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Water and cow urine quenched biochar rate effect on yield and yield parameters of wheat

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ABSTRACT

Biochar application to soil is important for crop production and productivity in Ethiopia mainly where high rainfall is available. This study was conducted in Jimma University College of Agriculture and Veterinary Medicine campus during 2019 cropping season to determine the effect of cow urine and water quenched biochar with the biochar application rate on wheat yield and yield components. A wheat pot experiment was sown with two biochar rates (6 t ha^{-1} and 4 t ha^{-1} quenched with (cow urine and water). The number of effective tillers, spike length, seeds per spike, above dry biomass and thousand seed weight revealed non-significant differences. However, plant height, yield per pot and harvest index indicated significant variation due to the treatment combination of cow urine quenched, water quenched biochar and biochar rate over the control treatment. Six (6) tones biochar quenched with cow urine showed the maximum result and followed by 4 tones biochar quenched with cow urine. Biochar application has a significant advantage over control treatment.

Keywords: Biochar, Cow urine, Water, Quenching, Rate.

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Introduction

Ethiopia is one of the largest producers of wheat in sub-Saharan Africa (Tanner and Mwangi, 1992). Wheat grows mostly in the highland areas of Ethiopia, at altitudes ranging from 1500 to 3000 m (Geleta *et al.*, 1994). Though Ethiopian agro-climatic condition is suitable for wheat production, productivity is low. This is because of depleted soil fertility (Woldeab *et al.*, 1991; Tanner *et al.*, 1993), low levels of chemical fertilizer usage limited knowledge on time and rate of fertilizer application (Woldeab *et al.*, 1991; Tanner *et al.*, 1993; Amsal *et al.*, 2000; CSA, 2012), and the unavailability of other modern crop management inputs (Woldeab *et al.*, 1991).

Biochar is a carbon-rich product created when any biomass is heated to temperature greater than 250°C in low or absence of oxygen (Antal and Gronli, 2003). In addition, it is the solid material obtained from the carbonization of biomass though pyrolysis, is a potential soil amendment and carbon sequestration medium (Lehmann and Joseph, 2009). Soil health is the foundation of a vigorous and sustainable food system (UNEP, 2012). As the land is farmed, the agricultural process disturbs the natural soil systems including nutrient cycling and the release and uptake of nutrients (Bot and Benites, 2005). Biochar often impacts on soil properties by alteration of soil pH, Increases CEC, retain nutrients and moisture and affects soil biota, roots & nutrient uptake (Lehmann *et al.*, 2011) and thus greatly affects crop yield (Chan *et al.*, 2007). Nutrient loss can be a limitation to the utilization efficiency of fertilizers and can be minimized using slow-release nitrogen fertilizers (Gentile *et al.*, 2009) or increasing adsorption sites.

The total nitrogen and phosphorus contents are typically higher in biochars produced from feed-stocks of animal origin than those of plant origin (Chan and Xu, 2009). Biochar adds basic cations to soils, improves soil water retention, and has the liming potential of acid soils (Glaser *et al.* 2002; Laird *et al.*, 2010; Sohi *et al.*, 2010; Van Zwieten *et al.*, 2010).

Production and productivity of crop plants in Jimma area are depleting from time to time. Jimma receives high rainfall per annum that causes soil to be acidic. This soil acidity decreases the yield of crop. Ndameu (2011) showed as the Biochar increases pH of acidic soils, agricultural productivity, and provides protection against some foliar and soil-borne diseases and reduces pressure on forests. Consequently, our intension is to evaluate biochar activities in this area with the present specific objectives: To determine the effect of cow urine quenched and water quenched biochar on wheat yield and yield components with the combination of biochar rate.

Materials and Methods

Experimental area description

This experiment was conducted in the main season of 2019 in Jimma University College of Agriculture and Veterinary Medicine. The study area is 350 km from south-west of Addis Ababa and located at 7°33'N and 36°57'E at an elevation of 1710 m above sea level. The mean annual maximum and minimum temperature of the area are 26.8 and 11.4°C, respectively and the mean annual rainfall is 1500 mm. The soil type of the experimental area is Nitsols (World Reference Base, 2006).

Table 1. Soil physico-chemical properties before the experiment.

Parameters	Values
pH	5.15
Bulk density	1.00
CEC (me/100 g)	14.13
EC(ds)	0.02
K (me/100 g)	3.15
Available P (mg kg $^{-1}$)	11.22
Mg (me/100 g)	3.13
Organic carbon (%)	3.38
Organic matter (%)	4.97
Total Nitrogen (%)	0.27

CEC: Cation exchange capacity, k = Potassium EC = Electrical conductivity, Mg = Magnesium.

