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Growth and Yield Performance of Tomato (*Solanumlycopersicum L*) in Soil Amended with Rice Husk Biochar in Gombe State

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Abstract: *Rice cultivation in Gombe State, Nigeria results in the production of enormous amount of rice husk (RH) as agricultural waste which can be converted into Rice Husk Biochar (RHB). While the impacts of RHB on plant yield has been widely reported, there is a lack of data regarding its use in pot substrates for greenhouse tomato production in the State highlighting the need of this study. Soil samples and RH were collected in Gombe State, while tomato (PADMA 108 F1) seeds were gotten from the Institute of Agricultural Research and Training in Jos. The RH was subjected to pyrolysis, physicochemical properties of the soil, RH and RHB before and after planting, and greenhouse experiment were done following standard methods. Results of the physiochemical analysis of soil and biocharshowed that higher values (7.8 for pH in H2O, 8.3 for pH in 0.01M* $CaCl_2$*, 49.6 for Cation Exchange Capacity, among others) were recorded in thebiochar compared with soil, at vegetative stage, plant height was highest in the control (*11.68 ± 5.99^{d}*), as well as number of leaves (*36.9 ± 33.6^{e}*), at flowering stage, plant height was highest in the control (26.67±5.51e),number of leaves was highest (*116.0 ± 39.6^{e}*) (*116.0 ± 39.6^{e}*) in T5 (50 tons/h), as well as leaf area (*21.37 ± 9.64^{d}*), while number of flowers was highest (*11.89 ± 6.49^{c}*) in T4 (40 tons/h), at fruiting and harvesting stage, number of fruits was highest (*2.00 ± 1.67^{a}*)in T4 (40 tons/h), and correlation analysis showed a strong positive association between growth and yield characteristics; the number of flowers and fruits was influenced by plant height, number of leaves, leaf area, and girt. The study concluded that tomato plant growth and yield can be enhanced by RHB.*

Keywords: Biochar, pyrolysis, rice-husk, tomato.

INTRODUCTION

Biocharaccording to Agegnehu*et al*. (2017), Godlewska*et al*. (2017), Tan *et al*. (2017), Xiao *et al*. (2017), and Ghorbani*et al*. (2019), is any biological residue from any organic-based materials created by gasification or pyrolysis at 300–600^{o}C without oxygen. Similarly, Hossain *et al*. (2019), posited that biochar is a resistant and stable type of organic matter that can remain in the soil for a number of years. A few typical feedstocks for biocharare forestry byproducts, organic industrial waste, manures, and agricultural residue (Semida*et al*., 2019; Wang *et al*., 2019). Biochar holds a lot of potentials because it can both improve soil qualities in a non-destructive way and enable an eco-friendly method of managing agricultural residues (Barus, 2016; Chen *et al*., 2018; Bu *et al*., 2019).

Significant byproducts of rice cultivation are rice husk, rice straw, and rice bran (Karam*et al*., 2022). Like any other plant residue, rice husk can be turned into biochar at the first stage of rice milling, when the paddy rice is husked (Karam*et al*., 2022). Notably, 20% of rice weight is made up of rice husk biochar (RHB), which is composed of 50% cellulose, 25–30% lignin, 15–20% silica, and 10–15% moisture (Singh, 2018). Turning rice husk into RHB and then recycling it back into the paddy field as a soil amendment is one efficient way to manage rice waste, and about 35% of rice husk's feedstock material can be converted into biochar (Karam*et al*., 2022). Notably, an estimated 1,032,993.6 metric tonnes of rice husk are produced in Nigeria each year and this has increased interest in turning waste or biomass through pyrolysis to biochar (Nwajiaku*et al*., 2018).

