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RESIDUAL EFFECT OF BIOCHAR ON BERSEEM PRODUCTIVITY AND SOIL QUALITY UNDER DIFFERENT FARM YARD MANURE AND NITROGEN LEVELS

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Article Info

Abstract

To study the residual effect of biochar on berseem productivity and soil quality under different farmyard manure and nitrogen levels, a field experiment was performed at Agronomy Research Farm, The University of Agriculture, Peshawar-Pakistan during Fall 2013-2014. Randomized complete block design was used for conducting experiment with three replications. Three residual biochar levels (0, 25 and 50 t ha-1), farm yard manure two levels (5 and 10 t ha-1) and two levels of nitrogen (15 and 30 kg ha-1) were included in experiment. 50 t ha-1 biochar applications resulted in elevated plant height, fresh and dry fodder yield. Higher values for these traits were observed with the addition of 25 t biochar to the previous crop. FYM at the rate of 10 t ha-1 produced taller plants, higher fresh and dry fodder yield. Plots treated with 30 kg N ha-1 resulted in taller plants, higher fresh and dry fodder yield. Similarly, farmyard application @10 t ha-1 resulted in higher soil carbon, soil total nitrogen and soil pH. Residual biochar @50 t ha-1 increased soil pH, EC, carbon and total nitrogen. It was concluded from the study that 50 t ha-1 BC, 10 t ha-1 FYM and 30 kg ha-1 N increased fodder yield, whilst BC application @50 and FYM application @10 t ha-1 improved soil physio-chemical properties.

Keywords:

Berseem, Biochar, Farm yard manure, Nitrogen, Soil fertility.

Introduction

Among the major constraints of promoting livestock production, low fodder production and lesser feed availability are considered the major limiting factor in Pakistan (Amanullah et al., 2005). Berseem, shaftal, lucerne, oats and barley are considered the leading winter forage crops of Pakistan. Among these crops, berseem is known as king of fodder due to its ability to produce more cuts and produces the highest fresh fodder yield (100-125 t ha-1). It can be grown as mixed crop with some other species like annual rye grass (Loliummul tiflorum Lam), oat (Avena sativa L.), or vetch (Vicia sativa L.) for hay production as well as green fodder purposes. Berseem is considered an important animal feed in Pakistan during winter season. It regulates various animal body functions such as it metabolizes energy nutrients carbohydrates and protein (Younas and Yaqoob, 2005). It as green fodder increases milk production capacity of animals. Most of the nutritional requirements of animal feeding are fulfilled by berseem during winter season in most part of the country (Achakzai, 2007). It is important not only because of fodder but also improves soil properties and nitrogen use efficiency of following cereal crop when included in cropping pattern (Wahab, 1990). Because of the high population pressure and unavailability of fodder, farmers usually exercise more fertilizer application to berseem (Khan et al., 2012). Nitrogen is one of the most important plant nutrients which are limiting in soil and that promote vigorous plant vegetative growth. Crop grown on N deficient soil suffer from poor plant growth and dry matter production. As compared to other plant nutrients N is required by plant in high quantity for growth and development. It is the main constituent of chloroplast necessary for higher yield and survival of plant. Application of nitrogen fertilizers results in long stature plants and promotes cell division (Aminifard et al., 2012). Increasing or decreasing the level of nitrogen may drastically affect overall plant performance, under deficient level the plant may develop shortened lateral branches, stunted growth and small leaf size as well as loss of chlorophyll. Its excess application may leads to lodging and makes the plant susceptible to diseases (Scheible et al., 1997; Zhang et al., 1999). Though the importance of inorganic fertilizer cannot be ignored, however, continuous application of inorganic fertilizer not only leads soil degradation but also increase production costs as well as various environmental problems are associated with heavy inorganic fertilization (Ali et al., 2012). In order to compensate these loses, agriculture scientists are in favor of including organic sources of nutrients (biochar and FYM) in farming system for improving crop performance and soil health (Lehmann and Rondom, 2006).

