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Research Article

Physical Fertility of an Ultisol Enhanced by Application of Urine-Decomposed Rice Husk Dust in Abakaliki Southeastern Nigeria

Ejaz Ul Haq* and Zahir Shah

Department of Soil and Environmental Sciences, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Pakistan

***Corresponding Author:** Ejaz Ul Haq, Department of Soil and Environmental Sciences, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Pakistan.

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Abstract

A field experiment was conducted to investigate the integrated effect of biochar and PK fertilizers on soil properties and maize yield at the research Farm of The University of Agriculture, Peshawar during summer 2015. The experiment was laid out in Randomized complete block design with three replications. The different levels of biochar were 0, 5, 10 and 15 t ha^{-1} and PK fertilizers were 50 - 30 and 100 - 60 kg ha^{-1}. Data on yield parameters, biological yield, plant height, grain yield, stover yield, thousand grain weight, and concentrations of NPK in maize grain, stover and soil along with bulk density, pH, EC and organic matter were recorded. The results showed that maize yield and yield components were significantly increased with increasing P and K levels. Maximum biological yield (7871 kg ha^{-1}), plant height (183 cm), stover yield (5402 kg ha^{-1}), grain yield (2702 kg ha^{-1}), thousand grain weight (252g) were recorded in treatments receiving P and K at the rate of 100 - 60 kg ha^{-1}. Sole application of biochar had no significant effect on maize yield. However, application of biochar significantly decreased soil bulk density with the lowest value of 1.4 g cm^3 was obtained at 15 t ha^{-1}. Results further showed that soil organic matter, total nitrogen and ABDTPA extractable P and K were also improved with the application of biochar and PK fertilizers. Total NPK uptake was also significantly increased with increasing PK fertilizers levels. However, the combined use of biochar at 15 t ha^{-1} and PK fertilizers at 100 - 60 kg ha^{-1} was better than sole application of biochar or PK fertilizers. These results suggested that combine application of biochar and PK fertilizers improved soil characteristics and yield and nutrients of maize. Application of biochar at 15 t ha^{-1} along with 100 kg P and 60 kg K is recommended for higher maize yields in the prevailing soil and environmental conditions.

Keywords: Biochar; PK Fertilizers; Maize; Soil Properties

Introduction

Maize is a principal summer crop cultivated in Pakistan. It is multipurpose cereal crop used as food, feed and raw material for the human, animals and industries respectively [1]. In Pakistan during 2008 - 2009 total area at national level under maize cultivation was 1052 thousand hectares with a total production of 3605 thousand tons with average grain yield of 3427 kg ha^{-1}. In Khyber Pakhtunkhwa the land under maize cultivation was 509 thousand hectare with overall average production of 904 thousand tons with an average grain yield of 1776 kg $hectare^{-1}$ [2]. In developing countries, maize is directly used and serves as principal diet for about 200 million peoples. In processed form it is used as starch and fuel. Starch in turn enzymatic conversion into products such as dextrin, sorbic, sorbitol and lactic acid. It is also used in domestic items such as ice cream, syrup, shoe polish, glue, beer, fireworks, ink, batteries, mustard, cosmetics, aspirin and paint [3]. Maize is the significant source of edible oil. Pakistan uses an enormous expanse of overseas exchange to import edible oil every year. The main product of maize are dextrin, solid glucose, powder glucose liquid glucose, and crystalline dextrose are prepared [4].

Maize is an extensive crop having higher potential than other cereals crops to consume huge quantity of nutrients from the soil during growth [5]. Intensive cultivation, growing of exhaustive crops, use of unnecessary and insufficient fertilizers supplemented by limited use of organic manures have made the soils not only defici-

ent in the nutrients, but also deteriorated the soil health, productivity is largely dependent on nutrient management. Maize needs fertile soil to produce optimum yield potential. Additions of organic manure not only supply the plant nutrients but also improve soil health [6]. The decrease in maize yields is a result of limited use of fertilizer application and nitrogen use efficiency. Degraded soils have lower mineral availability as a result of lower cation exchange capacity. These soils have low pH levels which result in large amount of nutrient loss especially nitrogen through leaching. Limited use of organic matter generally results in sandy soils [7].

Biochar is a solid fine grained porous material obtained from the hermo chemical conversion of plant biomass at relatively low temperature (350 - 600°C) in a low oxygen supply [8]. It consist of various elements like hydrogen (H), nitrogen (N), oxygen (O_2), sulphur (S), carbon (C) and ash in different quantities [9]. The quality which make biochar attractive as soil amendment is being porous highly (Arias., *et al.* 2008).

Applying biochar as soil amendment can also enhance soil fertility and reduces carbon evolution [10]. Formation of biochar from biomass increases carbon stability and then applied to soil the soil. Similarly, it also reduces increased level of carbon dioxide in atmosphere.

It also contains large quantity of corbon which is resistant to rapid degradation so it sequester corbon [11]. Application of biochar can alter soil physical property [12]. As soil application it can improve the fertility of agricultural soils [13].

Biochar Application Improves soil properties like increased water holding capacity, enhanced CEC, higher pH, reduce nutrients leaching and provide nutrient to the soil by itself [14]. Amending biochar to the soil increases crop yield. Applying biochar as soil amendment may improve microbial growth [15]. Amendment of biochar as soil conditioner lowers the fertilizer need as it attracts and release nutrient slowly for the later use of crop. Also, it improves the water holding capacity and hence safeguarding crop against water stress, also lower the methane emission from paddy soil.

Phosphorus is the major nutrient needed by the plant in large quantity for greater yield. It concern primarily with propagative size increase. In most soils phosphorus is a yield reducing nutrient [5]. Potassium is necessary to increase root growth, tolerance to drought, enzymatic activities, photosynthesis, cellulose formation, transportation of sugar and starch. It also improve protein content of plants, maintain turgor, decrease water loss, and protect plants against nematodes and diseases [16]. In Pakistan most of soils contain relatively greater amounts of total K, however only a small portion is in the available form to the plants. Most of the soils have < 150 mg kg^{-1} of exchangeable K, which is considered a critical limit for soil K deficiency [17].

The cultivable land is a restricted resource and its extension is not possible, thus better crop production on sustainable basis is a great concern. There is a diring need of developing new strategies like combined use of organic and inorganic fertilizers to the soil, in order to preserve and protect the current soil resources and to feed the present and future generations. The issue is directly related to maintain the soil quality, refers to the capacity of the soil to support better crop growth without resulting in soil degradation and impairing the environment. This study was therefore proposed to evaluate the combined effect of biochar and PK fertilizers on soil properties and maize yield in Peshawar valley.

Objectives

Main objective

To assess the integrated effect of biochar and PK fertilizer on yield of maize and soil quality.

Specific objectives

1. To evaluate the effect of biochar alone and in combination with PK fertilizer on yield and yield components of maize.
2. To determine the effect of combined use of biochar, P and K fertilizers on nutrient uptake of maize.
3. To evaluate the effect of biochar, P and K fertilizers on soil properties (bulk density, SOM and total nitrogen).

