

EFFECT OF CHICKEN LITTER BIOCHAR AND UREA ON THE GROWTH AND YIELD OF RICE (*Oryza sativa* L) IN JALINGO, TARABA STATE NIGERIA

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ABSTRACT

The use of nitrogen (N) fertilizers excessively in maintaining high rice yields due to nitrogen dynamics in soils not only is economically unsustainable but also causes environmental pollution. The objective of this study was to determine the effect of biochar and urea in improving rice productivity. The experiment was laid out in Randomized Complete Block Design (RCBD) with eight (8) treatments and three replicated times. Soil only (T1), Soil + normal fertilization (60kgN, 30kgP₂O₅ and 30kgK₂O) (T2), Soil + biochar + normal fertilization (60kgN, 30kgP₂O₅ and 30kgK₂O) (T3), Soil + biochar + 100% N (5tha⁻¹+60kgNha⁻¹) fertilization (T4), Soil + biochar + 75% N (5tha⁻¹+45kgNha⁻¹) fertilization (T5), Soil + biochar + 50% N (5tha⁻¹+30kgNha⁻¹) fertilization (T6), Soil + biochar + 25% N (5tha⁻¹+15kgNha⁻¹) fertilization (T7), Soil + biochar (no fertilization) (T8) were evaluated in the field trials. Selected rice plants growth variables such as Plant height, leaf length, number of tillers, productive tillers, plant biomass at harvest, root length and root weight likewise yield parameters such as weight of 1000 grain, dry grain and grain yield were determined. The data collected were subjected to Analysis of Variance (ANOVA) using statistical software SAS (Version 9.4) and significant means were separated using Tukey test at 5% level of probability. Results 90.50, 31.533, 23.33 and 19.53 revealed that application of biochar with 100% urea recommended rate significantly increased rice growth variables and grain yield. Application of biochar and urea application at 100% of the recommended rate can be used to improve rice productivity.

Key words: Biochar, Urea, Rice, Soil

INTRODUCTION

Nigeria is currently the largest rice producing country in Africa (RIFAN, 2017). This is as the result of conscientious efforts by the current administration to place more emphasis on agrarian production. With the available literature, annual rice production in Nigeria has increased from 5.5 million tons in 2015 to 5.8 million tons in 2017 (RIFAN, 2017). In 2015, Nigerians spent not less than ₦1bn on rice consumption, adding that while spending had drastically reduced, consumption had increased because of increased local production of the commodity. The consumption rate now is 7.9 million tones and the production rate has increased to 5.8 tons per annum. Nitrogen fertilizers use is expected to increase in a stabilized way up to 21.3 million tons in 2015 and 23.6 million tons by 2030 (FAO, 2000), suggesting that Nitrogen is an important nutrient in rice cultivation as it plays an essential role in sustaining high yield of crops (Peng *et al.*, 2002; Yang *et al.*, 2010). This is

probably one of the reasons why 70% of the chemical fertilizers used in rice cultivation are Nitrogen (N) fertilizer.

Nitrogen is generally applied to soils in a large quantity (Singh *et al.*, 2009; Kong *et al.*, 2008) due to demand of N by high yielding rice cultivars to achieve a desirable yield in modern agriculture (Zhu and Chen, 2002), chemical, biochemical, and microbial transformations of Nitrogen in soil (Zhu and Chen, 2002). Furthermore, there is no residual effect of Nitrogen in paddy fields (Moll *et al.*, 1982) because some of the Nitrogen is immobilized by microbes into soil organic fraction, and some is fixed by the clay minerals such as illite, vermiculite, and smectite whereas the rest are lost through denitrification, ammonia volatilization, and leaching. However, Nitrogen use can be efficiently managed through the use of biochar to improve Nitrogen and other important nutrients uptake in rice cultivation. Nutrient uptake by rice plants is not different from monocot crops such as wheat and maize

but the amount of nutrients absorbed varies with the growth stage of rice plant. Nitrogen absorption is low at seedling stage and peaks before heading stage (Guindo *et al.*, 1994; Liu *et al.*, 2007). The stage of highest Phosphorous uptake is young panicle developmental stage followed by the tillering stage (Maru *et al.*, 2015). The period of highest potassium uptake is before heading stage and little is absorbed after heading. Nutrient absorption differs with rice cultivar, fertilizer type, fertilization technology, soil type, and environmental factors (Singh *et al.*, 2009; Kong *et al.*, 2008). Biochar can be used to improve the physico-chemical properties of soil to boost rice yield. Biochar is pyrolysis biomass under limited or no supply of oxygen. Biochar has an impact on nutrient addition and nutrient retention in soils. Biochar consists mainly of mineral elements such as Calcium, Iron, Magnesium, Sodium, Potassium, Phosphorous, and Aluminium (Singh *et al.*, 2003; Kong *et al.*, 2008) with minimum amount of nitrogen. During pyrolysis, significant proportions of biomass nitrogen are lost by volatilization. The nitrogen remaining in the biochar and the fraction of nitrogen inside aromatic carbon structures of biochar tend to be poorly available for plants uptake. Biochar has a low density and high porosity that makes it possible to inhabit soil microorganisms and hold moisture up to three times its own weight thereby preventing nutrient leaching and volatilization. Surface water infiltration is improved in a biochar amended soil (Maru *et al.*, 2015).

