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Co-application of Biochar-Compost and Inorganic Nitrogen Fertilizer Affects the Growth and Nitrogen Uptake by Lowland Rice in Northern Ghana.

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Abstract: Inherent low soil fertility status limits productivity of rice in the lowland ecologies in Northern Ghana. Combining organic and inorganic nitrogen fertilizers could help to maintain the fertility of lowland soils for rice production. A screen house pot experiment was carried out to investigate the combined effect of biochar-compost and inorganic nitrogen fertilizer on the nitrogen uptake and agronomic performance of rice plants grown on an eutric gleysol lowland soil. Inorganic nitrogen fertilizer alone and its combinations with different types of biochar-compost (based on the proportions of biochar and compost) were used as treatment. A control (unamended soil) was also included. The incorporation of biochar-compost and inorganic nitrogen fertilizer improved the growth parameters and yield components of rice plants. The combination of biochar-compost and inorganic nitrogen fertilizer was also found to improve nitrogen uptake and nutrient use efficiency (NUE) in rice plants. This practice could be the most likely viable option for alleviating lowlands soil fertility issues and increasing rice productivity in Northern Ghana.

Keywords: Co-composted Biochar, Nitrogen Uptake, Nitrogen Use Efficiency, Eutric Gleysol, Northern Ghana

1. Introduction

Rice is the second most important food staple in Ghana, West Africa, after maize, and its consumption is increasing as a result of population growth, urbanization, and changes in consumer habits [1]. However, because the country is not self-sufficient in rice production, it is unable to meet its ever-increasing domestic demand and must rely heavily on imported rice [2]. In order for the country to achieve self-sufficiency in rice production and meet its increasing local demand, it will require sustainable production systems. The Northern part of Ghana is one of the major rice producing areas in the country [3]. There are abundant poorly drained lowlands and floodplains which are suitable for rice cultivation in the region [4]. Despite their suitability, the soils in the area have a low fertility status [5]. Small-scale farmers dominate rice cultivation in the area. They grow rice on as little as two hectares, yielding 1.2 tons per hectare on average [6]. Additionally, farmers cannot afford expensive chemical fertilizers. They use low fertilizer application rates to cut input costs, which contributes to low rice yield in the area. The soils in the area also have a low cation exchange capacity (CEC) as a result of low organic matter content and relatively low clay concentration. Low soil CEC may contribute to nutrient loss by leaching, particularly when nitrogen is supplied [5,7].

Nitrogen (N) is typically the main limiting nutrient in lowland rice cropping systems [8]. Soil N supply is a critical component of soil quality, but the effective soil N supply is influenced by anaerobic N mineralization-immobilization processes that are unique to flooded soils [9]. The supply of N from organic and inorganic fertilizer sources is thus vital to meeting rice crop's N requirements. Compost is an important amendment for increasing soil organic matter levels and sustaining soil fertility. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil [10]. Biochar, a carbon – based by-product of biomass pyrolysis [11], also has great potential for improving rice production and maintaining lowland soil fertility in Northern Ghana [12–14]. Biochar has been shown to offer a range of agricultural benefits, such as reduced nutrient leaching [15] and increased soil cation exchange [16]. Local organic input sources especially rice husk and cow-dung abound in the Northern region of Ghana. The direct use of fresh organic materials as soil amendment may not be sufficient to meet the nutrient requirement of high-yielding rice. Adding fresh organic materials such as rice husk and cow dung to flooded soils may develop toxic soil conditions for plants [17,18]. Therefore, converting these materials into compost or biochar would apparently make them more suitable as soil amendments. Composting with biochar have been investigated as a method to produce effective biochar-based slow-release organic fertilizers [19]. Co-composting of cow-dung and rice husk with rice husk biochar could therefore be an excellent way to improve the compost nutrient composition and make it suitable amendment in the flooded lowland soils.