Review of Literature

Hussain., *et al.* [18] performed a field experiment to evaluate the effect of different levels of phosphorus and potassium on the yield and yield components of maize. The experiment was laid out in RCB Design with four replications in a split plot arrangements, with two varieties, i.e. Azam and Kissan-90. There were three levels each of P and K i.e. (30, 60 and 90 kg ha^{-1}). The results suggested that higher rates of potassium and phosphorus fertilizers have significantly increased the weight $ear^{-1,}$ grains ear^{-1} and 1000-grains weight. The results further showed that K interacted significantly with maize varieties and phosphorus levels, while the sole, combi-

ned application of phosphorus with varieties, and potassium levels was found significant for grain yield of maize. It is concluded from the results that variety Azam with 90 kg P ha^{-1} and 60 K kg ha^{-1} performed well for maximum grain yield as compared to variety Kissan-90.

Masood., *et al.* [4] investigated the effect of phosphorus (P) levels 0, 50, 100, 150 and 200 kg ha^{-1} on yield of maize crop. Their results showed that P levels significantly improved yield and yield components. His results further showed that the maximum thousand grain weight (241g), grain yield (2415 kg ha^{-1}), biological yield (7999 kg ha^{-1}) and number of grain cob^{-1} (327) were obtained with the application of P at the rate of 100 kg ha^{-1} as compared to the control plots. They concluded that for maximum grain yield phosphorus at the rate of 100 kg ha^{-1} should be applied in the agro-ecological conditions of Peshawar.

Ali., *et al.* [19] carried out a field experiment to investigate the effect of different nitrogen sources (farm yard manure, biochar and mineral nitrogen) on yield and yield components of maize crop. Their results suggested that yield components of maize crop were significantly improved by all the N sources. Results further showed that nitrogen application produced maximum plant height and number of grains ear^{-1}, while maximum number of rows ear^{-1}, grain yield, biological yield and thousand grain weight were obtained from combined application of biochar and mineral fertilizer. The study suggested that combined application of biochar (30 t ha^{-1}) and mineral nitrogen (75 kg ha^{-1}) improved yield and yield components of maize crop.

Arif., *et al.* [20] investigated the effect of different nitrogen sources (urea, farm yard manure and biochar) on weeds control and maize phenology. their result shown that all the parameters were significantly increased. their results showed that combined application of biochar (25 ton ha^{-1}), nitrogen (150 kg ha^{-1}) and FYM (10 ton ha^{-1}) delayed tasseling, silking and maturity in maize crop, while weeds population were controlled with the combine application of biochar (25 ton ha^{-1}) and FYM (5 ton ha^{-1}). These findings suggested that combined application of biochar (25 ton ha^{-1}) and FYM (5 ton ha^{-1}) improved maize growth and efficiently weed controlled in maize.

Imran., *et al.* [21] carried out a field experiment on integrated use of biochar (0 and 15 t ha^{-1}) and phosphorus from two sources i.e. organic (farmyard manure and poultry manure) and inorganic source (SSP) to improve maize productivity. biochar was applied to main plots, while phosphorus from two organic sources with the ratios (100%, 75%, 50% and 25%) the remaining was compensated from SSP to make a sum of 100 kg Phosphorus ha^{-1}. Study shown that maximum 1000 grains weight, grains ear^{-1} and grain yield (285.6g), (366) (4013 kg ha^{-1}) were observed in the treatments receiving 25t biochar than in the control. The study further concluded that by combining 50% phosphorous from organic and 50% from inorganic source given maximum results.

Zhang., *et al.* [22] investigated the effect of biochar (0, 10, 20 and 40 t ha^{-1}) on rice production and greenhouse gases emissions. They applied biochar before rice transplantation and the emission of greenhouse gases (methane, carbon dioxide, and nitrous oxide) were observed with close chamber method at seven days interval throughout rice growing season. It was concluded from their findings that biochar had significantly decreased greenhouse gases and improved soil pH, total nitrogen, and organic corbon (36.9% to 18.6%). Soil bulk density was reduced and wheat yield was improved by biochar addition. The results indicated that biochar addition improved rice productivity, soil organic, soil pH, carbon, total nitrogen but reduced soil bulk density.

Rashid and Iqbal [23] carried out a field study on clay loam soils to investigate the effect of phosphorus fertilizer on the yield and quality of maize fodder. They found that application of phosphorus at 53 kg ha^{-1} improved the yield and maize fodder up to 57 kg ha^{-1}. The study further suggested that P concentration, dry matter, crude protein, fiber and ash content was also enhanced with phosphorus application.

Masto., *et al.* [24] carried out a field experiment to assess soil nutrients, biological properties and the yield of maize crop as effected by biochar and lignite fly ash. The results depicted that with application of biochar and lignite fly ash to soil improved the maize grain yield (11.4%, 28.1% respectively), phosphorus (110%) and potassium (64%) due to the presence of plant nutrients in lignite fly ash and biochar. The results further suggested that combined use of lignite fly ash and biochar increased microbial biomass (25.3%), fluorescein hydrolases activity (12.3%), alkaline phosphatase (32.2%) and soil enzymes like dehydrogenase activity (60.7%). The study concluded that the increase in yield and soil nutrients may be due to the sorption of the organic matter to mineral surface and pH-buffering which provide more reactive network for water, air and nutrient contacts in the soil.

Widowati and Asnah [25] conducted a field experiment to assess potassium fertilizer uptake and leaching, efficiency and effectiveness of K fertilization as influenced by biochar with various treatment combinations (without biochar and KCl, K1 200 kg ha^{-1} KCl, BK0 biochar, without KCl, BK1/4 biochar + 50 kg ha^{-1} KCl, BK 1/2 biochar + 100 kg ha^{-1}KCl, BK 3/4 biochar + 150 kg ha^{-1}KCl, and BK1 biochar + 200 kg ha^{-1} KCl). The results indicated that biochar application increased the availability of K by (14 - 184%), P (179 - 208%), total N (39 - 53%), Ca^{++} (61 - 70%) and K^{+} (69 - 89%). The study further suggested that sole application of biochar increased the maize yield by 14% over sole application of KCl fertilizer. From findings it was concluded that integrated use of KCl and biochar (50 kg ha^{-1}) resulted in maximum yield (137%).

Carter., *et al.* [26] conducted a pot experiment on soil properties, lettuce and cabbage plant growth as influenced by biochar application. The results shown that soil pH, some trace metals and exchangeable cations such as Mg, Ca and K were improved with application of biochar at 25, 50 and 150 g kg^{-1} to pot compared to no biochar treatments. The study further revealed that root biomass, the final biomass, plant height and number of leaves were also increased biochar application. The maximum biomass of 903% was observed in biochar treatments followed by 483% with biochar and fertilizer integration at same level.

Arif., *et al.* [27] carried out a two year field experiment on maize crop in order to investigate the integrated effect of biochar and legumes in summer gap to improve the productivity of cereal based cropping system. Wheat-maize-wheat cropping pattern was charted with the adjustment of legumes in summer gap. Legume crops (mungbean, cowpea and sesbania) with a control were grown in the summer gap with and without biochar application. There were two levels of biochar (0 and 50 t ha^{-1}) and four levels (0, 90, 120, 150 kg ha^{-1}) of N fertilizer applied to succeeding maize crop. The study revealed that application of biochar had significantly improved plant height and grain yield. The plots previously sown with legumes produced taller plants and high number of grains ear^{-1}. Nitrogen application increased plant height, number of grains ear^{-1}, thousand grains weight, grain and biological yield. The study further revealed that integrating biochar and legumes were found efficient for increasing yield, productivity and profitability.

