^{3+} toxicity and increase crop yields (Hue and Amien, 1989; Wong and Swift, 2003; Vieira *et al*., 2009) [5, 17]. When biochar applied as a soil amendment, it improves crop yield by stimulation of beneficial soil microbes such as mycorrhizal fungi (Warnock *et al*., 2007) [16], improves water holding capacity, and soil physical properties, (Kramer *et al*., 2004; Liang *et al*., 2010; Ogawa and Okimori, 2010) [6, 7, 10] and store carbon for long time, ameliorates degraded soils and reduces soil acidity (Major *et al*., 2010) [8]. Long term fertilizer experiments conducted in different locations of India also indicated FYM efficacy at par with lime in obtaining the good yield of crops. Here in all locations,

FYM has been applied at a rate of 10-15 t $ha^{-1}yr^{-1}$ in addition of 100% NPK. Although this technology seems promising in amelioration of soil acidity problem however availability of FYM at such higher rate for crop production is a questionable proposition. Under these circumstances, there is need to develop an innovative alternative management strategies based upon the locally available resources for sustainable crop production in acid soil regions of India.

Material and Methods

To test our hypotheses, a screen house experiment (controlled condition) was conducted by taking Barley as a test crop at ICAR- Indian institute of Soil Science, Bhopal during *Rabi* season 2014. The soils for pot experiment were collected from Ranchi having a pH of 6.2. Barley seed was sowing on 25th November 2014. Eight seeds were sown in each pot and six were retained for study. Pots were irrigated at every alternate day. The barley plant was harvested 60 days after sowing. Plant samples were dried in oven at 60°C until constant dry weight obtained. The plant samples were grinded and used for following chemical analysis. The details of the 13 treatments are given in Table 1. The experiment was set up in a completely randomized design.

Biochar Preparation and analysis

Subabul (*Leucaena Leucocephala*) stem and twigs were collected locally and dried at 80°C for 12 hours. The stems were chopped to 8-10 cm in length and were then pyrolized under oxygen limited conditions for 4 hours then allowed to cool overnight. Subsequently, the biochar was crushed manually and ground to pass through a 2-mm sieve.

Table 1: Details of treatment used in pot experiment.

Treatments	Treatments detail
T_1	Soil only
T_2	Soil + NPK
T_3	Soil + NPK + Biochar 1%
T4	Soil + NPK + Biochar 2 %
T5	Soil + NPK + Biochar 3 %
T6	Soil + Biochar 1%
T7	Soil + Biochar 2%
T8	Soil + Biochar 3%
T9	Soil + FYM 1%
T10	Soil + NPK + FYM 1%
T11	Soil + NPK + FYM 1% + Biochar 1%
T12	Soil + NPK + FYM 1% + Biochar 2%
T13	Soil + NPK + FYM 1% + Biochar 3%

NPK dose: Recommended does of fertilizers (GRD), 214: 142:107 (mg pot^{-1})

Results and Discussion

Effect of NPK, FYM and different levels of biochar (BC) on barley dry matter yield (g/pot) in pot experiment

Fresh weight and air dry weight of barley crop recorded at the time of harvest under NPK, FYM and different levels of biochar is given in Table 2.

Table 2: Effect of NPK, FYM 1% and different levels of biochar on dry matter yield of barley plants.

Treatment	Fresh weight (60 DAS)	Air dry weight (60DAS)
Control	17.5	3.09
NPK	22.4	3.44
NPK+BC 1%	26.7	5.11
NPK+BC 2%	30.3	5.32
NPK+BC 3%	30.5	5.56
BC1%	22.7	3.96
BC 2%	23.0	4.66
BC 3%	25.2	5.03
FYM 1%	22.5	3.87
FYM 1%+NPK	24.8	4.44
NPK+FYM 1%+BC 1%	31.3	5.83
NPK+FYM 1%+BC 2%	32.4	5.94
NPK+FYM 1%+BC 3%	32.6	6.18

*Biochar and FYM doses were on weight basis

Fresh weight, air dry weight and oven dry weight of barley plants were significantly increased due to application of NPK, FYM and different levels of biochar. Significantly increase in fresh weight, air dry weight and oven dry weight of Barley plant was recorded under NPK + FYM 1% + BC 3% (32.6 g pot^{-1}, 6.18 g pot^{-1} and 4.48 g pot^{-1} respectively), followed by NPK + FYM 1% + BC 2% (32.4 g pot^{-1} 5.94 g pot^{-1} and 4.34 g pot^{-1} respectively), and NPK + FYM 1% +BC1% (31.3 g $pot^{-1,}$ 5.83 g pot^{-1} and 4.05 g pot^{-1}) (fig. 1 and fig. 2). Similar results was found that biochar application had a positive effect on the crop yield attributes when comparing with control and micronutrient treatment without biochar Arif *et al.* (2012) [1] and Niaz *et al.* (2016) [4]. Lowest fresh weight, air and oven dry weight of barley crop was recorded at NPK (22.4 g pot^{-1}, 3.44 g pot^{-1} and 2.89 g pot^{-1}) and FYM 1% (22.5 g pot^{-1}, 3.87 g pot^{-1} and 3.0 g pot^{-1}) respectively.

