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Research Article

Impact of biochar amended with compost and arbuscular mycorrhizal inoculation on soil chemical properties, root colonization, and yield of cowpea (*Vigna unguiculata*)

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Abstract: The use of biochar, compost, and arbuscular mycorrhizal fungi (AMF) provides many opportunities for soil improvement. Hence, it is important to understand their impacts on soil and plant development to optimally exploit their potentials. A screenhouse experiment was conducted to investigate the effect of biochar amended with compost and arbuscular mycorrhizal on soil chemical properties, root colonization, growth, and yield of cowpea. The experiment was laid out in a completely randomized design with control, using different combinations of Gateway compost with two types of biochar; Gliricidia and *Panicum maximum,* in percentage and at different rates (2.5, 3.0, 3.5, and 4.0 t/ha), with 2, 4, 6 and 8g of mycorrhizal and mineral fertilizer (RD of SSP -60 kg P_2O_5) in combination with mycorrhizal, making 13 treatment combinations replicated 3 times**.** The results of the investigation revealed that the application of biochar, compost and AMF significantly ($p < 0.05$) increased the growth and yield parameters of the cowpea plant. The treatment [70% Gateway compost + 30 % Biochar (*Panicum maximum*) at 3.5 t/ha + 6g mycorrhizal] enhanced root colonization percentage. Biochar amended with compost application remarkably improved total N, soil organic carbon, soil pH, and available P than mineral fertilizer.

Keywords: Arbuscular Mycorrhizal, Biochar, Compost, Cowpea, Yield

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1. INTRODUCTION

Biochar is a carbon-rich solid material produced from the pyrolysis of organic materials (Lehmann & Joseph, 2009). According to Thies and Rillig (2009), biochar increases soil available nutrients and prevents the leaching of these nutrients when utilized as a soil amendment. It stimulates the activities of important soil microbes, acts as an effective carbon sink for several hundred years, sequesters atmospheric CO in soil, suppress emissions of other greenhouse gases and mitigate the detrimental effects of agrochemicals.

Biochar addition to the soil may improve the physicochemical properties of soil like bulk density, water holding capacity, nutrient retention, soil pH, and cation exchange capacity resulting in beneficial effects on plant growth (Reyad & Attia, 2015). Biochar is very stable in soil with a half-life, ranging up to thousands of years (Ippolito *et al*., 2020). Another soil amendment that is known to be very effective in supplying organic nutrients is compost; compost is the fertilizer made from deliberate biological and chemical decomposition and conversion of organic or plant residue (Olowoake, 2017). It improves the soil water and nutrient holding capacity, improves air infiltration, water infiltration and drainage, and allows for deeper rooting depths (Olowoake *et al*., 2018). Arbuscular mycorrhizal fungi (AMF) are specialized soil fungi that benefit many important crops and require an association with vascular plants to survive. Plants allow AMF to live within their roots and provide the fungi with sugars (carbohydrate) that enable them to grow. In exchange, the fungi provide the plant with additional water and nutrients that the plant could not otherwise extract from the soil, which can lead to improved plant health and yield (Siemering *et al*., 2016).

Cowpea is the most important vegetable crop grown and consumed globally (Kedebe & Bebeko, 2020). The seed of cowpea contains about 23% protein and 57% carbohydrate (Affrifah*et al*., 2021). It is a major component of farming systems in a variety of agro-ecological zones because of its ability to improve soil fertility through nitrogen fixation. It is a source of human food, livestock feed, green manure and income for smallholder farmers (Timko & Singh 2008; Walker *et al*., 2016).

