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RESEARCH ARTICLE

Effects of Compost tea on Productivity of Green bean (Phaseolus vulgaris L.) Varieties in Sudan Savanna of Nigeria

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ABSTRACT

Maintenance of soil productivity is one of the significant constraints affecting crop production in tropical region. Thus, field experiments were carried out in the 2018 rainy season at the Bayero University, Kano's Teaching and Research Farm of Faculty of Agriculture, and Federal College of Education, Katsina's Teaching and Demonstration Farm. The study aimed to evaluate compost tea's effect on the productivity of green bean varieties. The treatments comprised three compost tea rates (0, 50, and 100 l ha^{-1}) and two green bean varieties (Bean Cora and Haricot Contender). The treatments were combined factorially and arranged in a Randomised Complete Block Design (RCBD) replicated three times. Collected data from the field were subjected to an analysis of variance using Genstat statistical package. The results showed that use of compost tea at 100 l ha^{-1} significantly increased canopy height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, shoot dry matter, number of pods $plant^{-1}$, pod length, pod weight $plant^{-1}$, and green pods yield compared with the use of 50 l ha^{-1} and control. The results also indicated that varieties differed significantly ($p < 0.05$) in most studied characters. Bean Cora recorded a considerably greater green pod yield than Haricot Contender. Based on the findings of this study, Bean Cora is a favourable variety in this location. However, it is also suggested that application compost tea at 100 l ha^{-1} be used as an organic source of nutrients for green bean production in the Sudan Savanna of Nigeria.

Keywords: Compost tea, Growth, Yield, Bean Cora, Haricot Contender

INTRODUCTION

Food security and environmental concerns are significant challenges that motivate the farmers toward sustainable agricultural systems by using natural-deriving materials to reduce mineral fertilisers (Hussein et al., 2016). A sustainable crop production system in the tropical area is required to mitigate environmental pollution resulting from poor farming practices and continuous use of mineral fertilisers, resulting in nutrient depletion and a reduction in soil productivity (Haruna et al., 2018). In addition, farmers in tropical regions suffer from declining soil fertility and increasing soil salinity (Singh et al., 2009). The decrease in soil fertility in tropical areas results from continuous soil cultivation for an extended period without appropriate soil fertility management (Cheminingwa et al., 2011). Management of poor soil fertility in these regions is crucial to improve sustainable crop production (Haruna et al., 2018).

Attention is now focused on using organic materials as an alternative source of nutrients to mineral fertilisers. These practices have been recommended in tropical regions as a source of plant nutrients (Haruna et al., 2018). Tropical soils are often marked by low organic matter content and low mineralisation due to low rainfall and high alkalinity (Das et al., 2018). Organic fertilisers are slow in releasing nutrients, so applications of fast-release nutrients organic fertilisers are advocated to complement slow-release ones (Zaccardelli et al., 2012). The significance of this practice includes improving soil nutrient status and crop productivity (Martin, 2014). In addition, compost and poultry manure and other organic sources of nutrients significantly affect soil characteristics (Hussein et al., 2016).

Compost teas are new products derived from compost (Pane et al., 2013). However, they are not commonly used but are gaining popularity among organic farmers due to their capacity to supply nutrients and subdue many pathogens (Martin, 2014). Compost tea is an organic solution derived from compost fermentation in a liquid state for some period (Pane et al., 2013). The tea is prepared by mixing compost with water in the ratios of 1:5 to 1:10 (v/v), as reported by Morales-Corts et al. (2018). Compost teas are brewed explicitly for use as a soil organic matter builder, a nutrient source, and a disease suppressant (Ingham, 2000). The number of researches conducted to evaluate the nutritional benefits of compost teas on plant growth and yield is minimal. Still, reports suggest increasing crop growth and yield, especially vegetable crops (Pant et al., 2009). Research conducted by Zaccardelli et al. (2012) showed the potential of compost tea as a nutrients supplement to compost. The nutrients supplied by compost tea are more readily available than solid compost. Compost tea increases the population and diversity of soil microorganisms to improve plant growth (Zaccardelli et al., 2012).

Green bean (*Phaseolus vulgaris* L.) is a member of the family *Fabaceae* and is an essential leguminous vegetable crop cultivated worldwide for green pods and dry seeds (Abdel-Mawgoud et al., 2005). It is a source of plant proteins, carbohydrates, minerals, and vitamins (Datt et al., 2011). Thus, the production of green beans and other crops under soil application with compost tea as an alternative to mineral fertiliser has the potential of increasing crop growth and yield and improving soil fertility status (Moniruzzaman et al., 2009). This practice reduced mineral fertilisers and improved healthier human nutrition (Rady, 2011). The study's objective is to assess the effects of compost tea applications at different rates on the productivity of green bean varieties in the Sudan Savanna of Nigeria.