Research has shown that adding RHB to the soil enhances its quality and crop output by raising the soil's pH, moisture-holding ability, cation-exchange capacity, and microflora (Ojo*et al*., 2017), it improve soil nutrient status, improve water retention, promote carbon sequestration, increase cation exchange capacity, reduce nitrogen leaching, and lessen toxicity in contaminated soils (Wu *et al*., 2017; Dejene and Tilahun, 2019). In this regard, Zhang *et al*. (2020) demonstrated that as irrigation and RHB levels increased, tomato growth rates in terms of plant height and stem diameter also increased.The tomato plant (*Solanumlycopersicum* L.) is a well-known vegetable that is frequently grown in home gardens because it yields more with less space and contains vitamins A, C, and important minerals, especially Ca, Mn, and K (Ruben *et al*., 2020). Rawat*et al*. (2019) claimed that tomatoes also promote gastric secretion, act as blood purifiers, and maintain intestinal health. Additionally, producing and applying RHB to soil can be a useful way to sequester carbon (C), reduce emissions of methane (CH4) and nitrous oxide (N2O), lower the bioavailability of heavy metals and organic pollutants, and manage the leaching of pollutants and nutrients from soil (Oni *et al*, 2020). This can mitigate the effects of long-term cropping and overuse of chemical fertilizers which causes soil fertility to gradually decline due to organic matter erosion and instability, and in turn, lower plant quality and yields worldwide (Palavi*et al*., 2021). While the impacts of RHB on plant yield has been widely reported, there is a lack of data regarding its use in pot substrates for greenhouse tomato production in Gombe State, Nigeria. Also, burning rice husk biomass releases greenhouse gases, and growing human populations and activities limit the amount of land accessible for tomato production. Therefore, it is essential to improve the few land resources in order to increase crop productivity and lessen the detrimental effects of burning rice husks. This study is therefore necessary as it seeks to increase tomato production in order to meet the demands of the State's growing population while also reducing agricultural waste.

MATERIALS AND METHODS

Sample Collection

Topsoil was taken from the Biological Garden at the Federal University of Kashere, Gombe State, at a depth of 0–10 cm, while rice husk was collected from the rice processing mill in Gombe metropolis, Gombe state, Nigeria, while the tomato (PADMA 108 F1) seedswere collected from the Institute of Agricultural Research and Training in Jos, Nigeria.

Pyrolysis

The two-barrel metal retort method was used to accomplish this. After being filled with rice husk, the 114-liter retort chamber was suspended in a 208-liter drum with holes in the sidewalls surrounding the top and bottom. Smaller wood chips were then placed in the area between the two drums, dampened with kerosene (starter fluid) and ignited for three hours. The large metallic drum had a lid that supported the chimney operation and had an exhaust pipe. Following the pyrolysis, the drum was left to cool before the RHB was extracted and placed in a sanitized sack.

Determination of Physicochemical Properties of the Soil, Rice Husk and Rice HuskBiochar Before and After Planting

Standard techniques were used to determine the physical and chemical parameters such as soil texture, acidity, pH, E.C., C: N ratio, P, Na, Ca, K, Mg, H+, S, Mn, Fe, Cu, and B.

Green house experiment on the growth of tomato plant with different biochar amendment

Five treatments with three repetitions were adopted in aCompletely Randomized Design (CRD) of the experiment. In a seven-litre plastic container, five kilogrammes of topsoil and rice husk biochar were combined at four different rates (20, 30, 40, and 50 t/ha), while the control was the untreated soil (0 t/ha). After adding a small amount of water, the mixtures were let to stand for one weeks to ensure homogeneity. Next, two tomato seedlings from the nursery that had been grown for three weeks were transferred into each pot, and the pots were watered twice a day. Two weeks after transplanting, agronomic characteristics like the plant's height, number of leaves, leaf area, stem girth, number of flowers, and number of fruits were measured.

Data Analysis

The experiment was conductedin four replications, Analysis of Variance (ANOVA), and Pearson correlation analysis were done, and the Fisher grouping test was used to separate the means of all the datacollected and analyzed.

RESULTS

Physiochemical Properties of Soil, Biochar, and Treatments

The result of the physiochemical analysis of soil and biochar is shown in Table 1. Higher values were recorded in the treatment and biochar compared with soil for all the parameters studied. The highest pH (in H_2O) value of 7.8 was recorded for biochar while the least value of 5.1 was recorded in treatment 5, pH (in 0.01M $CaCl_2$) was highest (8.3) in biochar, and least (4.8) in treatment 5, Cation Exchange Capacity was highest (49.6) in biochar and least (2.2) in soil, electrical conductivity was highest (0.23) in treatment 5 and least (0.12) in soil, magnesium was highest (9.7) in treatment 5 and least (0.5) in soil, biochar had the highest (101.4) water holding capacity while soil had the least (9.7), phosphorous was highest (160) in biochar and least (2.7) in soil, sodium was highest (3.5) in biochar and least (0.17) in soil, nitrogen was highest (0.12) in biochar and least (0.019) in soil, potassium was highest (15.6) in biochar and least (0.06) in soil, calcium was highest (26.3) in biochar and least (1.62) in soil, organic carbon was highest (4.6) in biochar and least (0.153) in soil, organic matter was highest (7.92) in biochar and least (0.264) in soil, moisture content was highest (17.05) in treatments 2 and 3 respectively and least (5.8) in biochar, among others.