Kumar., *et al.* [28] carried out a field experiment to investigate soil health as influenced by biochar. The results suggested that below ground corbon was improved by biochar addition and increased soil fertility with added bonus of climate change mitigation with reduced pollution and emission of trace gases from the soil. With the application of biochar microbial activity, soil properties, soil organic and inorganic compounds were improved. Soil structure, crop yield, soil aeration and plant available water in soil was increased which in turn enables the plant to live longer with shortage of water.

Ali., *et al.* [29] performed field experiments to investigate the integrated effect of synthetic fertilizers, farmyard manure and biochar. The results of the study depicted that grains $spike^{-1}$, spikes m^{-2}, grain yield, thousand grain weight, phosphorus use efficiency, grain phosphorus uptake and biological yield was increased by 5.6%, 6.64%, 9.96%, 3.73, 29.03%, 19.67%, and 15.36% with the application of biochar over no biochar treatments. The results also showed that soil C (carbon), P (phosphorus) and K (potassium) by 54.02, 61.39 and 18.41%, with application of biochar. The results further shown the significant increase in soil phosphorus, calcium, and potassium and yield component with farmyard manure at 10 t ha^{-1}. It was concluded from the results that combination of biochar with farmyard manure or mineral nitrogen enhanced yield components of wheat and soil quality.

Usman., *et al.* [30] conducted a field experiments to evaluate the effect of various levels of NPK fertilizer on yield of maize-soybean intercropping and growth parameters. The experiment consisted of two factors: sole and intercrops (cropping system at two levels) and NPK fertilizer at three levels (0, 150 and 300 kg ha^{-1} of NPK 20:10:10). The experiment was laid out in RCB (randomized complete block design) with split plot arrangement three times replicated. The cropping systems were allocated to the main plots while the fertilizer levels were in the sub plots and concluded that, application of fertilizer significantly improved the yield and yield components and growth parameters of the crops in both seasons. Increasing levels of NPK fertilizer resulted in significant increase in the yield and growth parameters of maize and soybean in both years. Intercropping resulted in yield advantage in 2013 and 2014 showing 35% and 26% land saved respectively. Furthermore, the study suggested that productivity advantage obtained from the intercropping.

Materials and Methods

A field experiment was carried out to evaluate the integrated effect of biochar and PK fertilizers on maize yield and soil properties at the research Farm of the University of Agriculture Peshawar, during summer 2015. The experiment was laid out in a RCB design with three replications. The size of treatment plot was kept 4m

by 3.5m. There were two factors viz., biochar (mix wood biochar) and phosphorus (SSP) + potassium (SOP) fertilizer. The levels of biochar applied were (0, 5, 10 and 15 t ha^{-1}), and PK fertilizers at (0, 0), (50, 30) and (100, 60 kg ha^{-1}) respectively. The recommended dose of PK fertilizers for maize is 100, 60 kg ha^{-1} respectively.

The N at 150 kg ha^{-1} as urea was applied as a basal dose to all treatment plots.

The chemical composition of biochar is given in the table.

pH	E.C (dsm^{-1})	N (%)	P (%)	K (%)	C (%)
8.1	3.43	2.23	2.3	2.43	54

Table a

The experiment was comprised of the following treatment combinations.

Treatment	Biochar (t ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T1	0	0	0
T2	0	50	30
T3	0	100	60
T4	5	0	0
T5	5	50	30
T6	5	100	60
T7	10	0	0
T8	10	50	30
T9	10	100	60
T10	15	0	0
T11	15	50	30
T12	15	100	60

Table b

Maize variety Azam was sown in rows 75 cm apart with plant to plant distance 10 cm. biochar and fertilizers were applied before sowing and thoroughly mixed into the soil. Remaining ½ N was applied at knee height stage. All recommended cultural practices were followed during the growing period. Data was recorded on plant height, biological yield, stover yield, thousand grain weight and grain yield, Grain and plant samples were collected from each treatment plot at harvest and analyzed for NPK to determine the total nutrient uptake in maize. Data on 1000 grain weight was recorded. Soil samples (0 - 15 cm) was collected from each treatment plot after crop harvest and analyzed for soil fertility parameters (SOM, total N, total P, total K, and bulk density).

Agronomic Parameters

Data was recorded on the following parameters

1. **Plant height:** From each treatment plot, five maize plants were selected randomly at maturity and height was measured in centimeters from soil surface to top and average plant height was recorded.
2. **Thousand grain weight (g):** 1000 grain weight was recorded by randomly counting 1000 grains and weighed by using electronic balance.
3. **Biological yield (kg ha^{-1}):** Data on biological yield was recorded by weighing dry plants harvested from two central rows of each treatment and then converted into kg ha^{-1}.
4. **Grain yield:** Grain yield was recorded subsequently after shelling dry ears of two central rows from each treatment and transformed into kg ha^{-1}.
5. **Strove yield (kg ha^{-1}):** Stover yield was measured as follow:

   Total biological yield - grain yield = strove yield

Laboratory Analysis

Determination of soil pH [31] and E.C (Richards 1954)

The pH and E.C of soil samples was determined in 1:5 soil suspension. Ten gram of soil sample was mixed with 50 ml of distilled water and shaken for 30 minutes. The pH of the suspension was read using pH meter and E.C using E.C meter after proper calibration of the instruments.

Bulk density [32]

In this method the core sampler (100 cm^3) was inserted in soil to fill the core completely with care to avoid the compression. Soil was removed from the sides of the core. The obtained soil from core sampler was dried at 105^0C. The bulk density was calculated as;

$$\text{Bulk density} = \frac{mass}{volume}$$

Determination of extractable P and K [33]

The extractable P in soil sample was determined in AB-DTPA extract. 10g soil was shaken with 20 ml of AB-DTPA solution for

15 minutes. After filtration 5 ml ascorbic acid was added to one ml aliquot and volume was made up to 25 ml. After color development aliquot was read for P on spectrophotometer at 880 nm. However, Potash was read directly in the AB-DTPA extract on Flame photometer.