MATERIALS AND METHODS

The experiments were carried out in the 2018 rainy season at the Bayero University Kano's Teaching and Research Farm of Faculty of Agriculture (Latitude 11^{o} 58'N and Longitude 8^{o} 34'E; 475 m above sea level) and Department of Agricultural Education, Federal College of Education, Katsina's Teaching and Demonstration Farm (Latitude 12^{o} 56'N and Longitude 7^{o} 36' E; 464 m above sea level) both situated in the Sudan Savanna of Nigeria.

Treatments and Experimental Design

The treatments comprised three rates of compost tea (0, 50, and 100 l ha^{-1}) and two improved varieties of green beans (Bean Cora and Haricot Contender). The treatments were combined factorially and arranged in three replications of a Randomised Complete Block Design (RCBD). Compost tea was applied in two equal split dosages per treatment at 10 and 25 days after sowing as a soil drench.

Cultural Practices

The experimental site was prepared by clearing the land, ploughing, harrowing, and land levelling using a hoe. The experimental area was made up of three blocks consisting of six plots each. Each plot was 4.5 x 2 m in size, composed of six rows of 2 m long. The space between the plots was 0.5 m, and the interspace between the blocks was 1 m. The net plot was 3 x 1.5 m, consisting of four inner rows. Two seeds were sown per hill when rain was fully established in July at an inter-row and intra-row spacing of 75 cm and 25 cm. Weeding was done manually by using hoe at regular intervals. Neem oil was sprayed to control the pest at 2 ml L^{-1} at 3 and 5 weeks after sowing.

Data Collection

Five plants were randomly chosen and tagged from each net plot, from which data was measured six weeks after sowing. Canopy height was estimated from five selected plants in each net plot. The height of the five chosen plants was measured using the graduated meter rule from the base to the top of the canopy. The mean value of the selected plants was recorded. The number of branches per plant was measured from five selected plants from each net plot, and the mean value was recorded. The number of leaves per plant was estimated from five tagged plants, and the mean value was recorded. Shoot dry matter was measured from three random sample plants. The sample plants were uprooted and stuffed in an envelope, oven-dried to a constant weight. The sample plants were weighed individually, and the mean value was recorded. Leaf area per plant was estimated by measuring the width and length of the sample leaves using the centimetre rule multiplied by 0.67 (Yadav, 2015). These were measured from the five sample plants from each net plot. Three leaves were sampled from each selected plant, and the mean value was recorded. Estimation of leaf area per plant was done by multiplying the mean size of the leaf by the total number of leaves per plant.

The number of pods per plant was measured at harvest, the number of pods yielded by five sample plants per plot was recorded individually, and the mean value was calculated. The length of the ten pods per plot from five selected plants was measured using a centimetre scale from tip to bottom to obtain the pod's length. Pod thickness was measured using a vernier calliper from ten pods harvested from the five chosen plants. Pod weight per plant was estimated by weighing the pods harvested from five selected plants individually per plot. From the weight taken, the mean value was calculated. Green pod yields from two central rows of net plots were harvested, weighed, and expressed in kilograms per hectare (kg ha^{-1}).

$$\text{Green pod yield (kg ha}^{-1}) = \frac{\text{Yield per net plot (kg)} \times 10000\ \text{m}^2}{\text{Net plot area (m}^2)}$$

Data Analysis

Collected data from the experimental field were subjected to an analysis of variance (ANOVA) using Genstat Statistical Package (17th edition). Means showing significant differences were separated using SNK at a 5 % probability level.

RESULTS

Physical and chemical characteristics of soils

Table 1 shows the physical and chemical characteristics of the soil in the study sites before cropping and the chemical constitution of compost tea used in the study. The study sites' soil was sandy loam in texture, with a pH of 6.77 and 6.93 at both BUK and FCE Katsina, respectively. The soil organic carbon contents of the sample soils were 1.36 g kg^{-1} and 1.24 g kg^{-1}. The total nitrogen was 0.43 g kg^{-1} and 0.36 g kg^{-1}, and available phosphorus was 9.89 mg kg^{-1} and 10.19 mg kg^{-1} at BUK and FCE Katsina, respectively. Exchangeable bases, specifically Ca, Mg, K, Na, and CEC, were 2.12 and 2.28, 1.18 and 1.36, 0.32 and 0.19, 0.11 and 0.12, 4.68 and 4.95 cmol kg^{-1}at BUK and FCE Katsina, respectively. The chemical composition of the compost tea used in the study, i.e., total nitrogen, total phosphorus, potassium, and organic carbon, was 0.56 %, 924.38 mg kg-1, 4693.14 mg kg-1 6.03 %.