Despite the significant economic and health importance of cowpeas, optimal yields have not been achieved in Nigeria because of obstacles like insufficient rainfall (caused by frequent and erratic droughts), the use of low-yielding varieties, a decline in soil nutrients, excessive use of synthetic chemicals, infestations of pests, diseases, and parasitic weeds, as well as the high cost of inorganic fertilizers, which put it out of the reach of the resource-poor farmers who predominate(Omomowo & Babalola, 2021; Olowoake, 2014). The combined effects of compost with biochar and AMF on soil chemical properties and the yield of cowpea have not been studied extensively. In view of this, the current study was undertaken to assess the effect of biochar application with compost and *Arbuscular mycorrhizal* on soilchemical properties, root colonization and yield of cowpea.

2. MATERIALS AND METHODS

A pot experiment was carried out at Kwara State University, Faculty of Agriculture Screen House, (Latitude 8^0 71'N and Longitude 4^0 44'E) Malete. The climate is characterized by both the wet and dry seasons with a mean annual temperature that ranges from 25-28.9°C. In addition, the annual mean rainfall is about 1,150m, exhibiting the double maximal pattern between April and October of every year. The soil of Ilorin is formed from the Precambrian basement complex rocks and it is under the grassland savanna forest cover (Olowoake*et al*., 2018). Thirty-two pots were filled with 8.2 kg soil. The experimental design used in this study was a completely randomized design replicated three times. The treatments had thirteen major treatments combinations comprising the following:

1. Control (zero addition)
2. 50% compost + 50 % Biochar (Gliricidia) - 2.5 t/ha + 2g mycorrhizal
3. 60 % compost + 40 % Biochar (Gliricidia) -3.0 t/ha + 4g mycorrhizal
4. 70% compost + 30 % Biochar (Gliricidia) - 3.5 t/ha + 6g mycorrhizal
5. 80% compost + 20 % Biochar (Gliricidia) - 4.0 t/ha + 8g mycorrhizal
6. 50% compost + 50 % Biochar (Panicum maximum) -2.5 t/ha + 2g mycorrhizal
7. 60% compost + 40 % Biochar (Panicum maximum) -3.0 t/ha + 4g mycorrhizal
8. 70% compost + 30 % Biochar (Panicum maximum) -3.5 t/ha + 6g mycorrhizal
9. 80% compost + 20 % Biochar (Panicum maximum) -4.0 t/ha + 8g mycorrhizal
10. SSP 60 kg P_2O_5/ha + 2g mycorrhizal
11. SSP 60 kg P_2O_5/ha + 4g mycorrhizal
12. SSP 60 kg P_2O_5/ha + 6g mycorrhizal
13. SSP 60 kg P_2O_5/ha + 8g mycorrhizal

The compost, biochar and AMF were thoroughly mixed with the soil two weeks before planting. Single superphosphate (SSP) was applied two weeks after planting. Watering and weeding were carried out throughout the experiment. The results of analyses of the biochar and compost are summarized in Table 1

Table 1: Chemical Composition of Biochar and Compost

Treatment	Nutrient (%)							
	OC	OM	N	K	Avail P	Ca	Mg	Na
Gliricidiasepium	5.1	8.98	0.15	0.10	0.06	0.40	0.20	0.50
Panicum maximum	1.09	1.87	0.23	0.25	0.58	1.85	1.30	0.07
Gateway compost	-	-	1.23	0.5	4.6	26.0	0.53	37.3

Three cowpea seeds were planted and were later thinned into two seedlings/pot one week after planting. The treatments were arranged in a completely randomized design (CRD) with three replicates

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2.1 Soil Analysis

Pre-cropping chemical analysis of the experimental soil used in the screenhouse was carried out before the experiment and after harvest to determine the nutrient status of the soil. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962) and the soil pH was determined in 0.01M $CaCl_2$. The soil organic carbon and the total N were evaluated by the Walkey and Black (1934) method and the micro-Kjeldahl digestion method (Bremmer & Mulvaney, 1982) respectively. Available P was extracted by the method of Bray and Kurtz (1945) while exchangeable bases (Ca, Mg, K, and Na) contents were extracted with neutral 1M NH4OAc at a soil solution ratio of 1:10, and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer (AAS). Micronutrients were extracted with 0.1 EDTA and determined using the atomic absorption spectrophotometer.