Adding organic manures may enhance the fertility of soil and crop production by changing the physiochemical properties of soil including bioavailability of nutrients, water holding, cation exchange capacity, soil pH, microbial population and activity etc. (Walker et al., 2004; Clemente and Bernal, 2006; Muhammad and Khattak, 2009). Application of organic manure substantially enhances the yield over control (Abraham et al., 2002). The chemical properties of soil are affected by the addition of organic matter (OM) through different organic amendments and change in pH varies with the nature of OM (Walker et al.,2004). Biochar is fine grained charcoals produced from pyrolysis of plants and waste feed stocks high in organic carbon and hold some important plant nutrients like C, K, N, S, Ca, Mg, Al, Na, and Cu, which significantly affect crop growth. Biochar improve soil and enhance crop yield through a number of mechanisms including increased nutrient and moisture retention, improved soil structure and encouraged microbial activity, particularly when applied to poor or degraded soils (Blackwell et al., 2009). It also increase soil pH and CEC (Masulili et al., 2010), soil water holding capability, soil aggregation and soil vigor (Chan et al., 2008). The long term benefits of biochar include less leaching of nutrients and enhance their retention by the soil and easy uptake by the plants and thus promote the growth of plants (Lehmann et al., 2011). Application of BC, FYM and mineral N has a substantial effect on crop growth and yield as well as soil nutrient availability. Keeping in view the above facts the experiment was designed with the objectives to evaluate the residual and combine effect of biochar, FYM and mineral Non berseem productivity and soil quality under the agro climatic condition of Peshawar-Pakistan.

MATERIALS AND METHODS

To investigate the residual effect of biochar (BC) on berseem productivity and soil quality under different nitrogen and farmyard manure (FYM) levels, a field trail was performed at Agronomy Research Farm, the University of Agriculture Peshawar during winter 2013–2014. In the course of experiment, the effects of previously supplied biochar to maize crop at three levels such as 0, 25 and 50 t ha-1 were studied. In contrast, FYM was applied before sowing @5 and 10 t ha-1at the time of sowing in combination with nitrogen applied in two levels (15 and 30 kg ha-1) in two equal splits, half at sowing and remaining after first cut of berseem. A control was also included in the experiment for comparison. Berseem seed of local variety "Palosi Type" was sown on October, 15th, 2013@ 25 kg ha-1. The experiment was laid out in randomized complete block design with three replications having plot size of 4.5 m by 4 m. With the help of cultivator ,field was ploughed twice deeply up to 30 cm followed by planking. Ploughing was done carefully for non-disturbance the previous layout of the experiment. Seeds of berseem were sown in standing water (flooding) and later on the field was irrigated as per requirement of the crop. All other cultural practices were applied uniformly to each experimental unit. Data were recorded on plant height (cm), fresh and dry fodder yield (t ha-1) and some soil properties i.e. soil carbon, soil pH, soil electrical conductivity and soil total nitrogen.

The data on plant height was recorded by measuring the plant from the ground to top with the help of meter rod. Fresh fodder was cut in a unit area (1m-2) at three random places in each plots and weighed and then dried in sun for recording dry fodder yield and then converted to t ha-1 using standard formula. Soil pH was recorded using the McLean (1982) method in soil water suspension (1:5) with the help of lonalyzer/901 (ORION RESEARCH). soil EC was recorded using EC meter, Soil carbon was recorded with the procedure described by Nelson and Somers (1982), soil total nitrogen was determine by “Kjeldhal” method described by Bremmer and Malvaney (1982). Data obtained were statistically analyzed using analysis of variance techniques appropriate for randomized complete block design and least significant difference test was carried upon significant F-test (Jan et al., 2009).

RESULTS

Plant height (cm)

Data regarding plant height are presented in Table 1. Statistical analysis of the data revealed that plant height was significantly affected by previously applied BC, FYM and N. All interactions were found not significant. Planned mean comparison indicated that previously applied BC resulted in higher plant height as compared to no BC plots. Likewise, prominently higher plant height was observed in treated plots equated to control plots. Short stature plants (75.08 cm) examined in no BC plots whereas long stature plants (90.25 cm) were studied with biochar @25 t ha-1 Incorporation of FYM @10 t ha-1 resulted in higher plant height (86.72 cm) than 5 t ha-1 (82.78 cm). Higher plant height (88.33 cm) was recorded in plots treated with 30 kg ha-1 N as compared to 15 kg N ha-1 (81.17 cm).

Fresh fodder yield (t ha^{-1})

Data concerning fresh fodder yield are reported in Table 1. Analysis of the data revealed that fresh fodder yield was significantly affected by BC, FYM and N application levels. No significant differences were recorded for interactions. Planned mean comparison indicated that contrast between control vs rest and biochar vs no biochar were significant. The BC vs no BC contrast indicated that fodder yield was higher in BC plots as compared to no BC plots. Similarly, contrast of control vs rest exhibited that treated plots resulted in higher fresh fodder yield than control plots. Fresh fodder yield increased in plots treated with 50 t ha-1 BC (100 t ha-1).Boosted fresh yield (89 t ha-1) of berseem fodder was noted with 10 t ha-1 FYM. Likewise, mineral nitrogen at the amount of 30 kg ha-1enhanced fresh fodder yield(88 t ha-1).