Nitrogen Use Efficiency (NUE) has been widely used as a meter to relate N uptake with the quantity of N applied [20]. NUE is considered quite low on average in conventional agricultural systems [21]. Extensive research has been conducted to show the importance of combined application of inorganic and organic fertilizer on the yield of rice and nutrient status of soils [22–25]. Improved application and targeting of inorganic and organic fertilizer could conserve soil nutrients and increase their efficiency of uptake. In this regard, an integrated approach to soil nutrient management must be part of the overall strategy for increasing rice yield. The objective of this work was to examine the combined effect of biochar-compost and inorganic N fertilizer on the growth and nitrogen uptake by rice grown on a lowland soil, eutric gleysol. We hypothesized that combining biochar-compost and inorganic N fertilizer would result in increased N uptake by rice and, as a result, increased growth and other yield attributes.

2. Materials and Methods

2.1. Soil and Soil Sampling

The soil for this study was collected from Walewale, located at 10º28′29.0″ N and 0º47′55.5″ W in the West Mamprusi District in the Northern Region of Ghana, belonging to the Guinea Savannah Agro-Ecological Zone. The area is characterized by a single rainy season with an annual average rainfall of about 870 mm. The mean daily atmospheric temperature ranges from 24°C to 32°C [26]. The soil is locally known as Lima series and classified as Eutric Gleysol according to the FAO/UNESCO classification [26]. The soil is one of the dominant lowland soils of the interior savanna of Ghana used for rice cultivation. It occurs at the lowest part of a catena of Lima association and developed over shale or mudstone and sandstone [12]. The soil samples used for the pot experiment were randomly taken from the ploughed layer (0-20cm), bulked, homogenized and sub samples taken for routine characterization.

2.1. Soil Analysis

Bulk density of the soil was determined by the core method of [27]. Particle size distribution of the soil samples was determined by the Bouyoucos hydrometer method modified by [28] and the moisture content at field capacity was estimated. Soil pH was determined in water and 1M KCl. Total carbon and total nitrogen content of the soils were determined using a Leco Trumac Carbon Nitrogen Sulphur version 1.3 Analyser (LECO Corporation, Michigan, US). Available phosphorus was determined using the method of Bray and Kurtz [29]. Total phosphorus was determined using molybdate ascorbic acid method of Watanabe and Olsen [30]. Exchangeable bases were determined by the ammonium acetate method after which the concentration of bases was read on a Perkin Elmer Analyst 800 Atomic Absorption Spectrometer. The exchangeable acidity was determined by KCl extraction method. The cation exchange capacity was determined by the ammonium acetate method and the effective cation exchange capacities determined by summation of the respective exchangeable bases and exchangeable acidities.

2.3. Biochar-compost Preparation and Characterization

Rice husk served as feedstock for the biochar used in the study. The rice husk was charred at an approximate pyrolysis temperature of 450°C based on the recommendations of Lehmann et al., (2003) using a Kuntan kiln at the University Ghana school farm, Legon-Accra. Cow dung (CD) and rice husk (RH) in the ratio of 1:1 and 2:1 (v/v) served as materials for the preparation of base compost mixture. The base compost (with no biochar) was mixed with the rice husk biochar (RB) to achieve a compost-biochar ratio for the two compost types prepared on volume basis. The rice husk biochar was mixed with the 1:1 type compost to achieve compost-biochar mixture in ratios of 9:1, 8:2 and 6:4 (v/v). The 2:1 type compost was also mixed with the rice husk biochar to achieve compost-biochar mixture ratios of 8:2 and 6:4.

Biochar-compost pH was determined in water and 1M KCl. Total carbon and total nitrogen content of the soils were determined using a Leco Trumac Carbon Nitrogen Sulphur version 1.3 Analyzer (LECO Corporation, Michigan, US). Available phosphorus was determined using the method of [29]. Total phosphorus was determined using molybdate ascorbic acid method of [30].

2.4. Experimental Setup

The pot experiment was conducted in a screen house at the University of Ghana school farm. The experiment started from November, 2019 and ended in March, 2020. The maximum and minimum temperatures in the screenhouse throughout the experiment were 29 ºC and 33 ºC respectively. The rice variety used for this experiment was Jasmine 85. The seeds were obtained from Soil and Irrigation Research Centre, (SIREC-Kpong). The seeds were air – dried for three (3) days, sieved and cleaned of debris.