2.2 Arbuscular Mycorrhizal Root Colonization Study

Approximately 8 root hairs of 1 cm length each were chosen randomly from each cowpea plant in each of the pots for AM colonization studies (Phillips & Hayman, 1970). Root samples were rinsed with 50% ethanol thoroughly and then put in 10% KOH and heated in a water bath for 15 minutes and rinsed. The roots were then stained with a mixture of 1:1:1 of glycerol, lactic acid, and distilled water respectively. Thereafter, 0.05% methyl blue solution was applied and heated for 5 minutes and then rinsed again. 50% Glycerol was added to preserve the root samples which were mounted on compound microscope slides to visualize the fungal structure. AM colonization was done based on the presence or absence of arbuscules, hyphae, or vesicles (McGonigle *et al*., 1999) while the percentage of mycorrhizal colonization was estimated by the following formula:

$$\text{AM root colonization} = \frac{\text{number of roots colonized with AM}}{\text{Total number of roots examined}} \times 100$$

Data collected were; plant height, stem girth, number of leaves, number of nodules, number of days taken to attain 50% flowering, number of seed/pod, pod length, number of pod /plant, and seed yield/plant.

2.3 Data Analysis

The data collected were subjected to statistical analysis of variance and significant differences among the treatment means were evaluated using Duncan's Multiple Range Test (DMRT) at 5 % probability level.

1. RESULTS AND DISCUSSION

3.1 The chemical properties of the soil used for the experiment are presented in table 2. The soil class was loamy sand and slightly acidic, with a pH of 6.7. The pH of most agricultural soils in the tropics has been reported to range from 5.0 to 6.8 (Udo & Ogunwale, 1977). The available P was 2.77 mg/kg, indicating that it was low, compared with the critical level ranges from 10–15 mg/kg (Adeoye & Agboola, 1985). Similarly, the values of N, P, and K were below the critical values of the nutrients in the soil of the Guinea Savanna (Aduloju2004; Ayodele 1983).These relatively low levels of major nutrients signify the need for augmentation to enhance the optimal performance of cowpea.

Table 2: Physico-Chemical Properties of Experimental Soil

Parameters value	Soil test
pH (H_2O)	6.7
Org.C (%)	7.9
Total N (%)	0.82
P (mg/kg)	2.77
Exchangeable bases (cmol/kg)	
Mg	0.78
Ca	0.58
Na	0.43
K	0.28
Extractable micronutrients (mg/kg)	
Cu	0.90
Fe	107
Mn	106
Zn	7.0
Sand (%)	82.0
Silt (%)	15.0
Clay (%)	3.0
Textural class	Loamy sand

3.2 Effect of Soil Amendments (Compost, Biochar and Mycorrhiza) on Plant Height, Number of Leaves, And Stem Girth of Cowpea

Table 3 shows the results of the effects of biochar amended with compost and arbuscular mycorrhizal inoculation on plant height, number of leaves and stem girth of cowpea at 8 weeks. The results show that significant differences were observed for plant height, stem girth and number of leaves among the treatments. The pots treated with 80% Gateway compost + 20 % Biochar (Panicum maximum) at 4.0 t/ha + 8g mycorrhizal (T9),yielded higher values for plant height, number of leaves, and, stem girth. These values were significantly higher ($P<0.05$) when compared with other treatments. Among the pots treated with mineral fertilizer, SSP 60 kgP_2O_5/ha + 6g mycorrhizal (T12) produced statistically better values in terms of height, number of leaves and stem girth than T10, T11, and T13. The control without fertilizer had significantly lower growth parameters compared to other treatments. The improved growth in biochar and AMF-treated plants may be due to their effect on the activity of transport proteins located in membranes involved in controlling the cellular division, wall extensions, and cell elongation (Hashem *et al*., 2019). Also, Ahmadabadi*et al*. (2019) reported that biochar and compost particles in the rhizosphere improve water retention and nutrient availability, which results in higher growth parameters. In addition, it was observed that mycorrhization with arbuscular mycorrhizal increased plant height in cowpea, maizeand tomato (Onduru*et al*., 2008; Taylor et al., 2008). The synergistic effect of the three amendments (80% Gateway compost + 20 % Biochar (*Panicum maximum*) at 4.0 t/ha + 8g mycorrhizal) together accounted for the higher value of plant height, number of leaves and stem girth of cowpea. This is in line with the work of Ohsowski*et al*. (2017).