Effect of Compost tea and variety on canopy height

Compost tea application at different levels significantly affected the canopy height of green beans at both experimental sites (Table 2). The application of 100 l ha^{-1} of compost tea was significantly higher than that of 50 l ha^{-1} of compost tea, which was significantly higher than control at BUK and FCE Katsina. There was a significant difference between the green bean varieties concerning canopy height at BUK, with Haricot Contender significantly recorded taller plants than Bean Cora. No significant variation was observed between the varieties concerning the canopy height at FCE Katsina (Table 2).

Effect of compost tea and variety on the number of branches per plant

The application of compost tea at different levels significantly affected the number of branches per plant of green bean at both sites (Table 2). The application of 100 l ha^{-1} of compost tea was significantly higher than that of 50 l ha^{-1} of compost tea, which was significantly higher than control at BUK and FCE Katsina. There was no significant variation between the varieties concerning the number of branches per plant of green bean at both sites (Table 2).

Effect of Compost tea and variety on the number of leaves per plant

The application of compost tea at different levels significantly affected the number of leaves per plant of green bean at both experimental sites (Table 2). The application of 100 l ha^{-1} of compost tea was significantly higher than that of 50 l ha^{-1} of compost tea, significantly higher than control at both locations. There was a significant variation between the varieties regarding the number of leaves per plant of green bean at BUK, with Haricot Contender recording significantly more leaves per plant than Bean Cora (Table 2). No significant difference was recorded between the varieties concerning the number of leaves per plant at FCE Katsina

Effect of compost tea and variety on dry shoot matter

Compost tea application at different levels significantly influenced the dry shoot matter of green beans at both locations (Table 2). The application of 100 l ha^{-1} of compost tea was significantly higher than control but statistically similar to that of 50 l ha^{-1} of compost tea at BUK. At FCE Katsina, the application of 50 l ha^{-1} of compost tea and control were statistically similar but significantly lower than 100 l ha^{-1} of compost tea. There was a significant variation between the varieties in dry shoot matter, with Haricot Contender recording significantly higher mean values (7.66 g) and (7.52 g). In contrast, the lowest was obtained from Bean Cora (7.32 g) and (7.07 g) at both BUK and FCE Katsina, respectively.

Effect of compost tea and variety on leaf area per plant

Compost tea application at different levels significantly affected the leaf area of green bean at both sites (Table 2). The application of 100 l ha^{-1} of compost tea was significantly higher than that of 50 l ha^{-1} of compost tea, which was significantly higher than control at BUK and FCE Katsina. There was a significant variation between the varieties in terms of leaf area per plant at both experimental sites (Table 2). At BUK, Haricot Contender recorded a significantly higher leaf area per plant than Bean Cora. This trend was similar at FCE Katsina.

Effect of compost tea and variety on the number of pods per plant

Compost tea application at different levels significantly influenced the number of pods per plant of green bean at both experimental sites (Table 3). At BUK, 100 l ha^{-1} and 50 l ha^{-1} of compost tea are statistically similar but significantly higher than the control. At FCE Katsina, the application of 100 l ha^{-1} of compost tea was considerably higher than 50 l ha^{-1}, considerably higher than control. There were significant differences between the varieties to the number of pods per plant at both locations, with Bean Cora recording significantly more number pods than Haricot Contender. There was a highly significant interaction between compost tea with variety on the number of pods per plant of green bean at BUK (Table 4). The number of pods per plant significantly varies in both varieties at each level of compost tea from 0 – 100 l ha^{-1}. Bean Cora treated with 100 l ha^{-1} of compost tea significantly recorded more pods, which was statistically similar to the number of pods yielded by the same variety under 50 l ha^{-1} of compost tea.