Dry fodder yield (t ha^{-1})

Data on dry fodder yield are reported in Table 1. Statistical analysis of the data revealed that dry fodder yield was notably affected by BC, FYM and N application rate. All interactions were not significant. The biochar vs No BC contrast indicated that dry fodder yield was higher in BC plots (31 t ha-1). Likewise, control vs rest contrast showed that treated plots produced higher dry fodder yield as compared to control. Plots treated with 50 t ha-1 BC produced higher dry fodder yield (33 tha-1), followed by 25 t ha-1 (29 t ha-1) and lower (24 t ha-1) was recorded in no BC. High level of FYM @10 t ha-1produced higher dry fodder yield (30 t ha-1) while FYM 5 t ha-1 produced lower fodder yield (27 t ha-1). Nitrogen 30 kg ha-1 resulted higher (29 t ha-1) dry fodder yield than 15 kg N ha-1.

Soil C (%)

Individual effect of biochar and FYM significantly ($p<0.05$) influenced soil C content but the effect of mineral N application on soil C content was non-significant (Table 2). Interaction between biochar x FYM (p<0.0) (Fig. 1a) and biochar x N (p<0.0) (Fig. 1b) to affect soil C content were significant while the interactions N x FYM and BC x FYM x N were non-significant. For soil C content all contrasts (control vs rest and biochar vs no biochar) were significant (p<0.0 and p<0. , respectively). Soil C content was 49% higher in plots treated with high amount of BC (50 t ha-1) over the BC at the rate of (25 t ha-1). Similarly 27 % higher C content was observed in plots where FYM was incorporated@10 t ha-1 as compared to 5 t ha-1. Comparing the Control vs rest, soil C was 250 % higher in fertilized plots compared to the Control. Interaction between biochar and FYM showed that soil C content 27 % enhanced with application of BC @ 50 t ha-1 and FYM @10 t ha 1 compared to BC @ 25 kg ha-1 and FYM @ 5 t ha-1 whereas 15 % and 7 % higher soil C content was recorded at both levels of nitrogen (15 and 30 kg ha-1) in biochar applied plots at 25 and 50 t ha 1.

Soil Nitrogen (mg/kg)

Data on soil total soil N content are given in Table 2. The table clearly indicated that soil total nitrogen was significantly increased by farmyard manure and previously BC application but mineral N induced no effect. All the interactions found non-significant. All the contrasts remained significant. Samples taken from plots received high amount of biochar 50 t ha-1 had high N content followed by plots treated with 25 t ha-1biochar whereas lower N content was noted in BC control plots. Similarly, more content of soil N was observed in samples taken from 10 t ha-1 FYM incorporated plots and lower with 5 t ha-1.

Soil pH and EC (mS/cm)

Data of EC and soil pH are presented in Table 12. Residual BC induced a significant variation in pH and EC of soil, while pH only affected by FYM while EC remained unchanged. Similarly, significant interaction for BC x FYM was noted for soil pH and EC, the BC x FYM was found significant for soil PH while rest of the interactions were found non-significant.All contrasts remained not significant only EC was found significant in BC plots. EC and pH increased as BC level increased from 25 to 50 t ha-1. Over no BC plots higherelectrical conductivity (EC) and pH was recorded in samples collected from plots previously received with 50 t ha-1treated with 50 t ha-1 biochar as compared to no BC applied plots. Incorporation of FYM decreased soil pH and lower soil pH was recorded in 5 t ha-1 FYM applied plots as compared to 10 t FYM applications.

Table 1. Plant height (cm), fresh and dry fodder yield (t ha-1) of berseem as affected by biochar (residual), FYM and mineral nitrogen application.

Biochar (t ha^{-1})	**Plant height (cm)**	**Fresh fodder yield (t ha^{-1})**	**Dry fodder yield (t ha^{-1})**
0	75.08 b	72 c	24 c
25	90.25 a	86 b	29 b
50	88.92 a	100 a	33 a
L.S.D (0.05)	6.6	2.0	1.0
FYM (t ha^{-1})			
5	82.78	82	27
10	86.72	89	30
Significance Level	ns	**	**
Nitrogen (kg ha^{-1})			
15	81.17	83	28
30	88.33	88	29
Significance Level	*	**	**
Control vs Rest			
Control	63.33	60	20
Rest	84.75	86	29
Significance Level	**	**	**
Biochar vs No Biochar			
Biochar	82.67	93	31
No Biochar	88.92	72	24
Significance Level	*	**	**
Interactions			
BC x N	ns	ns	ns
BC x FYM	ns	ns	ns
N x FYM	ns	ns	ns
BC x N x FYM	ns	ns	ns

Means of the same category followed by different letters are significantly different from one another at 5 level of probability.
*=Significant at 5 % level of probability. ns = non-significant

Table 2. Soil pH, EC (ms/cm), soil carbon (%) and soil total N(mg/kg) as affected by biochar (residual), FYM and mineral nitrogen application.