Table 3. Effects of Biochar Amended with Compost and Arbuscular Mycorrhizal Inoculation on Plant Height, Number of Leaves, and Stem Girth of Cowpea

Treatment	Plant Height (cm)	Number of Leaves	Stem Girth (mm)
T1	39.0c	26.7c	2.80d
T2	58.7bc	26.9c	3.69cd
T3	61.0bc	31.7c	3.41dc
T4	63.0bc	33.3c	3.53cd
T5	87.7b	31.6c	3.60cd
T6	96.3b	39.0bc	3.56cd
T7	66.0b	34.3c	5.44b
T8	65.67bc	29.07c	4.29bc
T9	103.0a	61.7a	6.24a
T10	62.3bc	33.6c	4.68bc
T11	89.0b	40.0bc	4.49bc
T12	89.0b	49.3b	4.84bc
T13	41.7c	27.0c	3.76cd

Means having the same letter along the columns indicates no significant difference using Duncan Multiple Range Test at 5% probability level

Legend :

T1-No biochar/ no compost /no mycorrhizal (Control)
T2- 50% Gateway compost + 50 % Biochar (Gliricidia) -2.5 t/ha + 2g mycorrhizal
T3-60 % Gateway compost + 40 % Biochar (Gliricidia) -3.0 t/ha + 4g mycorrhizal
T4- 70% Gateway compost + 30 % Biochar (Gliricidia) -3.5 t/ha + 6g mycorrhizal
T5- 80% Gateway compost + 20 % Biochar (Gliricidia) -4.0 t/ha + 8g mycorrhizal
T6- 50% Gateway compost + 50 % Biochar (Panicum maximum) -2.5 t/ha + 2g mycorrhizal
T7- 60% Gateway compost + 40 % Biochar (Panicum maximum) -3.0 t/ha + 4g mycorrhizal
T8- 70% Gateway compost + 30 % Biochar (Panicum maximum) -3.5 t/ha + 6g mycorrhizal
T9- 80% Gateway compost + 20 % Biochar (Panicum maximum) -4.0 t/ha + 8g mycorrhizal
T10- SSP 60 kgP_2O_5/ha + 2g mycorrhizal
T11- SSP 60 kgP_2O_5/ha + 4g mycorrhizal
T12- SSP 60 kgP_2O_5/ha + 6g mycorrhizal
T13- SSP 60 kgP_2O_5/ha + 8g mycorrhizal

3.3 Effect of Soil Amendments (Compost, Biochar, and Mycorrhiza) on Number of Nodules and Root Colonization of Cowpea

The treatment effects on the number of nodules and % root colonization of cowpea are presented in table 4. The results indicate that the number of nodules was significantly ($p > 0.05$) influenced by 80% Gateway compost + 20 % Biochar (*Panicum maximum*) at 4.0 t/ha + 8g mycorrhizal application. The number of nodules per plant ranged between 3.3 and 19.3 with the control producing the least number of nodules while the application of T9 was the highest. AM fungal root colonization produced from pot amended with biochar, compost and AMF were significantly ($p > 0.05$) different from the pot amended with mineral fertilizer and AMF. However, the control pot resulted in root colonization that was significantly lower than amended cowpeas.