Effect of compost tea and variety on pod length

Compost tea application at different levels showed a significant variation on pod length of green bean at BUK, while at FCE Katsina, no significant difference was recorded (Table 3). At BUK, the application of 100 l ha^{-1} of compost tea gave the most extended pod length, significantly at par with control but statistically similar to that of 50 l ha^{-1} of compost tea. The varietal effect significantly influenced the pod length of green beans at both experimental sites. Bean Cora recorded the highest mean values of pod length (12.88 cm) and (12.91 cm), while the lowest (12.26 cm) and (11.86 cm) were recorded from Haricot Contender at BUK and FCE Katsina, respectively.

Effect of Compost tea and variety on pod thickness

The use of compost tea at different rates showed no significant differences in pod thickness of green bean pods at both sites (Table 3). There was significant variation between the varieties concerning pod thickness at BUK (Table 3). The highest pod thickness was recorded from Haricot Contender (8.55 mm), significantly higher than Bean Cora (8.14 mm). While at FCE Katsina, no significant variation was recorded between the varieties for pod thickness.

Effect of compost tea and variety on pod weight per plant

Compost tea application at different levels significantly affected the pod weight per plant of green beans at both sites (Table 3). At BUK, 100 l ha^{-1} of compost tea application was substantially higher than application 50 l ha^{-1} and control. This trend was similar at FCE Katsina. The results revealed a significant variation between the varieties at both experimental sites (Table 3). At BUK, Bean Cora recorded the highest pod weight per plant (70.91 g), significantly higher than Haricot Contender (61.54 g), which produced the least. This trend was similar at FCE Katsina. Bean Cora had the highest pod weight per plant (69.50 g), followed by Haricot Contender (61.54 g), which produced the least.

Effect of Compost tea and variety on green pod yield

Compost tea application at different levels showed significant influence on green pod yield of green bean at both experimental sites (Table 3). At BUK, the application of 100 l ha^{-1} of compost tea was significantly higher than that of 50 l ha^{-1} of compost tea which was significantly higher than control. This trend was similar at FCE Katsina. Effect of variety on green pod yield of green bean was significant at both locations. Bean Cora resulted in a higher green pod yield (3781.49 kg ha^{-1}) and (3706.86 kg ha^{-1}) than Haricot Contender (3285.80 kg ha^{-1}) and (3267.36 kg ha^{-1}) at BUK and FCE Katsina, respectively.

Table 1. Physical and chemical characteristics of the soil of the study sites and chemical composition of compost tea used in the study.

Properties	BUK	FCE Katsina	Compost tea	
Physical (%)			Chemical composition	Analytical value
Sand	74.50	78.80	Total nitrogen	0.56 %
Silt	14.60	11.70	Total phosphorus	924.38 mg l^{-1}
Clay	10.90	9.50	Potassium	4693.14 mg l^{-1}
Textural class	Sandy loam	Sandy loam	Organic carbon	6.03 %
Chemical composition				
pH in water	6.77	6.93		
pH ($CaCl_2$)	6.20	6.54		
Organic carbon (g kg^{-1})	1.36	1.24		
Total nitrogen (g kg^{-1})	0.43	0.36		
Available phosphorus (mg kg^{-1})	9.89	10.19		
Exchangeable bases (cmol kg^{-1})				
Ca++	2.17	2.28		
Mg++	1.18	1.36		
K+	0.32	0.19		
Na+	0.11	0.12		
CEC ($cmol^+$ kg^{-1})	4.68	4.95		

BUK = Bayero University Kano. FCE = Federal College of Education Katsina.

DISCUSSION

The significant increase in growth characters of green bean recorded in this study by application of 100 l ha^{-1} of compost tea may be associated with the presence of beneficial microorganisms that improved plant growth and health (Pane et al., 2014). These findings confirm the report made by Morales-Corts et al. (2018), who reported that garden waste compost tea significantly increased the growth of tomatoes. The significant increase in yield characters and green pod yield of green bean recorded in this study by applying 100 l ha^{-1} of compost tea could be due to the bio-stimulation of plants by upgrading their physiological status (Zaccardelli et al., 2012) and increase in nodulation by compost extracts (Datt et al., 2013). The finding of this study is in harmony with the report made by Bernal-Vicente et al. (2008), who reported a significant increase in melon productivity produced by root-treatment of seedlings with compost extracts carrying auxinic-like compounds. The significant variation observed in this research on growth characters of green bean varieties was attributed to the varieties genetic constitution and their response to the growing environment, as earlier reported by Abdel-Mawgoud et al. (2005). This is related to the assertion made by Das et al. (2018), who said that the genetic make-up of a variety determines its productivity. This finding conforms with the report of Sharma et al. (2013), who reported that differential response to ecology of green bean varieties results in variation in productivity. The yield characters and green pod yield of green bean varieties exhibited significant variations in this study. This could be attributed to the genetic composition of varieties, as supported by Das et al. (2018). Similar results were reported by (Hussein et al., 2016; Moniruzzaman et al., 2009), who also found a significant influence of cultivar on yield attributes in French bean. The significant interaction of compost tea with variety on the number of pods per plant could be due to the differential response of the varieties to compost tea application (Sultana et al., 2001). This finding conforms with the report made by Singh et al. (2009), who reported that varieties Pant Anupam and IVRFB-3 showed the highest response of green pod yields with the higher dose of nitrogen application.