Table 1: Physiochemical Properties of Soil and Biochar

Parameters	Soil	T2	T3	T4	T5	Biochar
pH (in H_2O)	6.7	6.7	6.2	5.5	5.1	7.8
pH (in 0.01M $CaCl_2$)	5.5	5.4	5.2	5.3	4.8	8.3
Cation Exchange Capacity (Cmol/Kg)	2.2	6.1	6.3	7.56	17.77	49.6
Electrical Conductivity (dSm)	0.12	0.19	0.14	0.21	0.23	0.16
Magnesium (Cmol/Kg)	0.55	1.08	1.32	1.63	1.86	9.7
Water Holding Capacity (%)	9.7	12.3	16.3	20.6	20.8	101.4
Phosphorus (mg/Kg)	2.7	3.01	3.35	4.22	5.7	160
Sodium (Cmol/Kg)	0.17	0.27	0.31	0.42	0.52	3.5
Nitrogen (%)	0.019	0.034	0.045	0.072	0.088	0.12
Potassium (Cmol/Kg)	0.06	0.91	0.231	0.445	9.83	15.6
Calcium (Cmol/Kg)	1.62	3.72	4.23	4.96	5.81	26.3
Organic Carbon (%)	0.153	0.235	0.551	0.721	0.923	4.6
Organic Matter (%)	0.264	0.405	0.95	1.243	1.591	7.92
Moisture Content	15.05	17.05	17.05	14.05	14.5	5.8
Particle Density (g/cm^3)	2.63	2.61	2.57	2.58	2.59	1.54
Bulk Density (g/cm^3)	1.68	1.67	1.65	1.69	1.68	0.63
Porosity (%)	36.122	36.015	35.798	34.496	35.135	59.091
Clay (%)	4.8	4.8	5.4	6.2	6.8	0.0
Silt (%)	18.7	19.3	19.8	20.5	21.1	0.0
Sand (%)	76.5	75.9	74.8	73.3	72.1	0.0

Agronomic parameters at Vegetative Stage

Table 2 shows the result of agronomic parameters at vegetative stage spanning 1 to 9 weeks. Plant height was highest in the control (11.68±5.99^{d}), followed by treatment 5 (10.78±5.48^{c}), treatment 4 (10.38±5.29^{c}), treatment 2 (9.07±5.43^{b}), and least in treatment 3 (6.86±3.26^{a}), number of leaves was highest in the control (36.9±33.6^{e}), followed by treatment 4 (34.00±29.44^{d}), treatment 5 (31.0±31.1^{c}), treatment 2 (29.33±26.28^{b}), and least in treatment 3 (27.44±24.48^{a}), leaf area was highest in treatment 5 (14.20±8.49^{d}), followed by treatment 4 (13.49±5.32^{c}), control (11.78±5.20^{b}), treatment 2 (8.76±4.38^{ab}), and least in treatment 3 (8.25±4.46^{a}), and girt was highest in treatment 4 (1.903±1.15^{a}), followed by treatment 2 (1.701±1.13^{a}), treatment 5 (1.691±1.01^{a}), treatment 3 (1.656±0.99^{a}), and least in the control (1.432±0.85^{a}). Significant difference was recorded in plant height, number of leaves, and leaf area across the different treatments but not in girt.