Biochar (t ha^{-1})	Soil pH	Soil EC ($mS.cm^{-1}$)	Soil Carbon (%)	Soil total N ($mg.kg^{-1}$)
0	7.26 b	2.575 c	0.770 c	0.07 c
25	7.19 c	2.792 b	1.476 b	0.085 b
50	7.38 a	3.542 a	2.210 a	0.117 a
L.S.D (0.05)	0.08	0.07	0.05	0.15
FYM (t ha^{-1})				
5	7.23	2.97	1.31	0.13
10	7.32	2.97	1.66	0.53
Significance Level	*	ns	*	*
Nitrogen (kg ha^{-1})				
15	7.31	2.97	1.43	0.29
30	7.24	2.97	1.54	0.37
Significance Level	ns	ns	Ns	ns
Control vs Rest				
Control	7.33	2.07	0.43	0.06
Rest	7.28	2.97	1.49	0.33
Significance Level	ns	ns	*	**
Biochar vs No Biochar				
Biochar	7.28	3.17	1.8	0.46
No Biochar	7.26	2.58	0.8	0.07
Significance Level	ns	*	*	*
Interactions				
BC x N	ns	ns	*	ns
BC x FYM	*	*	*	ns
N x FYM	ns	ns	Ns	ns
BC x N x FYM	ns	ns	Ns	ns

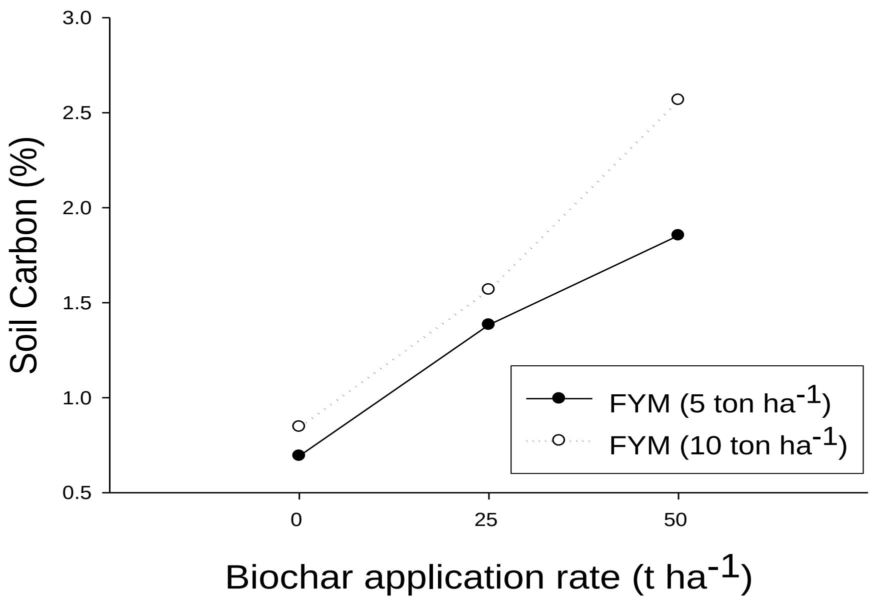

Fig 1(a). Interaction of BC and FYM for soil carbon (%)