Biochar consists largely of amorphous grapheme sheets, which give rise to large amounts of reactive surfaces where a wide variety of organic (both polar and non-polar) molecules and inorganic ions are absorbed and made available for plants absorption. High pH of biochar increased acidic soil pH. An increase in pH provides a wide range of benefits in terms of soil quality, notably by improving the availability of nutrients to plants, and in some Cases, it reduces the availability of detrimental elements such as Al and Fe (Maru *et al.*, 2015). Hence, there is a need to improve soil nutrient availability, nutrient uptake and nutrient use efficiency of rice plant.

However, if biochar can improve soil nutrients availability especially nitrogen in rice cultivation on the study area, then there is a need to measure and monitor nitrogen

concentration in soil solution during rice growing period. The objectives of this study were to: determine the effect of different level of poultry litters biochar on the growth and yield of rice and increase rice yield through the use of biochar and nitrogen fertilizer.

MATERIALS AND METHODS

Location of the study Area

The Experiment was conducted in Teaching and Research Farm of Taraba State University, Jalingo. The area is located between latitudes $11^{\circ}52'1''$ - $11^{\circ}57'1''$ N and longitudes $11^{\circ}19'1''$ - $11^{\circ}26'1''$ E. The area lies within the northern guinea savannah ecological zone of Nigeria. It covers about 40 ha. It has an average elevation of about 1,120m above sea level; the topography of the area is gently undulating and sloppy (Kefas, 2016).

Experimental Materials and Design

The experiment was conducted in Randomized complete block design (RCBD) consisting of eight (8) treatment with treatments replicated three times. The seed used was faro 44 sourced from the International Institute of Tropical Agriculture (IITA) Ibadan. The plot size was 20×10m and the net plot was 2×2m as shown in (Figure1). The treatments evaluated were as follows:

Soil only (T1),

Soil + normal fertilization (T2), NPK (15:15:15), 60kgN, 30kgP₂O₅ and 30kgK₂O

Soil + biochar + normal fertilization(T3) NPK (15:15:15), 60kgN, 30kgP₂O₅ and 30kgK₂O

Soil + biochar + 100% N fertilization (T4), (5tha⁻¹+60kgNha⁻¹)

Soil + biochar + 75% N fertilization (T5), (5tha⁻¹+45kgNha⁻¹)

Soil + biochar + 50% N fertilization (T6), (5tha⁻¹+30kgNha⁻¹)

Soil + biochar + 25% N fertilization (T7), (5tha⁻¹+15kgNha⁻¹)

Soil + biochar (no fertilization) (T8).

Biochar Production from Poultry litter

Poultry litter biochar was produced through pyrolysis process using muffle furnace under limited oxygen condition (Abbasi and Anwar 2015; Vijayanand *et al.* 2016). The Biochar used for this research was produced locally in Jalingo with about 30kg chicken litter, earthen pot (container), fire wood. The

earth pot was used as the container to heat the litters to produce biochar, the chicken litter was been put around the base to set on the triple stand (stones), the fire wood was placed under the earth pot and fire was ignited as the fire wood begins to burns, it generate heat that the earth pot becomes hot causing indirect burning of the chicken litter. At the interval of two hour the pot was open to mix/turn of the chicken litter from time to time until it turns black evenly. The fire was quenched and biochar was collected ready for used.

Methods of biochar and chemicals fertilizers application

One (1) kilogram (kg) of chicken litter biochar was spread evenly on the experimental plot and thoroughly mixed three days before transplanting. Twenty five (25) days nursed rice seed of faro 44 variety in a bed was prior to transplanting were planted at planting density of 25 plant per experimental plot with planting distance of 25cm between rows and 25cm within rows.

The synthetic chemicals fertilizer NPK 15:15:15 at 8g and urea at 100% N (24gN/plot), 75%N (18gN/plot), 50% N (12gN/plot), 25%N (6gN/plot) were measured using a weighing balance and applied on the soil surface of experimental plot based on the treatment description at the growth stage 2 weeks after transplanting and second application at booting and flowering stage.