Table 2: Agronomic parameters at Vegetative Stage

Parameters	**T1 (Control)**	**T2 (20 tons/h)**	**T3 (30 tons/h)**	**T4 (40 tons/h)**	**T5 (50 tons/h)**
Plant Height	11.68±5.99^{d}	9.07±5.43^{b}	6.86±3.26^{a}	10.38±5.29^{c}	10.78±5.48^{c}
Number of Leaves	36.9±33.6^{e}	29.33±26.28^{b}	27.44±24.48^{a}	34.00±29.44^{d}	31.0±31.1^{c}
Leaf Area	11.78±5.20^{b}	8.76±4.38^{ab}	8.25±4.46^{a}	13.49±5.32^{c}	14.20±8.49^{d}
Girt	1.432±0.85^{a}	1.701±1.13^{a}	1.656±0.99^{a}	1.903±1.15^{a}	1.691±1.01^{a}

* Means that do not share a letter are significantly different.

Agronomic Parameters at Flowering Stage

The result of agronomic parameters at flowering stage is shown in Table 3. Plant height was highest in the control (26.67±5.51^{e}), followed by treatment 5 (24.00±8.72^{d}), treatment 4 (23.57±2.38^{c}), treatment 2 (20.667±0.58^{b}), and least in treatment 3 (17.67±4.04^{a}), number of leaves was highest in treatment 5 (116.0±39.6^{e}), followed by the control (103.0±47.6^{d}), treatment 2 (99.67±13.61^{c}), treatment 3 (82.0±21.2^{b}), and least in treatment 3 (27.44±24.48^{a}),leaf area was highest in treatment 5 (21.37±9.64^{d}), followed by treatment 4 (18.097±1.212^{c}), treatment 3 (13.85±2.10^{b}), treatment 2 (13.27±1.78^{b}), and least in the control (12.93±6.25^{a}), girt was highest in treatments 4 and 5 respectively (3.20±1.25^{b}), followed by treatment 2 (3.38±1.11^{bc}), treatment 3 (2.96±1.03^{a}), and least in the control (2.29±0.71^{a}), and number of flowers was highest in treatment 4 (11.89±6.49^{c}), followed by treatment 5 (11.56±8.95^{c}), treatment 2 (9.44±6.00^{b}), treatment 3 (9.00±6.75^{b}), and least in the control (5.56±4.88^{a}). Significant difference was recorded in plant height, and number of leaves across the different treatments but not in leaf area between treatments 2 and 3, girt between the control and treatment 3, and treatment 4 and 5 respectively, and number of flowers in treatments 2 and 3, and treatments 4 and 5 respectively.

Table 3: Agronomic Parameters at Flowering Stage

Parameters	**T1 (Control)**	**T2 (20 tons/h)**	**T3 (30 tons/h)**	**T4 (40 tons/h)**	**T5 (50 tons/h)**
Plant Height	26.67±5.51[e]	20.667±0.58[b]	17.67±4.04[a]	23.57±2.38[c]	24.00±8.72[d]
Number of Leaves	103.0±47.6[d]	99.67±13.61[c]	82.0±21.2[b]	73.7±43.2[a]	116.0±39.6[e]
Leaf Area	12.93±6.25[a]	13.27±1.78[b]	13.85±2.10[b]	18.097±1.212[c]	21.37±9.64[d]
Girt	2.29±0.71[a]	3.38±1.11[bc]	2.96±1.03[a]	3.20±1.25[b]	3.20±1.25[b]
Number of Flowers	5.56±4.88[a]	9.44±6.00[b]	9.00±6.75[b]	11.89±6.49[c]	11.56±8.95[c]

*Means that do not share a letter are significantly different.

Agronomic Parameters at Fruiting and Harvesting Stage

Table 4 shows the result of agronomic parameters at fruiting and harvesting stage. Plant height was highest in treatment 5 (39.57±5.96[a]), followed by the control (37.00±7.92[ab]), treatment 4 (32.83±2.93[abc]), treatment 2 (30.98±3.18[bc]), and least in treatment 3 (28.75±7.31[c]), number of leaves was highest in treatments 2 and 5 respectively (168.3±15.24[d]), followed by treatment 3 (142.8±26.7[c]), treatment 4 (140.00±20.02[b]), and least in the control (133.2±57.1[a]), leaf area was highest in treatment 5 (21.13±8.52[a]), followed by the control (17.96±4.75[ab]), treatment 4 (17.80±4.18[ab]), treatment 2 (13.97±8.95[ab]), and least in treatment 3 (13.47±3.78[b]), girt was highest in treatment 2 (4.32±0.66[a]), followed by treatment 4 (4.29±0.276[a]), treatment 5 (4.05±0.59[a]), treatment 3 (3.85±0.64[ab]), and least in the control (2.79±0.86[b]), and number of fruits was highest in treatment 4 (2.00±1.67[a]), followed by treatment 5 (1.00±2.00[b]), treatment 3 (0.67±1.63[c]), treatment 2 (0.50±0.84[c]), and least in the control (0.33±0.52[c]). Significant difference was recorded in plant height, and number of leaves across the different treatments but not in leaf area between the control and treatments 2, girt, and number of flowers in the control, treatments 2 and 3 respectively.