AM root colonization was significantly ($p<0.05$) higher in the pot treated with 80% Gateway compost + 20 % Biochar (*Panicum maximum*) at 4.0 t/ha + 8g mycorrhizal (T9) than in other treatments (table 4). The treatment T9 significantly increased root colonization compared to the single super phosphate and mycorrhizal treatments (T10, T11, T12, and T13) by 27.8%, 18.5%, 32.3%, and 13.8% No significant differences were observed in root colonization between the treatments T10, T11, T12 and T13. The enhanced nodulation of cowpea resulting from the biochar and compost application could be due to the retention of the phosphorus in the compost, which makes more P to be available in the biochar-compost-amended soils. Sulemana*et al*. (2021) reported that by amending the soils with biochar-composts, microbial activity allowed the availability of more P in the biochar-compost-amended soils. Furthermore, the applied biochar could harbour essential micro nutrients required by the rhizobia for nodule formation. In other studies, Mia *et al*. (–2014) and Tagoe *et al*. (2008), it was reported that application of biochar enhanced nodulation in red clover and soybean, respectively. The higher AM root colonization observed with 80% Gateway compost + 20 % Biochar (Panicum maximum)-4.0 t/ha + 8g mycorrhizal could be attributed to the nutrient content of biochar and compost which could have attracted the fungi to colonize the plants. Biochar has been shown to increase mycorrhizal root colonization and create a microhabitat in soil (Warnock *et al.*, 2007). Likewise, compost has been found to maintain or increase the AM fungal root colonization (Cobb, 2018).

3.4 Yield Components of Cowpea as Influenced by Soil Amendments (Compost, Biochar, and Mycorrhiza)

Table5 shows the result of the effects of biochar amended with compost and arbuscular mycorrhizal inoculation on yield and yield components of cowpea. There was no significant differences in the number of days taken to attain 50% flowering among the treatments. The longest number of days to flowering (28) was observed in the control while the least number of days to flowering (26) was observed in plants grown with the fertilizer combinations of 80% Gateway compost + 20 % Biochar (Panicum maximum) at 4.0 t/ha + 8g mycorrhizal (T9). The maximum number of seed pods $^{-1}$ (42.7), pod length (20 cm) number of pod plant $^{-1}$(3.0), and grain yield plant^{-1} (5.5 g) were significantly highest in the pot amended with 80% Gateway compost + 20 % Biochar (Panicum maximum) -4.0 t/ha + 8g mycorrhizal (T9). Likewise, 41.8 % yield increase was observed in T9 over the control. The increase in the cowpea yield and its components could be as a result of the improved growth characteristics such as height, girth, nodulation and number of pod caused from the integration of biochar, compost and mycorrhizal treated pots. This is because biochar and compost contain some amounts of both major and minor nutrients, which could have been taken up by the plants for an enhanced partitioning of photosynthates. This is in line with the report of Njuge (2018), who stated that addition of mycorrhizal with soil amendments (biochar + vermicompost) enhanced the plant growth and yield of soybean.

Table 4. Effects of biochar amended with compost on number of nodules and arbuscular mycorrhizal root colonization of cowpea plants

Treatment	Number of nodules	% AM root colonization
T1	3.3e	40.8c
T2	12.0bcd	65.5b
T3	6.3de	54.2b
T4	8.0cde	54.5b
T5	13.0bcd	52.4b
T6	14.7bc	54.6b
T7	16.0b	66.9b
T8	13.0bcd	61.0b
T9	19.3a	78.9a
T10	9.3bcde	57.0b
T11	12.0bcd	64.3b
T12	10.7bcde	53.4b
T13	9.3bcde	68.0b

Means having the same letter along the columns indicates no significant difference using Duncan Multiple Range Test at 5% probability level