Germination test was conducted prior to planting. The seeds were nursed and transplanted 12 days after sowing using 3 seedlings per pot. Ammonium sulphate fertilizer alone or their combinations with five different biochar-compost (based on the proportions of biochar and compost) were used as treatments. Details of the rates of each treatment used are given in Table 1. The experiment was arranged in completely randomized design with three replicates. Basal P and K fertilizers were applied to all the experimental treatments at rates of 40 kg K_2O/ha and 45 kg P_2O_5/ha, respectively from muriate of potash and TSP (triple super phosphate). The inorganic fertilizers were applied in two equal splits in respective treatments at 7 and 42 days after transplanting. Watering was done to simulate flooded conditions similar to those found in lowland rice cultivation areas.

Table 1. Treatments used for the pot experiment.

Treatment Code	Description
T1	0 KgN/ha Compost + 0 KgN/ha AS (control)
T2	0 KgN/ha Compost + 100 KgN/ha AS
T3	150 KgN/ha Compost C1 + 70 kg N/ha AS
T4	150 KgN/ha Compost C2 + 70 Kg N/ha AS
T5	150 KgN/ha Compost C3 + 70 Kg N/ha AS
T6	150 KgN/ha Compost C3 + 100 Kg N/ha AS
T7	150 KgN/ha Compost C4 + 70 KgN/ha AS
T8	150 KgN/ha Compost C5 + 70 KgN/ha AS

AS = Ammonium Sulphate fertilizer. The various compost used are as follows; **Compost 1 (C1)** - Compost ratio CD:RH 1:1(9:1RB) i.e., compost was formed using one part of cow dung and one part of rice husk. After making the compost, 9 parts of it was mixed with one part of biochar, **Compost 2 (C2)** - Compost ratio CD:RH 1:1(8:2RB) i.e., compost was formed using one part of cow dung and one part of rice husk. After making the compost, 8 parts of it was mixed with one part of biochar, **Compost 3 (C3)** - Compost ratio CD:RH 2:1(9:1RB) i.e., compost was formed using two part of cow dung and one part of rice husk. After making the compost, 9 parts of it was mixed with one part of biochar, **Compost 4 (C4)** - Compost ratio CD:RH 2:1(8:2RB) i.e., compost was formed using two part of cow dung and one part of rice husk. After making the compost, eight parts of it was mixed with two parts of biochar, **Compost 5 (C5)** - Compost ratio CD:RH 2:1(6:4RB) i.e., compost was formed using two part of cow dung and one part of rice husk. After making the compost, six parts of it was mixed with four parts of biochar.

2.5. Estimation of Agronomic characteristics of rice plant

The plant growth and yield were monitored and analysed after transplanting. The growth parameters measured were the plant height and the number of tillers. The dry weight of the straw and root were recorded after oven drying under a temperature of 70°C for 3 to 5 days. The root volume was also estimated by volume displacement technique.

2.6. Nitrogen Uptake and Nitrogen Use Efficiency by Rice plants

The tissue N of the plant shoot was determined using a Leco Trumac Carbon Nitrogen Sulphur version 1.3 Analyzer (LECO Corporation, Michigan, US).

The plant N uptake was estimated as;

$$\text{Shoot N uptake (mg/pot)} = \text{shoot dry weight} \times \frac{\textit{Shoot N\%}}{100} \times 1000 \text{ mg} \quad [1]$$

The Nitrogen Use Efficiency (NUE%) was calculated according to the formula by Baligar, [31]

$$\text{NUE (\%)} = \frac{\text{Nitrogen uptake F (mg)} - \text{Nitrogen uptake C (mg)}}{\text{Quantity of nutrient applied (mg)}} \times 100 \quad [2]$$

Where F = the treatment and C = the control treatment

2.7. Statistical Analysis

The data were evaluated using analysis of variance (ANOVA). The means were compared by Fisher's Protected LSD test at 5% level of significance. The analyses were carried out using GENSTAT software (12th edition).