Table 4: Agronomic Parameters at Fruiting and Harvesting Stage

Parameters	**T1 (Control)**	**T2 (20 tons/h)**	**T3 (30 tons/h)**	**T4 (40 tons/h)**	**T5 (50 tons/h)**
Plant Height	37.00±7.92[ab]	30.98±3.18[bc]	28.75±7.31[c]	32.83±2.93[abc]	39.57±5.96[a]
Number of Leaves	133.2±57.1[a]	168.3±15.24[d]	142.8±26.7[c]	140.00±20.02[b]	168.3±38.2[d]
Leaf Area	17.96±4.75[ab]	13.97±8.95[ab]	13.47±3.78[b]	17.80±4.18[ab]	21.13±8.52[a]
Girt	2.79±0.86[b]	4.32±0.66[a]	3.85±0.64[ab]	4.29±0.276[a]	4.05±0.59[a]
Number of Fruits	0.33±0.52[c]	0.50±0.84[c]	0.67±1.63[c]	2.00±1.67[a]	1.00±2.00[b]

*Means that do not share a letter are significantly different.

Correlation Analysis

Table 5 shows the result of correlation analysis for the different agronomic parameters studied at different stages of tomato growth. A strong positive correlation was recorded for girt at vegetative and plant height at flowering stages (0.943), plant height and girt at vegetative stage (0.898), plant height at vegetative and flowering stages (0.814), leaf area at vegetative stage and plant height at fruiting (0.743), number of leaves and leaf area at vegetative stage (0.677), girt at flowering stage and number of fruits (0.581), number of leaves at vegetative and plant height at fruiting stages

(0.580), number of leaves at vegetative stage and number of fruits (0.559), girt at vegetative stage and number of flowers (0.556), number of leaves and leaf area at flowering stage (0.528), and leaf area and girt at flowering stage (0.542). Weak positive correlation was recorded between leaf area at vegetative and number of leaf at fruiting stages (0.496), plant height at vegetative stage and number of flowers (0.493), leaf area at vegetative and girt at flowering stages (0.488), plant height at flowering stage and number of flowers (0.481), number of leaf and plant height at fruiting stage (0.473), number of leaf at vegetative and fruiting stages (0.437), number of leaves and girt at fruiting stage (0.433), leaf area at flowering and girt at fruiting stages (0.421), girt at flowering and fruiting stages (0.404), among others.

Table 5: Correlation Analysis

	Num. @ Ft	**Girt @ Ft**	**Leaf Area @ Ft**	**Num. leaf @ Ft**
Girt @ Ft	0.344			
Leaf Area @ Ft	0.032	0.042		
Num. leaf @ Ft	0.140	0.433	0.039	
Plant Ht @ Ft	0.384	0.264	0.160	0.473
Num. of flower	0.229	0.307	0.327	0.324
Girt @ Fl	0.103	0.404	0.106	0.581
Leaf Area @ Fl	0.195	0.421	-0.062	0.280
Num. Leaf @ Fl	0.212	0.241	-0.097	0.150
Plant Ht @ Fl	-0.119	-0.352	0.226	-0.104
Girt @ Veg	-0.012	-0.324	0.150	-0.064
Leaf Area @ Veg	0.545	0.364	0.002	0.496
Num. Leaf @ Veg	0.559	0.267	-0.327	0.437
Plant Ht @ Veg	0.166	-0.242	0.057	0.049
	Plant Ht @ Ft	**Num. of flower**	**Girt @ Fl**	**Leaf Area @ Fl**
Num. of flower	0.320			
Girt @ Fl	0.262	0.012		
Leaf Area @ Fl	0.235	0.046	0.542	
Num. Leaf @ Fl	0.200	-0.199	0.365	0.528
Plant Ht @ Fl	0.026	0.481	-0.360	-0.282
Girt @ Veg	0.014	0.556	-0.417	-0.361
Leaf Area @ Veg	0.743	0.038	0.488	0.317
Num. Leaf @ Veg	0.580	0.033	0.323	0.150
Plant Ht @ Veg	0.264	0.493	-0.336	-0.336
	Num. Leaf @Fl	**Plant Ht @ Fl**	**Girt @ Veg**	**Leaf Area @ Veg**
Plant Ht @ Fl	-0.206			
Girt @ Veg	-0.402	0.943		
Leaf Area @ Veg	0.354	-0.370	-0.338	
Num. Leaf @ Veg	0.256	-0.253	-0.140	0.677
Plant Ht @ Veg	-0.310	0.814	0.898	-0.086
	Num. Leaf @ Veg			
Plant Ht @ Veg	0.196			