Determination of soil Organic matter [34]

One gram of air dried soil sample was treated with 10 mL of 0.5 N $K_2Cr_2O_7$ and 20 ml of concentrated H_2SO_4. After 30 minutes, 200 ml of distilled water added and filtered. After filtering, 2 - 3 drops of orthophenantholein was added and titrated against 0.5N $FeSO_4.7H_2O$. The volume of $FeSO_4.7H_2O$ consumed was noted and calculation were done to measure the percent organic matter in the soil by following formula:

$$\%SOM = \frac{\text{meq of K2Cr2O7} - \text{meq of FeSO4}}{\text{weight of soil sample x 0.69}}$$

Determination of total nitrogen [35]

Total N in soil sample was determined by the Kjeldhal Method of Bremmer [35]. In this method, 0.25g of the finely ground soil sample was digested with 3 ml of concentrated H_2SO_4 in the presence of K_2SO_4, $CuSO_4$ and Se in 100: 10: 1 ratio. After cooling, the digest was distilled with 20 ml of 40% NaOH solution into 5 ml boric acid mix indicator. The distillate was titrated against 0.01M HCl and the amount of N was determined as 1 ml of 0.01M HCl equals 140 ug N.

$$\text{Total\% N} = \frac{(\text{sample} - \text{blank}) \text{x } 0.005 \text{x } 0.014 \text{ x } 100 \text{ x } 100}{\text{weightofsoilsample}}$$

Plant Analysis

Determination of total N in plant sample

Total nitrogen in plant sample was determined by the kjeldhal method of Bremmer [35] as described for determining total N in soil samples.

Determination of P and K in plant sample

Total phosphorus and potash in plant samples was determined by the wet digestion method using perchloric and nitric acids as described by Kue [36]. In this method, 1.0g plant sample was digested with 10 ml of concentrated HNO3 and 4 ml of perchloric acid at 100 - 350C for 1 ½ hours. After cooling the digest was filtered and diluted to 100 ml. One ml of the digest was treated with 5 ml ascorbic acid and diluted to 25 ml with distilled water and read for P on spectrophotometer at 880 nm. Potash was read directly in the digest or flame photometer.

Statistical analysis and data management

The data was statistically analyzed by using analysis of variance appropriate for randomized complete block design. Means were compared by using LSD test at 5% level of significance, when the F-values was significant (Steel and Terrie, 1984).

Results and Discussions

A field experiment was conducted at the research farm of the Agriculture University Peshawar to evaluate the integrated effect of biochar and PK fertilizers on maize yield and yield components of maize and soil properties during summer 2015. The results obtained are presented below;

Yield and yields components

Plant height

Data obtained on maize plant height as influenced by integrated effect of biochar and PK fertilizers are presented in table 1. Analysis of the data showed that maize plant height linearly increased with increasing PK levels. The effect of PK fertilizers on maize plant height was found significant ($P < 0.05$). The taller plant height (183 cm) was recorded in the treatment receiving PK fertilizers at the rate of 100 - 60 kg ha^{-1} followed by 177 cm for treatments receiving PK fertilizers at 50 - 30 kg ha^{-1}. The lowest value of 140 cm for plant height was recorded in the control. Although not significant, sole application of biochar at 10 and 15 t ha^{-1} had increased plant height over control by 15 and 16 cm respectively.

However, the maximum plant height of 185 cm was observed in the treatments receiving biochar at 15 t ha^{-1} along with PK fertilizers at 100 - 60 kg ha^{-1}. The significance increase in maize plant height with PK fertilizers indicate the deficiency of phosphorus, potash or both in soil of the experimental site [18,23].

The non-significant effect of biochar on maize plant height is not surprising as the effect of biochar is mostly non-significant in the short term [37]. This was also only a three months experiment. Biochar may exert significant effect in the long - term [37,38].

It is therefore suggested that long - term experiment may be conducted to realize the real effects of biochar.

Thousand grain weight

Data obtained on 1000 grain weight of maize crop as effected by the integrated effect of biochar and PK fertilizers are presented in table 1. The results showed that 1000 grain weight was improved with higher levels of PK fertilizers. The results depicted that PK levels significantly increased thousand grain weight of maize but the effects of biochar and biochar x PK were nonsignificant ($P <$

0.05). It was further that on average the maximum thousands grain weight of 252 g was obtained with PK fertilizer at100 - 60 kg ha^{-1} followed by 248g obtained with PK fertilizer at 50 - 30 kg ha^{-1}. Both these values were significantly greater than that obtained for the control treatment (240g). Moreover, biochar alone or its interaction with PK levels had no significant change in the thousand grain weight of maize crop.

Although the integrated effect of biochar and PK fertilizers was non-significant but maximum thousand grain weight of 254g was obtained for the treatment receiving highest dose of PK fertilizers 100 - 60 kg ha^{-1} along with highest dose of biochar (15 t ha-1). Sole amendment of biochar at 5 and 10 t ha^{-1} had no effect on thousand grain weight compared with control. However biochar at 15 t ha^{-1} have somehow increased the thousand grain weight (243g) of maize as related to the control (240g). The significant increase in thousand grain weight of maize with PK fertilizer indicate the deficiency of phosphorus, potash or both in soil of the experimental site [18,23].

Treatment	Plant height	Thousand grain weight (g)
PK fertilizers (kg ha^{-1})	___ (cm) __	__ g __
PK1 (0 kg ha^{-1})	140 c	240 c
PK2 (50-30 kg ha^{-1})	177 b	248 b
PK3 (100-60 kg ha^{-1})	183 a	252 a
LSD (P < 0.05)	7.6 ***	6 ***
Biochar (t ha^{-1}) B1 (0 t ha^{-1})	140	240
B2 (5 t ha^{-1})	146	239
B3 (10 t ha^{-1})	154	242
B4 (15 t ha^{-1})	156	244
LSD (P < 0.05)	ns	ns
Interaction B2 x PK2	174	248
B2 x PK3	184	252
B3 x PK2	177	251
B3 x PK3	184	253
B4 x PK2	180	250
B4 x PK3	185	254
LSD (P < 0.05)	ns	ns

Table 1: Integrated effect of biochar and PK fertilizers on maize plant height and thousand grain weight.

B (biochar), PK (phosphorus and potassium), ns (non-significant), *** (significant) Different letters in columns shows significant difference between means.

Biological yield

Data obtained on maize biological yield as effected by the combined effect of biochar and PK fertilizers are shown in table 2. The results showed that biological yield was directly proportional to PK levels, i.e. yield increased linearly with increasing levels of PK fertilizers. Analysis of the data indicated that PK levels significantly increased the biological yield of maize but the effects of biochar and biochar x PK were non-significant (P < 0.05). The results further showed that higher biological yield of 7871 kg ha^{-1} was recorded in treatments with PK fertilizers at 100 - 60 kg ha^{-1} followed by 7788 kg ha^{-1} with PK fertilizer at 50 - 30 kg ha^{-1}. Both these values were significantly greater than that obtained for the control treatment 7322 kg ha^{-1}. Moreover biochar alone or its interaction with PK levels had no significant effect on biological yield of maize.

Although the integrated effect of biochar and PK fertilizer on biological yield of maize was non-significant. The maximum biological yield of 8063 kg ha^{-1} was obtained for the treatment receiving highest dose of PK fertilizers 100 - 60 kg ha^{-1} along with highest dose of biochar (15 t ha^{-1}). Sole application of biochar at 5 t ha^{-1} had no effect on biological yield compared with control. However, biochar at 10 and 15 t ha^{-1} have somehow increased the biological yield (7356, 7481 kg ha^{-1}) of maize as compared to control (7322 kg ha^{-1}) respectively.

The significant increase in biological yield of maize with PK fertilizers indicate the deficiency of phosphorus, potash or both in soil of the experimental site [18,23].