3. Results

3.1. Soil physicochemical properties

The physico-chemical properties of the soil used in the study are shown in Table 2. The soil has a bulk density of 1.32 Mg/m3. The particle analysis gave sand content of the soil as 32.75%, silt content, 38.50% and clay content, 28.75%. The soil is therefore clay loam according to the USDA texture classification. The experimental soil was strongly acid in reaction with pH in water being 5 and very strongly acid in reaction with pH in 1M KCl being 4.1. The soil has an organic carbon content of 13 g/kg. This is higher than most soils of the Savannah zone of Northern Ghana which generally have an average carbon content less than 5g/kg [32]. Similarly, total N of 0.8 g/kg and available P of 10.76 mg/kg are higher than the average of most Northern Ghana soils. The soil has a total P concentration of 124.5 mg/kg which is typical of Northern Ghana soils [32]. The exchangeable calcium and magnesium contents of the soil are 1.8 cmol/kg and 0.32 cmol/kg respectively. The exchangeable potassium is 0.49 cmol/kg with exchangeable sodium as 0.22 cmol/kg being the lowest. The soil has an exchangeable acidity (Al^{3+} and H^+) of 0.62 cmol/kg. The effective cation exchange capacity (ECEC) of the soil is therefore very low with a value of 3.42 cmol/kg.

Table 2. Physico-chemical properties of the soil used for the experiment.

Properties	Values
Physical properties	
Bulk density (Mg/m^3)	1.32
Sand content (%)	32.75
Clay content (%)	28.75
Silt content (%)	38.50
Textural class	Clay loam
Chemical properties	
pH 1:1 (H_2O)	5.00
pH 1:1 (KCl)	4.10
Organic C (g/kg)	13.00
Total N (g/kg)	0.80
Total P (mg/kg)	124.50
Available P (mg/kg)	10.76
Exchangeable Ca (cmol(+)/kg)	1.80
Exchangeable Mg (cmol(+)/kg)	0.32
Exchangeable K (cmol(+)/kg)	0.49
Exchangeable Na (cmol(+)/kg)	0.22
Exchangeable acidity (cmol(+)/kg)	0.62
ECEC (cmol(+)/kg)	3.42

ECEC = Effective Cation Exchange Capacity

3.2. Biochar-compost characterization

The results obtained from the characterization of the biochar-compost are presented in Table 3. Total N was higher in 1:1 compost type than 2:1 compost type. Highest available N occurred in C1 followed by C4.

Table 3. Chemical properties of the Biochar-compost

Sample ID	pH	TC	TN	TP	Av. P	Av. N	C:N
	(H_2O)	-----------mg/kg--------			-----------mg/kg--------		
C1	7.89	277.58	17.06	4333	2357.5	6896	16.3
C2	7.9	296.11	15.65	3933	1345	3330	18.9
C3	7.77	264.37	17.37	4000	2533	3204	15.2
C4	7.81	268.75	17.12	4100	1970	4388	15.7
C5	7.78	279.67	15.03	2438	2087	2970	18.6

TC = Total Carbon; TN = Total Nitrogen; TP = Total Phosphorus; Av. P = Average Phosphorus; Av. N = Average nitrogen; C:N = Carbon to nitrogen ratio.

3.3. Effects of various treatments on rice growth

The results of the effect of biochar-compost and inorganic N on weekly growth parameters are presented in Table 4 and Table 5. Plant height increased continuously with advancement of crop growth stages. T7 recorded the highest plant height at week 3, 4 and 5. T2 recorded the highest plant height of 107.53 cm at week 6 and this was highly significant ($p<0.001$) from all the treatments. The lowest plant height was observed for T1 throughout the weeks. Number of tillers increased continuously and attained a maximum value at week 4, after which it decreased towards maturity due to side tiller mortality and initiation of panicle primordia. The highest number of tillers was 53 and this was recorded in T7 at week 3. T1 recorded the lowest tiller numbers from week 3 through to week 6 followed by T2.