Data collection

Data were collected on the following parameters: Plant height (cm), Leaf length (cm), Number of Tillers, Number of Productive Tillers, plant biomass (g), Root length, Root weight (g), Weight of 1000 grain (g), weight of dry grain (g), and Gain yield (g) were measured.

Statistical Analysis

The data collected was subjected to Analysis of Variance (ANOVA) using statistical software SAS (Version 9.4) and significant means were separated using Tukey test at 5% level of probability.

RESULTS AND DISCUSSION

Effects of biochar and synthetic fertilizer on plant height at 30, 60, and 90 Days after transplanting (DAT)

The plant height was measured at 30, 60, 90 days after transplanting (DAT) and presented in (Table 1). There was no significant difference at 30 DAT between treatments, this could be as a result of no any reaction from the treatments. At 60 and 90 DAT there was a significant difference among the treatments. Treatment T4 recorded the highest plant height as comparable with T5, T6, T7, and T8 but taller than T1, T2, and T3. Treatments T1, T2, and T3 recorded the lowest the plant height as compared with the other treatments. The high plant height at T4 could be as the result of high release of Nitrogen (N) because the treatment contains biochar with 100% urea application as compared with other treatments.

The lower plant height at T1 could be attributed to the fact that the treatments contain soil only and nothing else as in the case of the rest of the treatments. This also confirmed the finding of Dale *et al.* (2006) that the application of compost contributed greatly to the plant growth when compared to control. This was in line with the reports of Asai *et al.* (2009) and Gaskin *et al.* (2010) that, though biochar possesses some essential elements required for plant growth but biochar can only be effective and improve plant growth when combined with other fertilizers (Blackwell *et al.*, 2009). Many reports have also shown that there was regular decrease in plant growth with the application of biochar alone when not used in combination with other fertilizers (Gaskin *et al.*, 2010).

Table 1: Effects of biochar and synthetic fertilizer on plant height of rice at 30, 60, and 90 Days after transplanting (DAT)

Treatments	30 DAT	60DAT	90DAT
SOIL	19.80 ^a ± 0.49	22.93 ^b ± 0.98	58.03 ^e ± 0.38
SOIL + NPK	20.47 ^a ± 0.78	24.20 ^b ± 0.56	69.27 ^d ± 3.73
SOIL + BIOCHAR + NPK	21.97 ^a ± 0.84	23.80 ^b ± 0.74	84.43 ^{abc} ± 1.50
SOIL + BIOCHAR + 100%N	21.97 ^a ± 1.00	27.70 ^a ± 0.49	90.50 ^a ± 1.33
SOIL + BIOCHAR + 75%N	20.50 ^a ± 0.47	24.73 ^{ab} ± 0.68	86.30 ^{ab} ± 2.29
SOIL + BIOCHAR + 50%N	20.63 ^a ± 0.77	24.67 ^{ab} ± 0.59	82.43 ^{bc} ± 0.93
SOIL + BIOCHAR + 25%N	20.30 ^a ± 0.12	24.83 ^{ab} ± 0.77	79.67 ^{bc} ± 1.01
SOIL + BIOCHAR	20.63 ^a ± 0.20	25.73 ^{ab} ± 0.07	78.33 ^c ± 1.26
Mean	20.78	24.83	78.62
S.E (±)	0.25	0.34	2.10

Different letters indicate significant difference between means in the same column using Tukey's means comparison test at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on leaf length at 30, 60, and 90 Days after transplanting (DAT)

The leaf length of the rice plant was significantly influenced by the treatments at 60 and 90 DAT (Table 2). There was no significant difference between the treatments at 30 DAT, which could be as the result of less reaction from the treatments. T4 gave the highest leaf length while T2 recorded the lowest leaf length.

There was significant difference between T1, T3, T5, T6, T7, and T8 as compared with T1 and T4. At 90 DAT T4, T6, T7, and T8 showed the highest leaf length while T2 gave the lowest leaf length. There was no significant difference T3, T5, as compared with T4, T6, T7, and T8 respectively. Agusalim *et al.* (2010) revealed that addition of rice husk biochar increased the number of rice tillers compared to untreated soil.