The analyzed result of the soil before the experiment revealed that the soil of the area is strongly acid. Different literatures indicated as the acidity and other physicochemical properties of the soil can be improved with the addition of biochar produced from different feed-stocks. The experiment done by other authors in the same area with this experiment site also confirmed the advantage of biochar. Dume *et al.* (2015) also indicated as a biochar addition can improve some characteristics of the soil such as acidity and other physicochemical properties of this area.

Biochar Production

Biochar was prepared from Banana dried leaf at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) using a conically formed metal kiln known as Con Tiki Kiln. The leaf dried on banana was collected and fired in the Con Tiki Kiln in open space. Dried banana leaf as biomass was pyrolyzed layer by layer in this metal kiln. As soon as the metal kiln was filled, the pyrolysis process was actively quenched with water for the first time and at the second round, it was quenched with cow urine in the same manner.

Treatments and experimental design

The present pot experimental study was designed with the factorial combination of two biochar quenching material (cow urine and water) and biochar rate (6 t ha^{-1} and 4 t ha^{-1}) with one control treatment (without biochar). The experiment was done by RCBD design with three replications.

Treatments detail

BQw6T = 6 tones biochar Quenched with water.
BQw4T = 4 tones biochar quenched with water.
BQu6T = 6 tones biochar quenched with cow urine.
BQu4T = 4 tones biochar quenched with cow urine.
Control = without biochar.

Data Collection

Soil sampling and preparation

Soil samples were collected at random from the top 0-30 cm prepared for pot experiment with auger. The soil samples were cleaned from root and other dusts, air-dried thoroughly, mixed and grounded to pass a 2 mm size sieve before laboratory analysis. Collected soil samples were prepared for determination of soil chemicals and physical properties such as texture, organic matter, bulk density, organic carbon, (EC), pH, and amounts of phosphorus (P), nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg) and cation exchange capacity (CEC) were analyzed in Jimma University College of Agriculture and veterinary medicine soil laboratory before the experiment.

Crop Phenology, growth, yield and yield parameters

Days to 50% flowering, plant height (cm), number of the effective tiller, spike length, seed per spike, above dry biomass, thousand seed weight, Harvest index and yield per pot has been recorded for the analysis.

Days to 50% flowering were taken randomly from five plants within a pot when 50 % of the plant population in a pot reached the respective phonological stages. Plant height were taken from five plants on pot basis when 50 % of the plants in a pot reached maturity stage by using tape meter from bottom region to the apex and the mean value was determined as mean plant height. The number of effective tillers also recorded at 50% maturity from five randomly selected plants in pot. For spike length and seed per spike the same plant selected for plant height, effective tiller were used for the spike length at the end of harvesting time. Above dry biomass, thousand seed weight and yield per pot were also taken during the harvesting time from all the plant in the pot and harvest index were calculated from them.

Data analysis

Data were subjected to analysis of variance (ANOVA) using (Gen Stat version 13). Significance differences between treatment means were delineated using Least Significance Difference (LSD) test at 5% probability level.

Results

Table 2. Days to fifty percent flowering (DFF), number of effective tillers (NET), spike length (SL), seed number per spike (SPS), above dry biomass (ADBM) and thousand seed weight (1000SW) as affected by biochar quenched with water, cow urine and rate.

		Parameters					
Rep	Treatment	DFF	NET	SL	SPS	ADBM	1000 SW
1	BQw6T	66.67	4.47	8.380	197.20	111.00	40.43
2	BQw4T	68.00	4.00	8.233	195.80	108.20	34.63
3	BQu6T	67.33	5.61	8.547	199.30	106.50	35.63
4	BQu4T	66.00	5.27	8.360	197.00	104.50	33.27
5	Control	67.00	3.93	7.967	195.00	107.80	31.57
	SEM(±)	0.955	0.74	0.837	5.66	11.47	6.86
	$LSD_{(0.05)}$	NS	NS	NS	Ns	NS	NS
	CV (%)	1.7	19.3	12.4	3.5	13.1	23.9