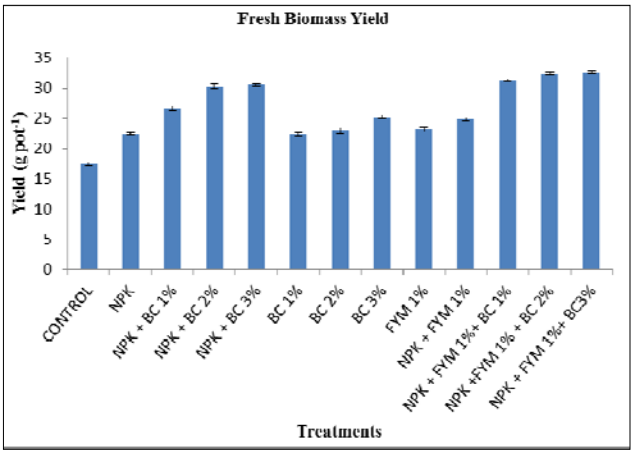

Fig 1: Effect of different treatments on fresh biomass yield of barley.

Percentage increase/decrease in crop productivity with different liming materials for its efficacy over control

Percentage (%) of fresh weight of barley plants was significantly increased due to incorporation of different liming materials (NPK, FYM and different levels of biochar). Significantly increase in percentage of fresh weight of barley plant was recorded under NPK+FYM 1% +BC 3% (86.61%), followed by NPK+FYM 1%+BC 2% (85.35%) and NPK+FYM 1% +BC 1% (78.97%), so increased their liming efficacy over control (fig. 3). Lowest percentage of fresh weight of barley crop was recorded at NPK (27.80%) and FYM 1% (31.73 %) respectively. The results reconfirm that there was significant increase in biomass yields when acid soils were amended with biochars (Atkinson *et al*., 2010 and Masud *et al.*, 2014).

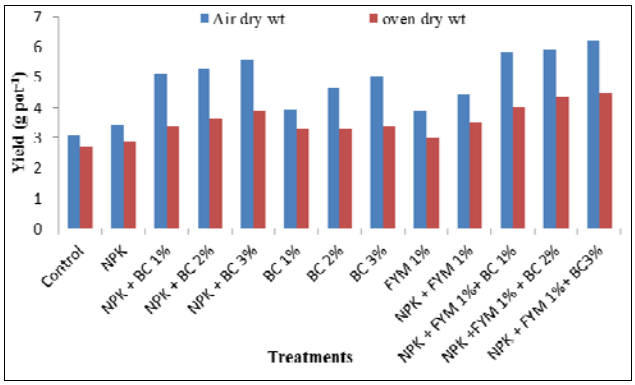

Fig 2: Effect of different treatments on air dry and oven dry biomass yield of barley.

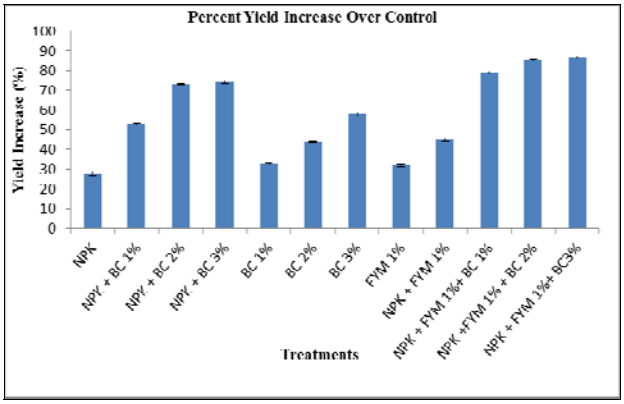

Fig 3: Effect of different treatments on biomass yield increase (%)

Conclusion

The biomass of barley crop improved through application of NPK + FYM 1% + BC 3%. Moreover, biochar, FYM and supplementation of recommended doses of macronutrients not only enhanced the yield significantly, but also improved the soil characteristics. This study is a base for recommending the use of biochar on large scale spectrum as policy matter and as a novel approach to improve barley production and reclamation of acid soil as supplementary of liming materials.

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