Table 3: Effects of biochar and synthetic fertilizer on leaf length at 30, 60, and 90 Days after transplanting (DAT)

Treatments	30 DAT	60DAT	90DAT
SOIL	19.77 ^a ± 1.07	23.80 ^{ab} ± 1.10	25.567 ^{bc} ± 0.84
SOIL + NPK	20.47 ^a ± 0.81	23.20 ^b ± 1.72	25.333 ^c ± 1.63
SOIL + BIOCHAR + NPK	22.30 ^a ± 0.40	25.43 ^{ab} ± 0.55	28.433 ^{ab} ± 0.03
SOIL + BIOCHAR + 100%N	23.03 ^a ± 0.64	27.70 ^a ± 0.49	31.533 ^a ± 0.28
SOIL + BIOCHAR + 75%N	21.53 ^a ± 1.24	24.73 ^{ab} ± 0.68	28.967 ^{ab} ± 0.38
SOIL + BIOCHAR + 50%N	22.43 ^a ± 0.23	24.67 ^{ab} ± 0.59	29.433 ^a ± 0.26
SOIL + BIOCHAR + 25%N	22.50 ^a ± 1.90	24.83 ^{ab} ± 0.77	29.833 ^a ± 0.38
SOIL + BIOCHAR	21.90 ^a ± 0.44	25.73 ^{ab} ± 0.07	29.400 ^a ± 0.35
Mean	21.74	25.01	28.56
S.E (±)	0.36	0.37	0.46

Different letters indicate significant difference between means in the same column using Tukey's means comparison test at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on number of tillers

The number of tillers due T3, T4, and T5 were significantly higher than T1, and T2 at 30 Days after transplanting (Table 3). T1 and T2 were significantly lowest as compared with the other treatments. At 60 and 90 Days after transplanting T4 was significantly higher in the number of tillers than other treatments. T1 was significantly lowest at 60

and 90 Days after transplanting as compared with the rest of the treatment. This could attributed to the differences in nutrients availability in the soil due to co-application of biochar and urea only might have caused the differences in the aforementioned growth variable, confirming the findings of Brady and Weil (2008) that biochar improves soil productivity and N plays an important role in sustaining high yield of rice (Maru *et al.*, 2015)

Table 4: Effects of biochar and synthetic fertilizer on number of tillers at 30, 60, and 90 Days after transplanting (DAT)

Treatments	30 DAT	60DAT	90DAT
SOIL	1.67 ^b ± 0.07	3.67 ^d ± 0.64	5.40 ^d ± 0.50
SOIL + NPK	1.60 ^b ± 0.12	5.27 ^{cd} ± 0.87	9.60 ^{cd} ± 1.10
SOIL + BIOCHAR + NPK	6.67 ^a ± 0.77	9.60 ^{ab} ± 0.70	18.07 ^b ± 1.49
SOIL + BIOCHAR + 100%N	8.47 ^a ± 0.73	11.27 ^a ± 0.18	23.33 ^a ± 0.33
SOIL + BIOCHAR + 75%N	7.47 ^a ± 1.70	9.07 ^{ab} ± 0.64	17.87 ^b ± 0.64
SOIL + BIOCHAR + 50%N	6.13 ^{ab} ± 1.55	8.53 ^{ab} ± 1.16	16.80 ^b ± 1.17
SOIL + BIOCHAR + 25%N	5.13 ^{ab} ± 0.82	7.87 ^{bc} ± 0.48	16.00 ^b ± 1.17
SOIL + BIOCHAR	6.47 ^a ± 0.58	10.47 ^{ab} ± 0.24	14.07 ^{bc} ± 0.84
Mean	5.45	8.22	15.14
S.E (±)	0.57	0.54	1.12

Different letters indicate significant difference between means in the same column using Tukey's means comparison test at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on productive tillers

The effect of treatments on productive tillers is presented in (Table 5); there was significance variation among the treatment. T4 recorded more productive tillers while T1 recorded the least productive tillers. T3, T5 and T7 were not significantly difference but were higher than T1. The differences in number of tillers due to the effect of biochar on nutrient

availability and nutrient use efficiency of N fertilization might have caused the differences in productive tillers. The productive tiller of T4 was significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1.(Gamage *et al.*, 2012) showed that incorporation of rice husk charcoal to the rice field improved soil fertility to give more yield of rice.

Table 5: Effects of biochar and synthetic fertilizer on number of productive tillers at 90 Days after transplanting (DAT)

Treatments	Number of productive tillers
SOIL	3.80 ^e ± 0.60
SOIL + NPK	8.07 ^d ± 0.82
SOIL + BIOCHAR + NPK	14.13 ^{bc} ± 0.13
SOIL + BIOCHAR + 100%N	19.53 ^a ± 0.47
SOIL + BIOCHAR + 75%N	14.20 ^{bc} ± 0.58
SOIL + BIOCHAR + 50%N	15.13 ^b ± 1.20
SOIL + BIOCHAR + 25%N	13.00 ^{bc} ± 1.10
SOIL + BIOCHAR	10.47 ^{dc} ± 0.66
Mean	12.29
S.E (±)	0.96

Different letters indicate significant difference between means in the same column using Tukey's means comparison test at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on Total plant biomass (g) at harvest