Key: Ft = Fruiting stage, Ht = Height, Fl = Flowering stage, Veg = Vegetative stage, Nnm = Number

DISCUSSION

Important byproducts of rice productionare Rice husk, rice straw, and rice husk which is produced at the initial stage of rice milling, when the paddy rice is husked (Karam*et al*., 2022). Like any other plant residue, rice husk can be turned into biochar, and Rice husk biochar (RHB) makes up 20% of the weight of rice and is composed of 50% cellulose, 25–30% lignin, 15–20% silica, and 10–15% moisture (Singh, 2018). Any biological residue from organic materials generated by gasification or pyrolysis at 300–6000C without oxygen is known as biochar (Ghorbani*et al*., 2019; Semida*et al*., 2019; Wang *et al*., 2019).Biochar is a dependable energy source that can help offset the drawbacks associated with the usage of chemical fertilizersbecause of its potential to bio-fortify the soil and lessen soil nutrient loss through leaching, (Adebajo*et al*., 2019).

The results of the physiochemical analysis of soil and biochar revealed higher values in the treatment and biochar compared with soil for every parameter examined(Table 1). Biochar had the highest pH values in H_2O and 0.01M CaCl2, whereas treatment 5, which contained 50 tonnes of biochar per hectare, had the best pH values for plant development (5.1). The pH of the soil changed from mildly acidic (6.7) to acidic (5.1) when biochar was added, suggesting that the proper amount of biochar must be applied to the soil to minimize any detrimental effects on soil pH.In a similar manner, Adebajo*et al*. (2019) in their study that examined the effects of rice husk biochar on the growth of soil microorganisms and tomato yieldfound that a higher pH of rice husk biochar suggests that the biochar raised the pH of the soil and increased the availability of nutrients to the plants, thereby improving the plant growth.. Additionally, values for other physiochemical parameters, such as electrical conductivity, cation exchange capacity, water holding capacity, phosphorous, sodium, potassium, calcium, nitrogen, organic carbon, organic matter, and moisture content, were lowest in soil and highest in biochar, whereas magnesium content was lowest in soil and highest in treatment 5, which contained 50 tonnes of biochar per hectare (Table 1). Significant differences were noted for the various physiochemical parameters examined across the various treatments, demonstrating the potential of biochar in boosting soil nutrients. These results are consistent with those of Mishra *et al*. (2017), who discovered that adding rice-husk biochar to the soil aided in the introduction of nutrients, which in turn aided in the numerous enhancements of the tomato plant. Following pyrolysis, the majority of the feedstock's mineral contents were found in the biochar, which was consistent with earlier findings by Adebajo*et al*. (2019).