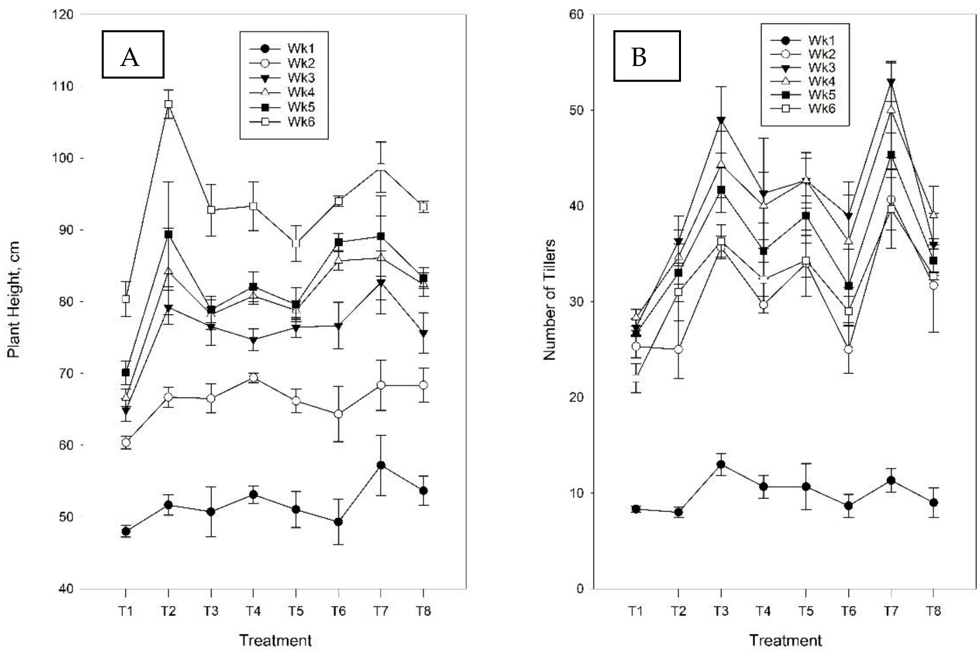

Figure 1. Effect of Biochar-compost and nitrogen fertilization on the weekly A) plant height and B) number of tillers of rice. Wk = Week. (Error bars represent the standard deviation of means, n = 9).

3.4. Effects of various treatments on dry weight of shoot and root and root volume

The results of the dry weights of the shoot and root and the root volume are given in Table 6. The shoot dry weight of the various treatments was significantly higher than that of the un-amended soil (i.e., T1). The highest shoot dry weight of 58.03 g was obtained by T7. The soil with no amendment recorded the lowest root dry weight of 11.77 g, followed by T2, 35.79g.

Significantly higher ($p<0.001$) root dry weight of 61.81g was recorded when 150 kg N/ha Compost C4 was applied along with 70 kg N/ha AS (i.e., T7), which is about 80.96 % increase in dry weight over the T1 (control). 150 kg N/ha Compost C3 applied together with 70 kg N/ha AS i.e., T5 produced higher root dry matter weight of about 24.47 % than 150 kg N/ha Compost C3 applied together with 100 kg N/ha AS, T6.

In the same manner, combined application of biochar-compost and inorganic N fertilizer significantly influenced root volume of the rice plant. T3 recorded the highest root volume of 143.3 cm^3 followed by T7 and T5 with 128.30 cm^3 and 126.70 cm^3 respectively. The root volume of T1, T2 and T8 were not significantly different from each other. The un-amended soil recorded the lowest root volume of 64 cm^3 followed by soil amended with only ammonium sulphate fertilizer, 71.7 cm^3

Table 6. Effect of Biochar-compost and nitrogen fertilization on dry weight of shoot, root and root volume.

Treatment	Shoot dry wt. (g)	Root dry wt. (g)	Root volume (cm^3)
T1	29.32 a	11.77 a	64.0 a
T2	49.52 b	35.79 b	71.70 ab
T3	54.31 b	50.03 bcd	143.30 c
T4	53.08 b	41.79 bc	120.70 bc
T5	53.48 b	56.07 cd	126.70 c
T6	50.47 b	42.35 bc	121.70 bc
T7	58.03 b	61.81 d	128.30 c
T8	52.48 b	41.95 bc	101.70 abc
Fpr	0.006	< 0.001	0.038
CV%	14.3	21.5	26.4

Fpr = Fisher's Probability; CV% = Coefficient of Variation. Means with same alphabets are statistically similar ($p<0.05$, $n = 9$)

3.5. Effect of soil amendment on shoot N uptake and NUE of rice plants

Table 7 summarizes the results of the effect of the various treatments on shoot N uptake and NUE of rice plants. Amending the soil with biochar-compost and inorganic N fertilizer significantly increased shoot N uptake by the rice plants. Highest shoot N uptake (602 mg/pot), representing 60% increase over the un-amended soil was seen in T7. Shoot N uptake in soil amended with only ammonium sulphate was statistically similar to soil amended with combinations of biochar-compost and ammonium sulphate fertilizer.