The effects of treatments on total plant biomass at harvest varied significantly within the treatment (Figure 1). T4 recorded the heaviest weight of biomass while T1 recorded the lowest weight of biomass. T6 and T7 were not significantly difference but were higher than T1. The differences in total plant biomass due to the effect of biochar on nutrient availability and nutrient use efficiency of N fertilization might have caused the differences in the total plant biomass. The total plant biomass of T4 was significantly different from

other treatment although T4 had 100% N fertilization, that is, 100% more than in T1. A metadata analysis done by Biederman and Harpole 2013 also confirmed biochar capability in increasing the above ground biomass in most of the experiments. Fertilizer didn't have any considerable effect on soil as well; rather fertilized farm yard treatment caused slightly reduced yields than their non-fertilized counter parts. Carter *et al.*, 2013 also found a similar trend where they observed the growth of Lettuce and Cabbage and found increased growth of vegetables at non-fertilized biochar treatments rather than fertilized ones.

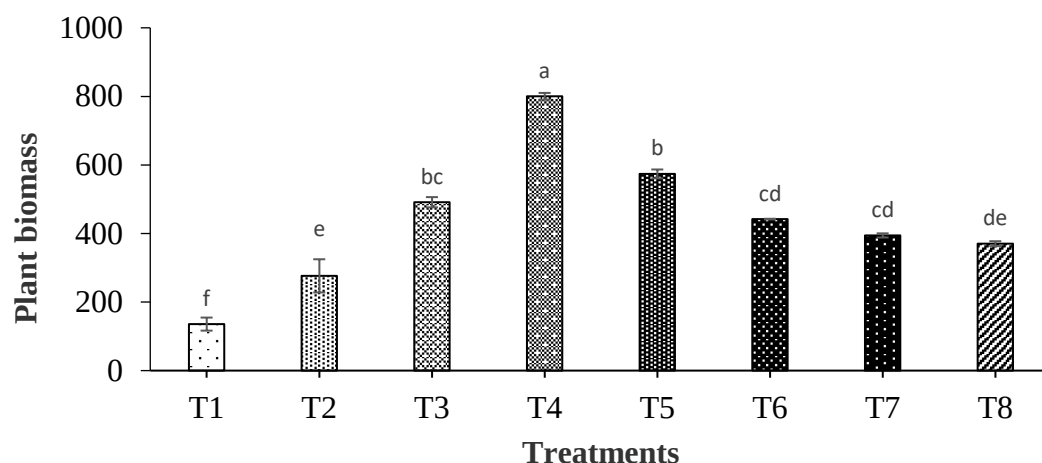


Figure 1. Mean ($\pm$ s.e). Total plant biomass at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on Root length (cm) at harvest

The Effects of treatments on Root length at harvest varied significantly within the treatment (Figure 2). T4 recorded the longest root while T1 recorded the shortest root length. T3 and T5 were not significantly difference but were higher than T1. Also, T7 and T8 show no significant difference but were higher than T1. The differences in Root length due to the effect

of biochar on nutrient availability and nutrient use efficiency of N fertilization might have caused the differences in Root length. The Root length of T4 was significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1. Agusalim *et al.* (2010) mentioned that rice husk biochar enhances plant growth by improving the soil properties.

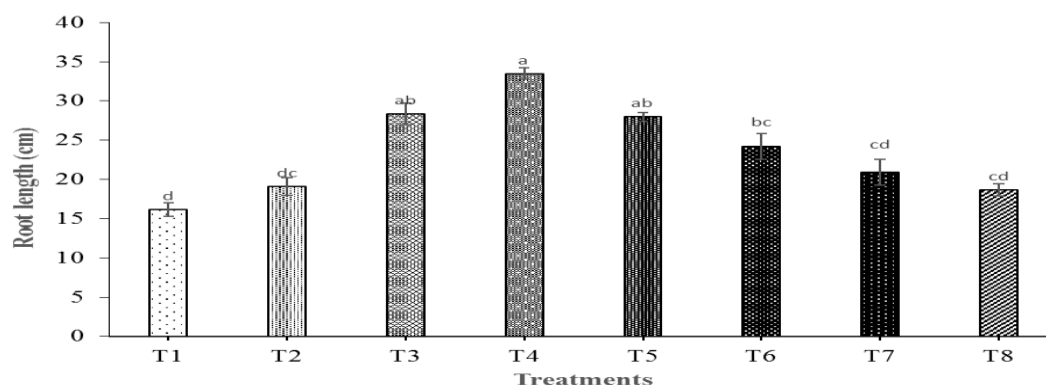


Figure 2. Mean ($\pm$ s.e). Root length (cm) at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on Root weight (g) at harvest

The Effects of treatments on root weight (g) at harvest varied significantly within the treatment (Figure 3). T4 recorded the heaviest root while T1 recorded the lighter root.