Biochar is a charcoal product that improves agricultural yields and has been shown to have good effects on plant physiology, biomass production, and crop yield (Adebajo*et al*., 2019). The study's agronomic characteristics at the vegetative stage, which covered weeks 1 through 9, revealed that while girt was highest in T4 (40 tons/h) and lowest in the control, plant height, number of leaves, and leaf area were highest in the control when compared to the other treatments. Additionally, there were notable variations in plant height, leaf count, and leaf area among the various treatments, but not in girt (Table 2). The great performance of the tomato seedlings in the control group as compared to the various degrees of treatments may have resulted from the tomato seeds being sown a weeks after the biochar was applied. During this time, the biochar may not have completely decomposed in the soil and released its nutrients. This claimis corroborated byWang *et al*. (2019) and Karam*et al*. (2022). In the study by Adebajo*et al*. (2019), before tomato seeds were sown, a 14-day period was given to allow the biochar to break down and release vital nutrients, and an increase in plant height due to biochar application was reported and attributed to the positive effect of biochar in supplying essential nutrients for vegetative growth of plants. In a similar manner, Agbna*et al*. (2017) found that adding biochar to soil enhanced agronomic characteristics such tomato plant height, leaf count, and fresh and dried plant parts. Furthermore, it was found that adding rice husk and Siam weed biochar to the soil increased tomato plant yields without the need for fertilizers (Lorn*et al*., 2017; Adebajo*et al*., 2019).

Additionally, during the flowering stage, plant height was highest in the control, number of leaves and leaf area was highest in T5 (50 tons/h), girt was highest in T4 (40 tons/h) and T5 (50 tons/h), respectively, and number of flowers was highest in T4 (40 tons/h). These results show a significant difference in plant height and number of leaves among the various treatments, but not in leaf area between treatments 2 and 3, girt between treatments 4 and 5, and number of flowers in treatments 2 and 3, and treatments 4 and 5, respectively (Table 3). Additionally, the results of agronomic parameters at the fruiting and harvesting stage showed that T5 had the highest plant height and leaf area (50 tons/h), T2 had the highest number of leaves (20 tons/h) and T5 had the highest number of leaves (50 tons/h), T2 had the highest girt (20 tons/h), and T4 had the highest number of fruits (40 tons/h). These results showed that there was a significant difference in plant height and number of leaves between treatments 2 and 3, but not in leaf area. Previous reports have documented these differences in the effects of varying biochar concentrations on tomato and other crop development and production. For example, Shashi*et al*. (2018) found that amendments with 20 t/ha of rice-husk biochar had the highest agronomic parameters on maize, whereas Adebajo*et al*. (2019) found that at the fruiting stage, soil amended with 20 t/ha biochar had higher values than those treated with 40 t/ha, but soil amended with 40 t/ha had the highest number and weight of fruits.Notably, ricehusk biochar's higher physicochemical values at T5 (50t/h) in soil (Table 1) may also be linked to its higher tomato yield (Table 4), which supports the claim made by Adebajo*et al*. (2019) that biochar can have a significant impact on soil moisture, nutrient dynamics, and crop yield and that its activities in soil can last longer, and according to Sani*et al*. (2020), applying biochar has the potential to increase crop yields. In tomatoes, it has been demonstrated that applying 300 g/5 m^2 (0.6 t/ha) of timber waste biochar along with 250 g/5 m^2 (0.5 t/ha) of Trichoderma significantly increases plant height, number of leaves per plant, plant dry weight, and fruit yield in terms of number and fresh weight per plant (Adebajo*et al*., 2019). Similarly, another study discovered that as irrigation and biochar levels increased, tomato growth rates in terms of plant height and stem diameter increased (Zhang *et al*., 2020).

Furthermore, Table 5 displays the correlation analysis results for the various agronomic factors examined at various tomato growth stages. At several stages of tomato growth, a strong positive association was found between growth and yield characteristics; the number of flowers and fruits was influenced by plant height, number of leaves, leaf area, and girt. In a similar vein, Alfred and Paul (2024) found that vine characteristics like vine length, internode length, and internode diameter, as well as leaf characteristics like leaf length and leaf diameter, all influenced sweet potato yield in their study of sweet potato diversity in Nigeria. Chen *et al*. (2021), Yan *et al*. (2022), and Regessa*et al*. (2023) also supported these conclusions. The yield of tomato plants and the performance of agronomic indicators were generally affected by the application of biochar. Numerous research have demonstrated that rice husk biochar increases crop productivity and lessens drought conditions, especially on low fertility soils in both greenhouse and field settings(Adebajo*et al*., 2019; Hossain *et al*., 2019).

CONCLUSION

According to this study, tomato plant growth and yield can be enhanced by biochar made from rice husk. A minimum of 14 days should pass following the application of biochar to the soil before tomato seedlings are sown or transplanted, and the biochar could be administered at a dose of 50 t/ha since this produced a greater number and weight of tomato fruits.

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