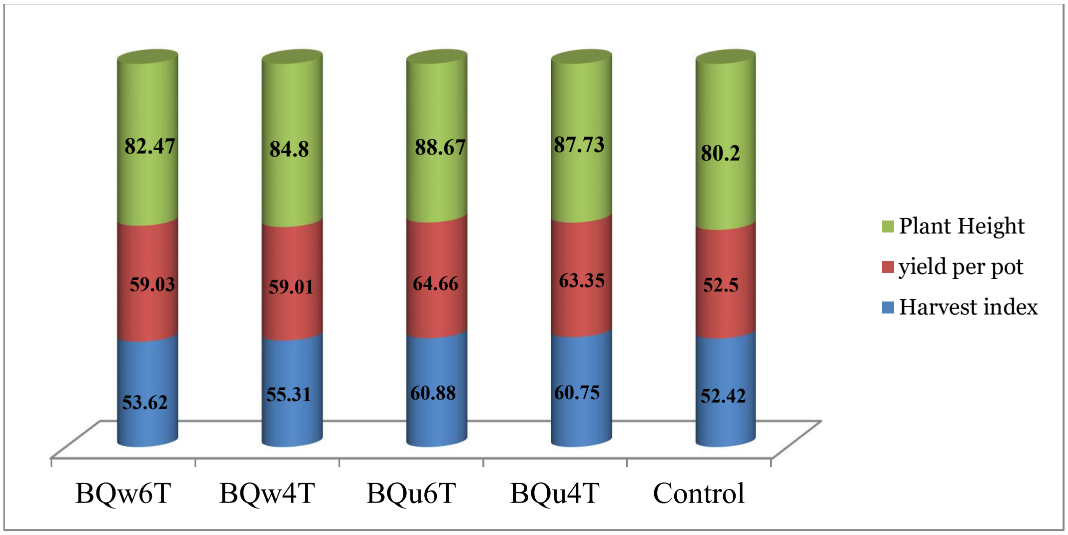
CV= Coefficient of variance, LSD = Least significance difference, SEM = Standard error of mean, DFF =Days to 50% flowering, NET= Number of effective tiller, SL= Spike length, SPS= Seed per spike, ADBM =Above dry biomass, 1000 SW= Thousand seed weight.

Cow urine quenched and water quenched biochar with biochar rate combination showed a significant difference in plant height. The maximum plant height was observed on the treatment obtained BQu6T and the minimum was on control treatment. The number of effective tillers, spike length, seeds per spike, above dry biomass and thousand seed weight revealed non-significant differences due to the treatment combination effect of biochar quenched with water and with cow urine accompanied by biochar rate. It is also evident that even if the non-significance variation was seen in the treatments; a big variation was seen in between the control treatment and biochar treatment whether by biochar quenching material or rate. Whereas minor differences have seen in between the treatments, obtained biochar quenched with water and with cow urine. Numerically the least number of effective tillers found in the control treatment and the maximum in BQU6T treatment. In the same manner, spike length and seed per spike showed the maximum number in BQu6T. But, numerically the maximum 1000 seed weight was in BQw6T and the minimum was in the control treatment. The cow urine and water quenched biochar rate application had a significant effect on harvest index and yield per pot over the control treatment. However, non-significant differences was indicated in between biochar quenched with water, urine, and rate. The greater harvest index and grain yield per pot were observed in treatment received BQu6T and the minimum was recorded in the control treatment.

Table 3. Plant height, Yield per pot and Harvest index as affected by biochar quenched with water and cow urine.

	Plant Height	Yield Per Plot	Harvest Index
SEM(±)	2.88	2.47	4.69
$LSD_{(0.05)}$	6.64	5.69	10.81
CV (%)	4.20	9.90	10.40

SEM = Standard error of mean, CV = Coefficient of variance, LSD = Least significance difference.



Discussion

As far as biochar concerned, whether quenched by cow urine or water; the non-significance difference was observed between all treatments throughout all parameters except plant height, harvest index, and grain yield. The greater number was seen on biochar quenched with cow urine and the smaller in the control treatment. This indicated that nitrogen in cow urine might be increased some growth and yield parameters. A non-significance difference between all treatments of biochar might be from the high heat and high evaporation of nitrogen from the applied urine due to the quenching of the biochar in hot kontiki. Besides, this result showed as biochar application increased the yield of wheat. The result of this experimental data (spike length, seed per spike, harvest index and grain yield) showed that biochar application rate positively increases yield and yield parameters. Similarly, Ahmad *et al.* (2016) confirmed as biochar application had a positive effect over the control. In addition, they confirmed that biochar application, irrespective of application rate, had a positive impact on yield. Wang *et al.* (2012) and Zhang *et al.* (2012) also found in their studies that an application of biochar enhanced the yield of cereals. Schmidt *et al.* (2015); Pandit *et al.* (2017) indicated that Kon-Tiki biochar hot charged with cow urine or NPK gave yield increases of over 200% in Nepal.

Conclusion

From the present result, the wheat data taken indicted as the addition of biochar can increase production by improving agronomic data of wheat crop. However, we have observed, as there is no significant difference between biochar quenched with water and urine accompanied by 4 and 6 tons per hectare. The difference is the numerical difference among the treatments. Biochar quenched with animal urine with 6 tons has relatively advantageous than biochar quenched with water and 4 tons. However, we concluded as the biochar application has a significant advantage over control treatment.

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