T6 and T7 were not significantly difference but were higher than T1. The differences in Root weight due to the effect of biochar on nutrient availability and nutrient use efficiency of N fertilization might have caused the differences in Root weight. The Root weight of T4 was

significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1.

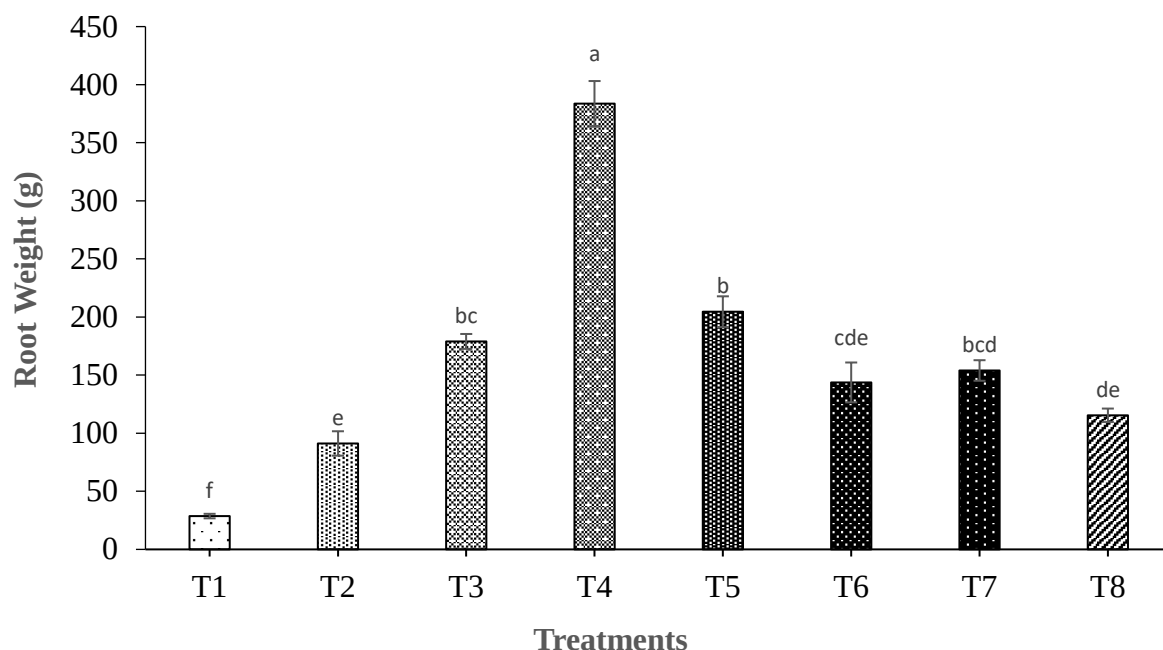


Figure 3. Mean ($\pm$ s.e). Root weight (g) at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on Weight of 1000 grain (g) at harvest

The Effects of treatments on Weight of 1000 grain varied significantly within the treatment (Figure 4). T4 recorded the heaviest grain while T1 recorded the lighter grain. T2 and T8 were not significantly difference but were higher than T1. Also, T6 and T7 show no significant difference but were higher than T1. The differences in Weight of 1000 grain due to the effect of biochar on nutrient availability and

nutrient use efficiency of N fertilization might have caused the differences in Weight of 1000 grain. The Weight of 1000 grain of T4 was significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1. Zhang *et al.* (2010) and Shackley *et al.* (2012) reported that rice husk biochar increased rice yield. The 1000 grain weight was higher in composted rice straw with NPK fertilized plants than that of composted rice straw (Son *et al.*, 2013).