Legend

T1- No biochar/ no compost /no mycorrhizal (Control)
T2- 50% Gateway compost + 50 % Biochar (Gliricidia) -2.5 t/ha + 2g mycorrhizal
T3-60 % Gateway compost + 40 % Biochar (Gliricidia) -3.0 t/ha + 4g mycorrhizal
T4- 70% Gateway compost + 30 % Biochar (Gliricidia) -3.5 t/ha + 6g mycorrhizal
T5- 80% Gateway compost + 20 % Biochar (Gliricidia) -4.0 t/ha + 8g mycorrhizal
T6- 50% Gateway compost + 50 % Biochar (Panicum maximum) -2.5 t/ha + 2g mycorrhizal
T7- 60% Gateway compost + 40 % Biochar (Panicum maximum) -3.0 t/ha + 4g mycorrhizal
T8- 70% Gateway compost + 30 % Biochar (Panicum maximum) -3.5 t/ha + 6g mycorrhizal
T9- 80% Gateway compost + 20 % Biochar (Panicum maximum) -4.0 t/ha + 8g mycorrhizal
T10- SSP 60 kgP_2O_5/ha + 2g mycorrhizal
T11- SSP 60 kgP_2O_5/ha + 4g mycorrhizal
T12- SSP 60 kgP_2O_5/ha + 6g mycorrhizal
T13- SSP 60 kgP_2O_5/ha + 8g mycorrhizal

Similar results were reported by Alkobaisy*et al*. (2020), where their study showed that vermicompost and AMF significantly increased the grain yield of soybean. The lower number of pods and lower yield of cowpea from pots treated with SSP and mycorrhizal when compared with T9 may be as a result of P fixation in the soil. This is in line with the report from Akinbode and Ayeni (2017), which stated that P may be present in the soil but not available to the growing plant because it is insoluble in such situation.

Table 5. Effects of Biochar Amended with Compost and Arbuscular MycorrhizalTreatment Inoculation on Yield Parameters of Cowpea

Treatment	Days to 50% Flowering	Number of Seed/Pod	Pod Length (cm)	Number of Pod/Plant	Yield/Plant (g)
T1	28.0a	22.3c	10.3c	2.0b	3.2b
T2	28.0a	30.0bc	16.7b	2.7ab	4.5b
T3	27.7ab	35.7bc	16.3b	2.7ab	4.5b
T4	27.3ab	24.7bc	14.0bc	2.0b	3.7b
T5	28.0a	39.7b	16.3b	3.0a	5.3a
T6	27.7ab	37.0bc	17.0b	2.7b	4.7b
T7	27.7ab	34.3bc	17.7b	2.7b	4.8b
T8	27.3ab	32.0bc	17.0b	2.6b	4.2b
T9	26.0ab	42.7a	20.0a	3.0a	5.5a
T10	28.0a	34.7bc	17.7b	2.6b	4.8b
T11	27.7ab	28.3bc	17.0b	2.3b	4.5b
T12	27.0ab	36.0bc	18.3a	2.6b	4.6b
T13	28.8a	41.3a	22.3a	3.0a	5.2a

Means having the same letter along the columns indicates no significant difference using Duncan Multiple Range Test at 5% probability level.

Legend

T1- No biochar/ no compost /no mycorrhizal (Control)
T2- 50% Gateway compost + 50 % Biochar (Gliricidia) -2.5 t/ha + 2g mycorrhizal
T3-60 % Gateway compost + 40 % Biochar (Gliricidia) -3.0 t/ha + 4g mycorrhizal
T4- 70% Gateway compost + 30 % Biochar (Gliricidia) -3.5 t/ha + 6g mycorrhizal
T5- 80% Gateway compost + 20 % Biochar (Gliricidia) -4.0 t/ha + 8g mycorrhizal
T6- 50% Gateway compost + 50 % Biochar (Panicum maximum) -2.5 t/ha + 2g mycorrhizal
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T10- SSP 60 kgP_2O_5/ha + 2g mycorrhizal
T11- SSP 60 kgP_2O_5/ha + 4g mycorrhizal
T12- SSP 60 kgP_2O_5/ha + 6g mycorrhizal
T13- SSP 60 kgP_2O_5/ha + 8g mycorrhizal