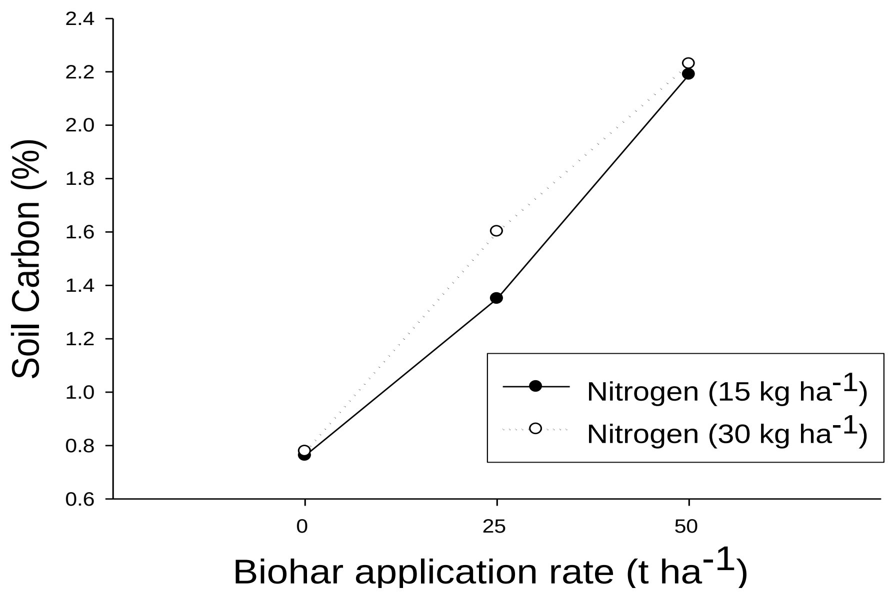

Fig 1(b). Interaction of BC and N for soil carbon (%)

DISCUSSION

Livestock play a significant role in the economy of Pakistan which added 51.8% agriculture value and 11.3 % gross domestic product (Government of Pakistan, 2010-2011). In Pakistan, especially in Khyber Pakhtunkhwa, the major constraints for promoting livestock productivity are low fodder production and lesser feed availability. During shortage period of feed in winter months animals' nutritional requirements endure through berseem (Sarwaret al., 2002). Nitrogen significantly increased fresh and dry fodder yield of berseem. It could be due to the fact that nitrogen is an integral part of chlorophyll and many enzymes responsible for plant growth which promotes vegetative growth. Another possible reason for higher fodder yield of berseem probably due to nitrogen mediates the utilization of phosphorus and potassium and other essential elements in plants which results in improved vegetative growth (Singh and Yadav,2004). At specific level of fertilizers application, the dry matter accumulation increases depending upon presence of nitrogen and phosphorus in the soil. These results are in agreement with Trivediet al.(2010) and Hoodaet al. (2004) who also reported increase in fresh and dry fodder yield with increasing level of nitrogen. Incorporation of farm yard manure @10 t ha-1 produced higher fresh and dry fodder yield. The possible reason for more biomass production of berseem might be the fact that farm yard manure developed the organic matter content of the soil which increased soil fertility and crop productivity. Farmyard manure promotes nutrients availability and increased crop biomass. Likewise, Aziz et al.(2010) FYM enhanced dry matter production by increasing growth and development. Increased in fodder yield with biochar amendment plots might be due to the increase in soil fertility and reduced leaching. Similarly, biochar application increased the yield (46%) and biomass production by 39% (Marco et al., 2006).Soil micro-organisms population and activities were increased by incorporation of organic manures which promotes nitrogen fixation. Being a nodulated crop, berseem does not need high dose of mineral nitrogen as it can fix atmospheric nitrogen through symbiosis. However, to ensure rapid microbial population and mineralization, initially starter dose of mineral nitrogen application is needed. Plant stature affects crop in several ways and a key component of forage yield also have direct effect on biological yield. Application of higher rates of N (30 kg ha-1)produced long stature plants. It might be due to the favorable effect of N on promoting cell enlargement and cell division (Iqtidaret al., 2006).Farmyard manure and biochar significantly increased the amount of total nitrogen in soil whereas control plots resulted in lower content of soil nitrogen. Islamet al. (2006) found that crop residue slightly increased nitrogen content than without residue management. Soil carbon content was significantly improved with FYM incorporated plots and biochar amended plots as compared to control plots. Mineralization and decomposition of biochar increased due to application of mineral N application hence, biochar increase organic matter content and soil carbon content (Brodowskiet al., 2007). FYM significantly enhanced carbon content in soil. This increase could be attributed due to the synergetic effect of manures on soil physical and chemical properties and accelerate the activities of soil micro organisms. Likewise, Huang et al. (2007) reported that increased in FYM application from 0 to 15 t ha-1 significantly increased soil carbon content. Organic manures enhanced soil health and promotednutrient use efficiency (Chaudhryet al., 1998). Losses of soil nitrogen through leaching can be reduced with incorporation of FYM. Similarly, Sharif et al. (2004) found that compost and organic manure had significant variation in soil total N content. Similarly, Rasheed et al.(2003) stated that organic manures application enhanced N in soil as compared to soil where no amendment was practiced. Biochar application @50 t ha-1significantly increased Ca and Mg content in soil. Positively charged particles of soil (Ca and Mg) are more important dynamic involved in soil fertility. The reduction in soil pH with FYM could be associated with the release of H+ as result of various organic acids production during decomposition. Similarly, Sharif et al. (2004) reported that incorporation of organic manure reduced soil pH.

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