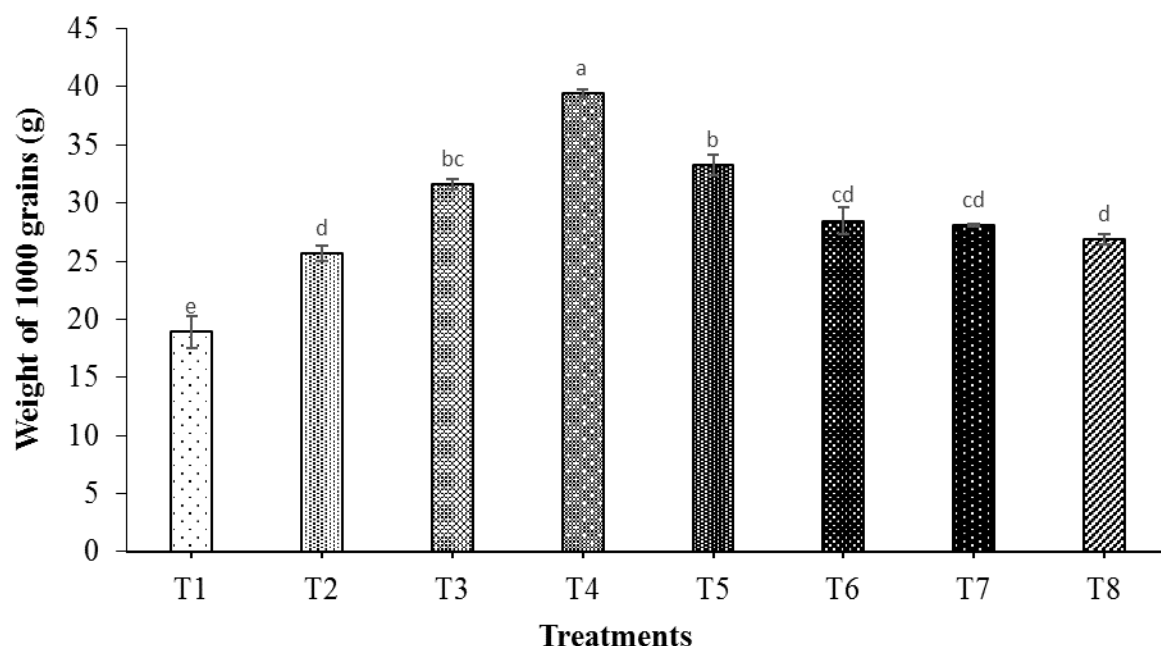


Figure 4. Mean ($\pm$ s.e). Weight of 1000 grain (g) at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on dry grain (g) at harvest

The weight of dry grain varied significantly within the treatment (Figure 5). T4 recorded the highest weight of dry grain while T1 recorded the lowest weight of dry grain. T3 and T6 were not significantly difference but were higher than T1. Also, T7 and T8 showed not significantly difference but were also significantly difference as compared with T1.

The differences in number of tillers due to the effect of biochar on nutrient availability and nutrient use efficiency of N fertilization might have caused the differences in the weight of dry grain. The weight of dry grain of T4 was significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1.

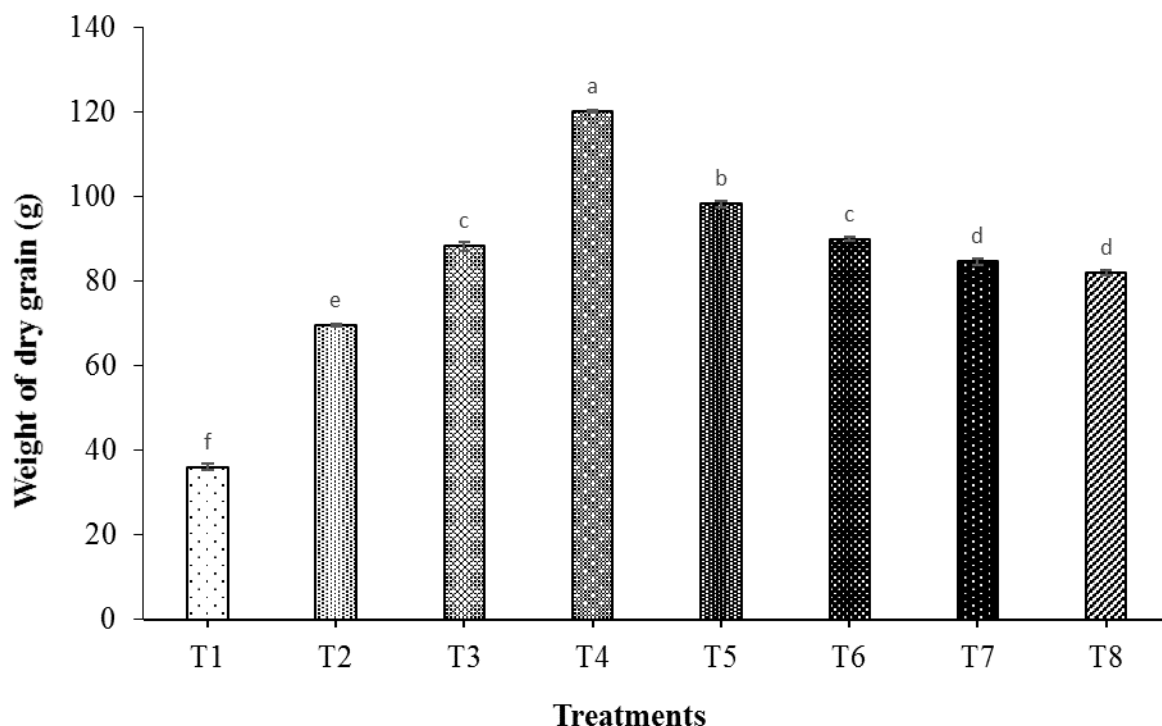


Figure 5. Mean ($\pm$ s.e). Weight of dry grain (g) at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