Highest nutrient use efficiency of 39.51% was seen in T7 which represents 25% and 31% increment over T2 and T6 respectively. T5 also recorded the second highest nutrient use efficiency with 37.94%. Generally, the NUE decreased steadily with increased amount of N applied from inorganic fertilizer as evident in T2 and T6 which had the least nutrient use efficiency among all the treatments.

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Table 7. Effect of Biochar-compost and nitrogen fertilization on N uptake and NUE of rice plant.

Treatment	Shoot N uptake (mg/pot)	NUE %
T1	241.10 a	-
T2	534.60 b	29.40
T3	529.10 b	35.50
T4	523.00 b	30.80
T5	585.50 b	37.90
T6	577.60 b	27.40
T7	602.00 b	39.50
T8	520.70 b	30.50
Fpr	0.002	0.40
CV%	16.3	22.9

Fpr = Fisher's Probability; CV% = Coefficient of Variation. Means with same alphabets are statistically similar ($p<0.05$, $n = 9$)

3.6. Yield components

Table 8 summarizes the results of combined application of biochar-compost and inorganic N fertilizer on the rice growth parameters and yield components at harvesting stage. Plant height, aboveground biomass weight (straw and grain weight), number of tillers, number of panicles and 1000 grain weight were all significantly affected by the soil amendments used. Grain weight ranged from 23.03g to 29.20g. The highest grain weight was obtained in T2 and T7, which represents about 20% increase over the control treatment.

Table 8. Effect of Biochar-compost and nitrogen fertilization on the rice growth and yield component.

Treatment	Plant height (cm)	Aboveground Biomass Weight (g/pot)	Number of tillers (/pot)	Number of panicles (/pot)	1000 grain weight (g)
T1	102.70 a	131.20 a	14.00 a	14.00 a	23.03 a
T2	105.70 ab	209.80 b	23.67 cd	21.67 bcd	29.20 c
T3	111.20 bc	248.40 c	20.00 b	19.67 b	27.00 b
T4	117.80 c	266.80 c	21.67 bc	20.50 bc	26.17 b
T5	108.50 ab	245.40 c	22.33 bc	23.33 cd	26.30 b
T6	109.00 ab	273.30 c	26.00 d	24.33 d	26.80 b
T7	108.80 ab	260.00 c	19.67 b	19.00 b	29.20 c
T8	106.30 ab	255.40 c	21.33 bc	21.33 bcd	26.50 b
Fpr	0.03	<0.001	<0.001	<0.001	<0.001
CV%	4.10	6.9	9.4	9.9	4.3

Fpr = Fisher's Probability; CV% = Coefficient of Variation. Means with same alphabets are statistically similar ($p<0.05$, $n = 9$)

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4. Discussion

4.1. Characteristics of Biochar-Compost

The biochar-compost characterization revealed a slightly alkaline pH within a range ideal for a matured compost. This can be attributed to the addition of biochar during the composting process. The total carbon content of the compost was found to increase with increasing biochar content. The functional groups available on biochar surfaces is known to favour the retention of nutrients and prevent losses from compost. Biochar is also carbon-rich, highly aromatic and can even offer physical protection to carbon and hence the high total carbon concentration in the compost with high biochar content. Gasco et. al, [33] pointed out a synergistic effect of biochar on compost which promotes C stabilization through the formation of organo-complexes. Addition of biochar during the composting process changes the compost properties, and quality and can lead to improved physicochemical properties (organic carbon content (OC), pH, moisture content) and nutrient availability (nitrogen, phosphorous and other important nutrients) in the end product [34,35]. The co-composting process also results in an organic coating on the biochar particles which reduces the hydrophobicity of biochar and improves nutrient retention conditions which may lead to improved agronomic performance [36,37].