The non-significant effect of biochar on biological yield of maize is perhaps not surprising as the effect of biochar is mostly non-significant in the short term [37]. This was also only a three months experiment. Biochar may exert significant effect in the log - term [37,38]. It is therefore suggested that long - term experiment may be conducted to realize the real effects of biochar.

Grain yield

The data obtained on maize grain yield as effected by the integrated effect of biochar and PK fertilizers are presented in table 2. The results depicted that grain yield was improved linearly with increasing levels of PK fertilizers. Analysis of the data indicated that PK levels significantly improved the grain yield of maize but there was no significant effect of biochar and biochar x PK fertilizers. The results further showed that on average the maximum grain yield of 2702 kg ha^{-1} was obtained with PK fertilizer at100 - 60 kg ha^{-1} followed by 2630 kg ha^{-1} obtained with PK fertilizer at 50 - 30 kg ha^{-1}. Both these values were significantly greater than that obtain-

ed for the control treatment 2412 kg ha^{-1}. Moreover biochar only or its interaction with PK levels had no significant on the grain yield of maize. Although non - significant the maximum grain yield of 2735 kg ha^{-1} was obtained for the treatment receiving highest dose of PK fertilizers at 100 - 60 kg ha^{-1} along with highest dose of biochar (15 t ha^{-1}). Sole application of biochar at 5 and 10 t ha^{-1} had no effect on grain yield compared with control. Grain yield (2513 kg ha^{-1}) of maize was somehow enhanced as compared to the control (2412 kg ha^{-1}) with biochar at 15 t ha^{-1}.

The significant increase in grain yield of maize with fertilizer indicate the deficiency of phosphorus, potash or both in soil of the experimental site [18,23].

Stover yield

Stover yield of maize as effected by the integrated effect of biochar and PK fertilizers are shown in Table 2. The results showed that stover yield was increased with increasing levels of PK fertilizers. Analysis of the data indicated that PK levels significantly increased the stover yield of maize but the effects of biochar and biochar x PK were non-significant (P < 0.05). The results further showed that maximum stover yield of 5402 kg ha^{-1} was obtained with PK fertilizer at100 - 60 kg ha^{-1} trailed by 5224 kg ha^{-1} obtained with PK fertilizer at 50 - 30 kg ha^{-1}. Both these values were significantly superior to the control (4911 kg ha^{-1}).

Moreover, biochar alone or its interaction with PK levels did not cause any substantial modification in the maize stover yield.

Although the combined influence of biochar and PK fertilizer on maize stover yield was not prominent, the extreme stover yield of 5428 kg ha^{-1} was found for the treatment getting highest dose of PK fertilizers at 100 - 60 kg ha^{-1} along with highest dose of biochar (15 t ha^{-1}). Alone application of biochar at 5 and 10 t ha^{-1} had no influence on stover yield related with the control. However biochar at 15 t ha^{-1} have somehow increased the stover yield (4967 kg ha^{-1}) of maize related to control (4911 kg ha^{-1}). The significant increase in stover yield of maize with PK fertilizer indicate the deficiency of phosphorus, potash or both in soil of the experimental site [18,23].

Soil properties as influenced by integrated effect of biochar and PK fertilizers after maize harvest Soil pH

The results obtained on the integrated effect of biochar and PK fertilizers, on soil pH are presented in table 3. The results showed that there was no significant difference in soil pH were observed among PK fertilizers and biochar treatments. Although not significant, soil pH enhanced with increasing levels of biochar amendment. Similarly no significant difference were observed among fertilizer treatments. Moreover all the interactions were found non-significant. The maximum value of pH 7.60 was recorded in the treatments receiving biochar at 15 t ha^{-1} followed by 7.53 for biochar at 10 t ha^{-1}.

The effect of PK fertilizer alone and in combination with biochar was non-significant. The non-significant effect of biochar on soil pH might be due to existence of calcium carbonate which acts

Treatments	Biological Yield	Grain yield	Stover yield
PK fertilizers (kg ha^{-1})	____kg ha^{-1}____		
PK1 (0 kg ha^{-1})	7322 c	2448 c	4911 c
PK2 (50-30 kg ha^{-1})	7787 b	2630 b	5224 b
PK3 (100-60 kg ha^{-1})	7871 a	2702 a	5402 b
LSD (P <0.05)	306 **	26 ***	268 **
Biochar (t ha^{-1})			
B1 (0 t ha^{-1})	7322	2412	4911
B2 (5 t ha^{-1})	7343	2428	4915
B3 (10 t ha^{-1})	7357	2437	4919
B4 (15 t ha^{-1})	7481	2514	4967
LSD (P <0.05)	ns	ns	ns
Interaction			
B2 x PK2	7752	2624	5262
B2 x PK3	7924	2723	5334
B3 x PK2	7802	2631	5272
B3 x PK3	7918	2734	5418
B4 x PK2	7812	2650	5196
B4 x PK3	8063	2735	5428
LSD (P <0.05)	ns	ns	ns

Table 2: Maize biological yield, grain yield and stover yield as influenced by integrated effect of biochar and PK fertilizers.

B (biochar), PK (phosphorus and potassium), non – significant (ns), * (significant)

Different letters in columns shows significant difference between means.

as buffering agent [38,39]. Biochar may exert significant effect in long-term [37,40] as this was short-term study.

Soil EC

The data on soil EC as influenced by integrated effect of biochar and PK fertilizers is presented in table 3. Analysis of the data revealed that there was no significant influence of biochar and PK fertilizers on soil EC. Like soil pH, soil EC increased with increasing levels of biochar but the differences were however statistically non - significant ($P < 0.05$). Soil EC was not influenced significantly by PK fertilizer treatment. The interactions between biochar and PK fertilizers for soil EC were also non - significant. The maximum value of electrical conductivity 0.134 dsm^{-1} was recorded in the treatments applied with highest level of biochar at 15 t ha^{-1} followed by 0.133 dsm^{-1} biochar at 10 t ha^{-1} [37,38].

Bulk density of soil

Bulk density of soil as effected by integrated effect of biochar and PK fertilizer is given in table 3. Analysis of data revealed that application of biochar significantly decreased soil bulk density over control. However PK fertilizer alone and in integration with biochar had no effect on soil bulk density. The minimum value 1.39 g cm^{-3} for soil bulk density was noted in treatments receiving biochar at higher level (15 t ha^{-1}) followed by 1.41 g cm^{-3} for biochar at 10 t ha^{-1} (Helene Pühringer, 2016; Chaudhry., *et al*. 2016).

Treatments	Soil pH	EC	Bulk density
PK fertilizers (kg ha^{-1})	___	_(dsm^{-1})_	_(g cm^{-3})_
PK1 (0 kg ha^{-1})	7.49	0.124	1.45
PK2 (50-30 kg ha^{-1})	7.49	0.125	1.45
PK3 (100-60 kg ha^{-1})	7.50	0.125	1.44
LSD ($P < 0.05$)	ns	ns	Ns
Biochar (t ha^{-1})			
B1 (0 t ha^{-1})	7.49	0.124	1.45
B2 (5 t ha^{-1})	7.53	0.126	1.45
B3 (10 t ha^{-1})	7.60	0.133	1.41
B4 (15 t ha^{-1})	7.60	0.135	1.40
LSD ($P < 0.05$)	ns	ns	ns
Interaction			
B2 x PK2	7.53	0.128	1.45
B2 x PK3	7.54	0.129	1.44
B3 x PK2	7.57	0.132	1.41
B3 x PK3	7.58	0.133	1.41
B4 x PK2	7.59	0.133	1.39
B4 x PK3	7.59	0.134	1.40
LSD ($P < 0.05$)	ns	ns	ns

Table 3: Effect of biochar and PK fertilizers on soil pH, EC and Bulk density.