Effects of biochar and synthetic fertilizer on Grain yield

The effects of treatments on grain yield varied significantly within the treatment (Figure 6). T4 recorded the heaviest weight of grain yield while T1 recorded the lighter weight of grain yield. T3 and T6 were not significantly difference but were higher than T1. Also, T7 and T8 showed not significantly difference but were also significantly difference as compared with T1. The differences in number of tillers

due to the effect of biochar on nutrient availability and nutrient use efficiency of N fertilization might have caused the differences in the weight of grain yield. The weight of grain yield of T4 was significantly different from other treatment although T4 had 100% N fertilization, that is, 100% more than in T1. Asaduzzaman and Pramanik (2005) reported that the grain yield increased by about 5% over control for addition of 10 t/ha rice straw.

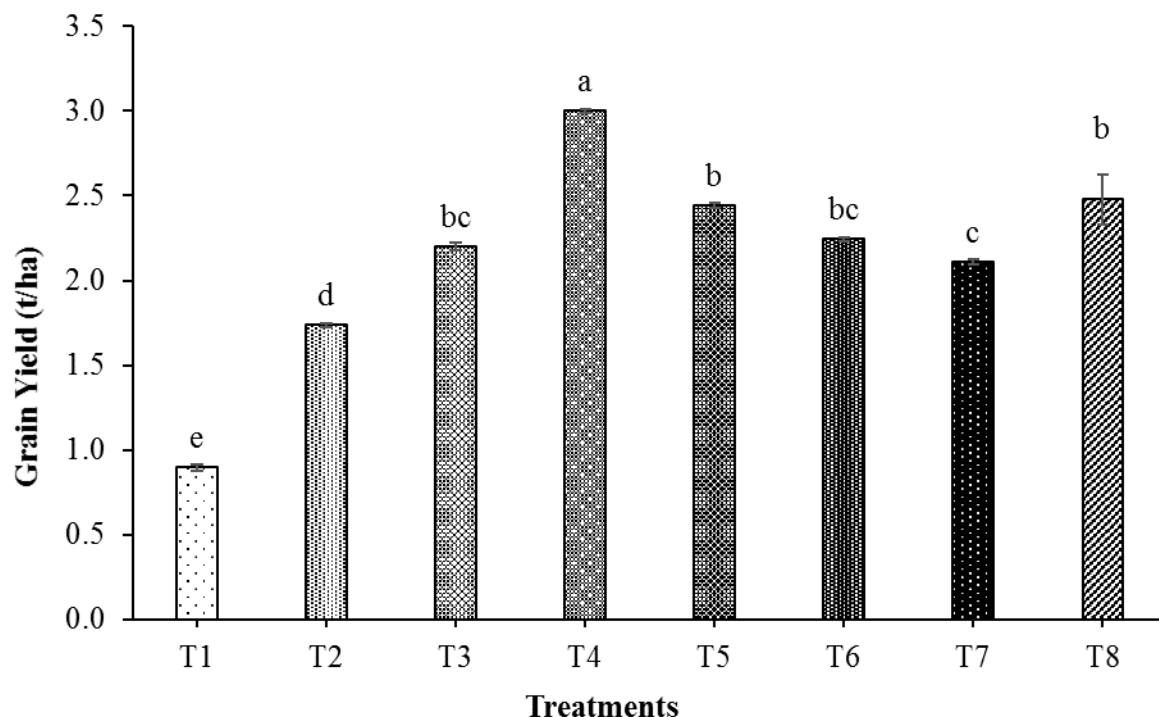


Figure 6. Mean ($\pm$ s.e). Grain yield (kg/ha) at harvest from the treatments: T1 (Soil), T2 (Soil+NPK), T3 (Soil+Biochar+NPK), T4 (Soil+Biochar+100%N), T5 (Soil+Biochar+75%N), T6 (Soil+Biochar+50%N), T7 (Soil+Biochar+25%N) T8 (Soil+Biochar). Means with the same letters are not significantly different from one another at $p \leq 0.05$.

CONCLUSION

Combined application of chicken litter biochar and urea increased soil nutrient availability, dry matter yield, crop nutrient recovery, and agronomic efficiency in rice cultivation. Soil + biochar + 100% N fertilization recorded highest in all the parameters while Soil only recorded the lowest in most of the parameters.

RECOMMENDATIONS

Based on the finding of this study, the following are recommended; Farmers in the study area should adopt Soil + biochar + 100% N ($5\text{t/ha}^{-1} + 60\text{kgN/ha}^{-1}$) Fertilization Multi-location trials may also be conducted to ascertain the validity of the result obtained in this study.

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