4.2. Rice growth parameters at vegetative stage

Generally, treatment with higher nitrogen levels from inorganic fertilizer produced taller plants as seen in T2 and T6 (Table 4). Increasing plant height with increasing N levels was associated with greater availability of nutrient in soil and higher uptake by plants [38]. There was greater formation of tillers when 150kg N/ha biochar-compost was applied along with 70kg N/ha ammonium sulphate fertilizer in the soil. The increase in the tiller numbers is most likely due to the synergistic interaction among the organic and inorganic sources of N on the plant. T3 and T7 compost types performed better and this could be as a result of their high nutrient composition especially total N and available N. The control produced the least number of tillers. Some signs and symptoms of nitrogen deficiency including; very thin and slender tillers, yellowing of leaves and early senescence of older leaves appeared in the plants from the unamended soil. Increasing N fertilizer rate to 100kg in did not cause any greater change in the number of tillers in T2 and T6 as we expected (Table 5). This could be due to the channeling of available N from the inorganic source into promoting growth of other parts of the plants, such as increasing plant height instead of developing more tillers.

4.3. Shoot and root dry weight and root volume at vegetative stage

Nitrogen is very important for the growth and development of the aboveground and belowground structures of the rice plant [8]. T3, T5 and T7 outperformed all other treatments (Table 6) owing to their superior biochar-compost chemical properties (Table 3). Improvement in the shoot and root dry weight and root volume of rice plant could indicate synergistic effect between the two N sources. Another element could be the potential of biochar and compost to improve the soil's characteristics. Ahmed, [26] also found that applying organic amendments and inorganic N fertilizers together with rice husk biochar in the eutric gleysol resulted in a higher rice biomass yield. Treatment with high N rates; T2 and T6, did not cause any greater effect on the biomass weight and root volume. This implies reduce rate of inorganic N fertilizer combined with biochar-compost was more efficient.

4.4. Nitrogen uptake and N Use Efficiency

Uptake of nutrients by crop plants in adequate amount and proportion is very important for producing higher yields. Similarly, distribution of absorbed or accumulated nutrients in shoot and grain (higher N in grain) is associated with yield improvement [39]. Higher NUE by plants could reduce fertilizer input costs, decrease the rate of nutrient losses, and enhance crop yields. Co-application of biochar-compost and inorganic fertilizer increased the nitrogen use efficiency of the rice plant. This indicates that nitrogen retention in the soil was enhanced by the application of the two nitrogen sources. The high NUE is associated with the high shoot N uptake in those treatments. High N uptake in amended soils could be related to the split method of application of the inorganic N fertilizer. This might have decreased N losses in the soil as the element was supplied to the plant at the critical development stages of the rice plants. NUE was not improved at appreciable levels although we realized NUE decreased with increasing rate of N from inorganic fertilizer (Table 7). This is consistent with the study of Moe et. al, [22]. Invariably, there could be a positive interaction effect between organic and inorganic N sources which enhances N uptake and NUE by the rice plant.

4.5. Influence of soil amendment on yield components.

Rice plants growth parameters and yield components were enhanced by the incorporation of biochar-compost and ammonium sulphate fertilizer (Table 8). Yoshida [40] emphasized that nitrogen plays a key role in rice yield because plant nitrogen status affects the development of grain yield component. Higher grain production in T7 could be as a result of improved N synchrony between soil amendment and the plant needs. These results indicate that combinations of biochar-composts along with reduced inorganic N rates could be more efficient practice.

5. Conclusions

This study provides firsthand information on the effects of biochar-compost (made from rice husk and cow dung) and inorganic N fertilizer on lowland rice growth and N uptake in eutric gleysol from Northern Ghana. Co-applying biochar-compost and reduced inorganic N fertilizer was shown to improve lowland rice growth and yield components. The results of rice growth parameters and yield components also matched with nitrogen uptake and nitrogen use efficiency (NUE) across the treatments.

The integrated use of biochar-compost and inorganic N fertilizer has the potential to significantly improve the suitability of lowland soils for sustainable rice production in Northern Ghana. More research is needed to determine the full effect of the soil amendments on the soil conditions as well as rice productivity under field paddy environment in Northern Ghana.

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