B (biochar), PK (phosphorus and potassium), ns (non – significant)

Soil organic matter

Data obtained on SOM as influenced by biochar and PK fertilizers treatments after crop harvest are presented in table 4. Investigation of the data exposed that soil organic matter was not influenced significantly by any level of biochar, PK fertilizers, or their interactions. However, increasing biochar application levels generally resulted in greater amount of organic matter.

Although the results were statistically non - significant ($P < 0.05$). The maximum rate of soil organic matter % 0.562 was recorded in treatments receiving biochar at 15 t ha^{-1} followed by 0.555% for treatments receiving biochar at 10 t ha^{-1}. The effect of PK fertilizers however have no remarkable effect on soil organic matter (Chaudhry., *et al.* 2016).

Soil total N

Data acquired on soil total nitrogen as effected by integrated of biochar and PK fertilizers are shown in table 4. Study of the data shown that soil total nitrogen was not significantly affected by any level of biochar, PK fertilizers or their interactions. However, increasing biochar application levels generally resulted in higher amount of soil total nitrogen. Although the results were statistically non - significant ($P < 0.05$).

The maximum value of soil total nitrogen 0.127% was recorded in treatments receiving biochar at 15 t ha^{-1} trailed by 0.125% in treatments applied with biochar at 10 t ha^{-1}. The minimum value for soil total N% 0.119 was observed in the control. The effect of PK fertilizers were not remarkable on soil total nitrogen (Chaudhry., *et al*. 2016).

The non-significant effect of biochar on soil total nitrogen is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38]. Biochar may exert significant in long-term [37,38]. It is therefore suggested that long term experiment may be conducted to realize the real effect of biochar.

AB-DTPA extractable Phosphorus in soil

Phosphorus concentration in soil as affected by various levels of biochar and PK fertilizers are offered in table 4. The results indicated that soil phosphorus content was not significantly increased by any level of biochar, PK fertilizers or their interactions. However increasing levels of PK fertilizers and biochar levels generally resulted in greater amount of soil phosphorus content. On average higher soil P content 2.71 mg kg^{-1} was recorded in treatments treated with PK fertilizer at 100 - 60 kg ha^{-1} followed by 2.69 mg P kg^{-1} for treatments receiving PK fertilizers at 50 - 30 kg ha^{-1}, while minimum phosphorus content 2.49 mg kg^{-1} was recorded in control [41,42]. Response of soil P content to biochar, maximum P content 2.58 mg kg^{-1} was observed in the treatments receiving biochar at 15 t ha^{-1} followed by 2.56 mg kg^{-1} for biochar at 10 t ha^{-1}, however these results were statistically non-significant ($P < 0.05$). The highest value of soil P was observed in treatments receiving integrated biochar and PK at higher level (15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively), however the results were statically non - significant.

The non-significant effect of biochar on soil phosphorus content is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38].

AB-DTPA Extractable Soil Potassium

Data acquired on soil potassium as effected by integrated of biochar and PK fertilizers are offered in Table 4. Study of the data shown that soil K content was not significantly enhanced by any level of biochar, PK fertilizers or their interactions. However, increasing K fertilizer levels linearly increased soil K content compare to control. Although the results were statistically non - significant ($P < 0.05$). The higher value of soil K 70.33 mg kg^{-1} was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 70.27 mg kg^{-1} for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} while the lowest value for soil K content 69.2 mg kg^{-1} was recorded in control [41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had somehow, improved soil K content. The highest soil K content 70.60 mg kg^{-1} was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively.

Integrated effect of biochar and PK fertilizers on Stover and grain N, P and K concentration

N concentration in maize Stover

The data on total N concentration in maize stover as affected by biochar and PK fertilizers are presented in table 5. Analysis of the data shown that total N concentration in maize stover was not significantly influenced by any level of biochar, PK fertilizers or their interactions. However, increasing PK fertilizer levels linearly increased stover N content compare to control. Although the results were statistically non - significant ($P < 0.05$).

Treatments	Organic matter	N	P	K
PK fertilizers (kg ha^{-1})	___%___		_(mg kg^{-1})_	
PK1 (0 kg ha^{-1})	0.540	0.119	2.49	69.20
PK2 (50-30 kg ha^{-1})	0.541	0.119	2.69	70.27
PK3 (kg ha^{-1})	0.542	0.121	2.71	70.33
LSD ($P < 0.05$)	Ns	ns	ns	ns
Biochar (t ha^{-1})				
B1 (0 t ha^{-1})	0.540	0.119	2.49	69.20
B2 (5 t ha^{-1})	0.545	0.122	2.53	69.47
B3 (10 t ha^{-1})	0.561	0.126	2.56	70.07
B4 (15 t ha^{-1})	0.570	0.128	2.58	70.13
LSD ($P < 0.05$)	ns	ns	ns	ns
Interaction				
B2 x PK2	0.548	0.121	2.70	70.10
B2 x PK3	0.554	0.122	2.71	70.60
B3 x PK2	0.550	0.124	2.70	70.60
B3 x PK3	0.554	0.124	2.70	69.93
B4 x PK2	0.553	0.127	2.68	70.00
B4 x PK3	0.565	0.127	2.72	70.80
LSD ($P < 0.05$)	ns ns		ns ns	

Table 4: Soil organic matter, total nitrogen, phosphorus and potassium as influenced by integrated effect of biochar and PK fertilizers.

B (biochar), PK (phosphorus and potassium), ns (non – significant).

The maximum N 0.52% was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 0.513 for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} and lowest value 0.496 N% was recorded in control [41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased stover N content.

The stover N content 0.526% was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 0.524% for biochar and PK at 10 t ha^{-1} and 50 - 30 kg ha^{-1}. However the results were statistically non - signi-

ficant ($P < 0.05$). The increase in N content in maize stover with PK fertilizers is may be due higher biological yield and grain yield.

Phosphorus concentration in maize Stover

P content in maize stover as affected by biochar and PK fertilizers are presented in Table 5. Analysis of the data shown that P content in maize stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased stover P content. The maximum P content 0.315% was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 0.281% for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} and the lowest value 0.173 P% was recorded in control [23,41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased P content in maize stover.

The maximum stover P content 0.329% was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 0.204% for biochar and PK at 10 t ha^{-1} and 50 -30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$). The non-significant effect of biochar on stover P content is perhaps not surprising as the effect of biochar is mostly non-significant in short-term [37,38]. Biochar may exert significant in long - term [37,38]. It is therefore suggested that long term experiment may be conducted to realize the real effect of biochar.