3.5 Compost, Biocharand Arbuscular Mycorrhizal Effect on Some Soil Chemical Properties

The effect of compost, biochar and arbuscular mycorrhizal application on the post-cropping soil chemical analysis is presented in table 6. Biochar and compost addition significantly increased pH, organic carbon, total nitrogen, phosphorus and potassium content of soil with 80% Gateway compost + 20 % Biochar (*Panicum maximum*) -4.0 t/ha + 8g,mycorrhizal having the highest and control having the lowest. Research has shown that application of manure and biochar significantly has an impact on the chemical, physical and biological properties of the soil. Most of these effects are due to an increase in soil organic matter (Agboola & Moses, 2015; Olowoake *et al*., 2021) resulting from compost and manure application. Therefore, biochar and compost are excellent sources of major plant nutrients such as N, P and potassium (K), and also provide many of the secondary nutrients that plants require. Soil organic carbon and mineral N increased significantly with increase in biochar and compost application. These results are in agreement with report of Agboola and Moses (2015). The increase may be due to N fixation by the plant and supply of N content in the compost through mineralization associated to the improvement of soil conditions for microorganism's development and activity, as a result of an increase in soil pH due to biochar application. pH tends to increase while exchangeable acidity decrease, with increasing rates of biochar and compost due to the displacement of H^+, Fe^{2+}, Al^{3+}, Mn^{4+} and Cu^{2+} ions from the soil adsorption site (Onwonga *et al*., 2010). Abban-Baidoo (2020) also found that the soil available P increased with biochar and compost application.

Table 6. Effect of Compost, Biochar and Arbuscular Mycorrhizal on Some Chemical Properties at Harvest

Treatment	pH (H_2O)	Available P ($mgkg^{-1}$)	K c $molkg^{-1}$	OC	N
				gkg^{-1}	
before Experiment	6.7	2.77	0.28	0.79	0.082
After Experiment					
T1	6.1c	9.9e	0.20c	1.03d	0.11d
T2	7.3a	25.1d	0.36b	1.39c	0.29b
T3	7.4a	41.9b	0.46b	2.55b	0.29b
T4	7.2a	40.8b	0. 38b	2.20	0.29b
T5	7.4a	46.5b	0.36b	2.55b	0.28b
T6	7.3a	30.7c	0.38b	2.59b	0.28b
T7	7.3a	34.0c	0.46b	2.55b	0.27b
T8	7.4a	37.1c	0.36b	2.66b	0.24b
T9	7.5a	51.2a	0.52a	3.96a	0.44a
T10	6.8b	18.8d	0.29b	2.60b	0.33b
T11	6.9b	15.1d	0.28c	2.00b	0.22c
T12	6.7b	17.6d	0.23c	1.87c	0.21c
T13	6.8b	19.5d	0.23c	1.40c	0.15d

Impact of Biochar, Compost, and Mycorrhizal Inoculation on Cowpea Yield and Soil Properties

Means having the same letter along the columns indicate no significant difference using Duncan Multiple Range Test at 5% probability level.

Legend

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T5- 80% Gateway compost + 20 % Biochar (Gliricidia) -4.0 t/ha + 8g mycorrhizal
T6- 50% Gateway compost + 50 % Biochar (Panicum maximum) -2.5 t/ha + 2g mycorrhizal
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T11- SSP 60 kgP_2O_5/ha + 4g mycorrhizal
T12- SSP 60 kgP_2O_5/ha + 6g mycorrhizal
T13- SSP 60 kgP_2O_5/ha + 8g mycorrhizal

4. CONCLUSION

AMF, compost and biochar treatment improved the growth of cowpea plant by positively affecting the growth and yield parameters. Additionally, the ability of AMF, compost and biochar to improve root colonization, number of noodles and other yield parameters may have significantly contributed to growth promotion and high yield of cowpea than mineral fertilizer and AMF. However, the combined application of AMF, compost and biochar was more effective compared to that of mineral fertilizer and AMF.

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