Potassium concentration in maize Stover

Potassium concentration in maize Stover as effected by biochar and PK fertilizers are presented in table 5. Analysis of the data shown that K content in maize Stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased Stover K content. The maximum K content 0.694% was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 0.651% for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} and the lowest value 0.505 P% was recorded in the control [23,41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased K content in maize Stover.

The maximum Stover K content 0.715% was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 0.706% for biochar and PK at 10 t ha^{-1} and 50 - 30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$). The non-significant effect of biochar on Stover K content is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38].

Treatments	N in maize stover	P in maize stover	K in maize stover
PK fertilizers (kg ha^{-1})		_____ (%)___	
PK1 (0 kg ha^{-1})	0.496	0.17 c	0.505 c
PK2 (50-30 kg ha^{-1})	0.513	0.28 b	0.651 b
PK3 (100-60 kg ha^{-1})	0.524	0.31 a	0.694 a
LSD ($P < 0.05$)	ns	0.023***	0.037***
Biocahr (t ha^{-1}) B1 (0 t ha^{-1})	0.496	0.17	0.505
B2 (5 t ha^{-1})	0.506	0.18	0.519
B3 (10 t ha^{-1})	0.508	0.20	0.523
B4 (15 t ha^{-1})	0.517	0.22	0.532
LSD ($P < 0.05$)	0.033	0.028	0.042
B2 x PK2	0.510	0.28	0.661
B2 x PK3	0.519	0.33	0.696
B3 x PK2	0.513	0.29	0.652
B3 x PK3	0.525	0.34	0.706
B4 x PK2	0.524	0.29	0.684
B4 x PK3	0.526	0.33	0.715
LSD ($P < 0.05$)	0.057	0.05	0.073

Table 5: Effect of biochar and PK fertilizers on N, P and K content in maize stover.

B (biochar), PK (phosphorus and Potassium), ns (non – significant), *** (significant)

Different letters in columns shows significant difference between means.

N concentration in maize grain (%)

The data on total N concentration in maize grain as affected by biochar and PK fertilizers are presented in Table 6. Analysis of the data shown that total N concentration in maize grain was not significantly influenced by any level of biochar, PK fertilizers or their interactions. However, increasing biochar level at 15 t ha^{-1} produced maximum N concentration in grain compare to control. Although the results were statistically non - significant ($P < 0.05$).

The maximum N 1.14% in maize grain was recorded in treatments receiving biochar at 15 t ha^{-1} followed by 1.07% N for treatments receiving biochar at 10 t ha^{-1} and lowest value 0.93 N% was recorded in control. [37,38]. Sole application applications of PK fertilizers also increased N content in grain over control [41,42]. There was no prominent effect of biochar and PK fertilizers integration on grain N content.

The non-significant effect of biochar on N content in mazi grain is perhaps not surprising as the effect of biochar is mostly non-significant in short-term [37,38].

Phosphorus concentration in maize grain

P concentration in maize grain as effected by biochar and PK fertilizers are presented in table 6. Analysis of the data shown that P content in maize grain was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased grain P content.

The maximum P content 0.685% was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 0.631% for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} and the lowest value 0.173 P% was recorded in control [23,41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased P content in maize grain. The maximum P content 0.713% in maize grain was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 0.680% for biochar and PK at 10 t ha^{-1} and 50 -30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$).

The non-significant effect of biochar on stover P content is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38].

Potassium concentration in maize grain

K concentration in maize grain as effected by biochar and PK fertilizers are presented in table 6. Analysis of the data shown that K content in maize Stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased grain K content. The maximum grain K content 0.244% was recorded in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 0.219% for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} and the lowest value 0.116 K% was recorded in control [23,41,42]. Sole application of biochar at 10 and 15 t ha^{-1} had some increased K content in maize Stover over control.

The maximum Stover K content 0.248% was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 0.247% for biochar and PK at 10 t ha^{-1} and 50 - 30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$).

Treatments	N in maize grain	P in maize grain	K in maize grain
PK fertilizers (kg ha^{-1})	____ (%)___		
PK1 (0 kg ha^{-1})	0.93	0.42 c	0.116 c
PK2 (50-30 kg ha^{-1})	0.99	0.64 b	0.221 b
PK3 (100-60kg ha^{-1})	1.01	0.67 a	0.241 a
LSD ($P < 0.05$)	ns	0.044***	0.04***
Biochar (t ha^{-1})			
B1 (0 t ha^{-1})	0.93	0.42	0.116
B1 (5 t ha^{-1})	1.0	0.45	0.134
B2 (10 t ha^{-1})	1.07	0.53	0.153
B3 (15 t ha^{-1})	1.14	0.54	0.158
LSD ($P < 0.05$)	ns	ns	ns
Interaction			
B2 x PK2	0.96	0.61	0.221
B2 x PK3	1.04	0.68	0.240
B3 x PK2	1.05	0.63	0.210
B3 x PK3	1.05	0.68	0.247
B4 x PK2	1.11	0.64	0.223
B4 x PK3	1.09	0.71	0.248
LSD ($P < 0.05$)	ns	ns	ns

Table 6: Grain N, P and K content as influenced by integrated effect of biochar and PK fertilizers.

B (biochar), PK (phosphorus and potassium), ns (non – significant), *** (significant)

Total N, P and K uptake in maize grain and stover as effected by integrated effect of biochar and PK fertilizers

Total N uptake in maize grain and stover

Total N uptake in maize grain and stover as effected by biochar and PK fertilizers are presented in table 7. Analysis of the data shown that total N uptake in maize grain and Stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased total N uptake in maize. The maximum N uptake 125 kg ha^{-1} was observed in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 121 kg ha^{-1} for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} while the lowest N uptake 105 kg ha^{-1} was recorded in the control (Baque., *et al.* 2006). Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased total N uptake but the results were at par with control.

The maximum value of total N uptake 129 kg ha^{-1} was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 122 kg ha-1 for biochar and PK at 10 t ha^{-1} and 50 -30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$). The non-significant effect of biochar on total N uptake of maize is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38]. Biochar may exert significant in long - term [37,38]. It is therefore suggested that long term experiment may be conducted to realize the real effect of biochar.

Total P uptake in maize grain and stover

Total P uptake in maize grain and stover as effected by biochar and PK fertilizers are presented in table 7. Analysis of the data shown that total P uptake in maize grain and Stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizer levels linearly increased total P uptake in maize. The maximum P uptake 81 kg ha^{-1} was observed in treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 71 kg ha^{-1} for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} while the lowest P uptake 49 kg ha^{-1} was recorded in control. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased total P uptake but the results were at par with the control.

The maximum value of total P uptake 84 kg ha^{-1} was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 81 kg ha^{-1} for biochar and PK at 10 t ha^{-1} and 50 -30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$). The non-significant effect of biochar on P uptake is perhaps not surprising as the effect of biochar is mostly non-significant in short - term [37,38].

Total K uptake in maize grain and stover

Total K uptake in maize grain and stover as effected by biochar and PK fertilizers are presented in table 7. Analysis of the data shown that total K uptake in maize grain and Stover was significantly ($P < 0.05$) influenced by PK fertilizers. Increasing PK fertilizers levels linearly increased total K uptake in maize. The maximum K uptake 75 kg ha^{-1} was observed in the treatments receiving PK fertilizers at 100 - 60 kg ha^{-1} followed by 71 kg ha^{-1} for treatments receiving PK fertilizer at 50 - 30 kg ha^{-1} while the lowest K uptake 49 kg ha^{-1} was recorded in control. Sole application of biochar at 10 and 15 t ha^{-1} had somehow increased total K uptake but the results were statistically non- significant.

The maximum value of total K uptake 78 kg ha^{-1} was recorded when biochar and PK fertilizers were integrated at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively followed by 75.5 kg ha^{-1} for biochar and PK at 10 t ha^{-1} and 50 -30 kg ha^{-1}. However the results were statistically non - significant ($P < 0.05$). Biochar may exert significant in long - term [37,38]. It is therefore suggested that long term experiment may be conducted to realize the real effect of biochar.

Treatments	N uptake in maize	P uptake in maize	K uptake in maize
PK fertilizers (kg ha^{-1})	_____(kg ha^{-1})____		
PK1 (0 kg ha^{-1})	105 c	44 c	45 c
PK2 (50-30 kg ha^{-1})	117 b	72 a	68 b
PK3 (100-60 kg ha^{-1})	121 a	78 b	74 a
LSD ($P < 0.05$)	8*	4***	5***
Biochar (t ha^{-1}) B1 (0 t ha^{-1})	105	44	45
B1 (5 t ha^{-1})	112	45	48
B2 (10 t ha^{-1})	116	53	50
B3 (15 t ha^{-1})	123	53	52
LSD ($P < 0.05$)	Ns	ns	ns
Interaction B1 x PK2	118	69	69
B1 x PK3	124	80	74
B2 x PK2	122	72	67
B2 x PK3	125	81	76
B3 x PK2	128	72	71
B3 x PK3	129	84	78
LSD	ns	ns	ns

Table 7: Total N, P and K uptake in maize grain and stover as effected by biochar and PK fertilizers.

B (biochar), PK (phosphorus and potassium), ns (non – significant), * (significant)

Summary

A field experiment was conducted to assess the integrated effect of biochar and PK fertilizers on maize yield and soil properties at the Research Farm of Agriculture University Peshawar during summer 2015. The experiment was laid out in RCB design with three replications. The size of treatment plot was kept 4 m by 3.5 m. The different doses of biochar and PK fertilizers were applied at the rate of (0, 5, 10 and 15 t ha^{-1}) while PK fertilizers were applied at

rate of (50 - 30 and 100 - 60) of recommended dose. The PK doses were added to the soil in the form of single super phosphate and sulphate of potash, respectively. The soil under experiment was alkaline calcarious in nature. Maize crop was sown on 25 - 06 - 2015 and harvested on 5 - 10 - 2015. Surface samples at 15 cm depth were collected for analysis of physico - chemical characteristics before and after harvest.

The results indicated that plant height, biological yield, stover yield, grain yield and thousand grain weight improved significantly with PK fertilizers while sole application of biochar had no significant effect on yield and yield component of maize. However maxim plant height, biological yield, stover yield, grain yield, and thousand grain weight (185 cm), (8063 kg ha^{-1}), (5428 kg ha^{1}), (2735 kg ha^{-1}), (254 g) were observed in treatments treated with full dose of PK fertilizers along with biochar at 15 t ha^{-1} respectively, while the lowest plant height, biological yield, stover yield, grain yield and thousand grain weight were observed in the control.

Soil bulk density was significantly decreased with higher level of biochar. PK fertilizers had no significant effect on soil bulk density. The lowest value (1.38 gcm^{-3}) for bulk density was recorded in the treatments receiving biochar at 15 t ha^{-1}.

Soil pH, EC, organic matter and soil total nitrogen was increased with biochar at highest dose but results were statistically non - significant ($P < 0.05$) while PK fertilizers had no prominent effect on soil pH, EC, organic matter and soil total nitrogen. The maximum pH, EC, organic matter and total nitrogen was observed in the treatments receiving biochar at 15 t $ha^{-1.}$ The maximum pH (7.60), EC (1.35 dsm^{-1}), O.M (0.57%), and total N (0.128%) was recorded in treatments receiving biochar at 15 t ha^{-1} respectively, while the lowest values for pH, EC, organic matter and total nitrogen were recorded in the control.

AB-DTPA extractable P and K were increased with increasing PK fertilizers levels but the results were non - significant. Sole application of biochar at higher level also increased soil extractable P and K. The maximum P (2.72 mg kg^{-1}) and K (70.80 mg kg^{-1}) concentration was recorded in the treatments receiving biochar and PK fertilizers at 15 t ha^{-1} and 100 - 60 kg ha^{-1} respectively, while lowest values for P and K (2.49 mg kg^{-1}) and (69.20) recorded respectively in the control.

Total P and K concentration in maize stover were significantly increased with increasing PK levels. Sole application biochar had no significant on P, and K concentration in maize stover. However, the maximum stover P (0.33%) and K (0.715%) concentration was observed in the treatments receiving higher level of PK fertilizers along with higher of biochar respectively, while the lowest was recorded in the control.

Total P and K concentration in maize grain was significantly increased with increasing PK levels. Sole application biochar had no significant on N, P, and K concentration in maize stover. However, the maximum stover P (0.71%) and K (0.247%) concentration was observed in the treatments receiving higher level of PK fertilizers along with higher of biochar respectively, while the lowest was recorded in the control.

Total N, P and K uptake in maize was significantly increased with increasing PK fertilizers levels. Sole application biochar had no significant on total N, P, and K uptake in maize. However, the maximum N (129 kg ha^{-1}) P (84 kg ha^{-1}) and K uptake (78 kg ha^{-1}) was observed in the treatments receiving higher level of PK fertilizers along with higher of biochar respectively, while the lowest was recorded in the control [43-54].

Conclusions

Based on findings the following conclusions could be drawn from the experiment conducted are

- Plant height, biological yield, Stover yield, grain yield and thousand grain weight were increased significantly with increasing level of PK fertilizer.
- Integrating biochar at 15 t ha^{-1} and PK fertilizers at 100 - 60 kg ha^{-1} produced maximum plant height biological yield, Stover yield, thousand grain weight and total grain yield then sole PK fertilizer.
- Biochar application 10 and 15 t ha^{-1} had somehow increased yield and yield component over control
- Soil total N, organic matter, soil pH, soil EC was increased with increasing level of biochar then over PK fertilizers alone and control.
- Soil bulk density was significantly decrease by biochar at 10 and 15 t ha^{-1}
- Soil ABDTPA P and K was higher when combined biochar and PK fertilizer
- N, P and K uptake was higher for biochar and PK fertilizers when integrated at higher level.

Recommendations

Based on conclusions it can be recommended that;

- The combine use of biochar 15 t ha^{-1} with PK fertilizers 100 - 60 kg ha^{-1} showed maximum results for yield and yield components and soil quality then sole PK fertilizers hence recommended for given crop and soil.
- Biochar at 15 t ha^{-1} and above may be applied to improve soil properties.
- Long - term experiment may be conducted to realize the real effect of biochar.

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