Table 2. Effect of compost tea and green bean varieties on canopy height (cm), number of branches per plant, number of leaves per plant, shoot dry matter (g), and leaf area per plant (cm^{2}) of green bean at 6 WAS at BUK and FCE Katsina in 2018 rainy season.

Treatments	BUK					FCE Katsina				
	Canopy height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Shoot dry matter (g)	Leaf area plant^{-1} (cm^{2})	Canopy height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Shoot dry matter (g)	Leaf area plant^{-1} (cm^{2})
Compost tea (CT)										
0 l ha^{-1}	16.09^{c}	7.00^{c}	23.08^{c}	7.18^{b}	1187.28^{c}	15.90^{c}	6.82^{c}	22.29^{c}	6.82^{b}	1155.61^{c}
50 l ha^{-1}	17.15^{b}	7.43^{b}	24.44^{b}	7.45^{ab}	1313.83^{b}	17.13^{b}	7.32^{b}	23.98^{b}	7.22^{b}	1314.48^{b}
100 l ha^{-1}	18.24^{a}	8.00^{a}	26.03^{a}	7.89^{a}	1509.08^{a}	18.38^{a}	7.87^{a}	25.63^{a}	7.85^{a}	1436.26^{a}
SE±	0.178	0.125	0.350	0.188	27.880	0.259	0.090	0.251	0.199	25.300
Varieties (V)										
Bean Cora	16.93^{b}	7.42	24.23^{b}	7.32^{b}	1300.70^{b}	17.18	7.31	23.91	7.07^{b}	1277.65^{b}
Haricot Contender	17.38^{a}	7.54	24.81^{a}	7.66^{a}	1372.76^{a}	17.10	7.36	24.02	7.52^{a}	1326.59^{a}
SE±	0.146	0.102	0.285	0.154	22.700	0.211	0.074	0.205	0.163	20.700
Interaction										
CT x V	0.277	0.684	0.284	0.721	0.512	0.418	0.712	0.195	0.709	0.344

Means followed by a different letter(s) differ significantly at $p < 0.05$ using Student Newman Keuls (SNK). BUK = Bayero University Kano. FCE = Federal College of Education Katsina.

Table 3. Effects of compost tea and green bean varieties on the number of pods per plant, pod length (cm), pod thickness (mm), pod weight per plant (g), and green pod yield (kg ha^{-1}) of green bean at BUK and FCE Katsina in 2018 rainy season.

Treatments	BUK					FCE Katsina				
	No. pods plant^{-1}	Pod length (cm)	Pod thickness (mm)	Pod weight plant^{-1} (g)	Green pod yield (kg ha^{-1})	No. pods plant^{-1}	Pod length (cm)	Pod thickness (mm)	Pod weight plant^{-1}(g)	Green pod yield (kg ha^{-1})
Compost tea (CT)										
0 l ha^{-1}	16.19^{b}	12.22^{b}	8.25	62.68^{c}	3340.42^{c}	16.11^{c}	12.34	8.36	62.86^{c}	3323.85^{c}
50 l ha^{-1}	16.88^{a}	12.66^{a}	8.33	66.19^{b}	3530.07^{b}	16.94^{b}	12.37	8.48	65.71^{b}	3482.27^{b}
100 l ha^{-1}	16.12^{a}	12.82^{a}	8.45	69.44^{a}	3730.45^{a}	17.56^{a}	12.44	8.37	68.53^{a}	3655.11^{a}
SE±	0.234	0.126	0.109	0.891	51.700	0.160	0.167	0.082	0.714	37.000
Varieties (V)										
Bean Cora	17.36^{a}	12.88^{a}	8.14^{b}	70.91^{a}	3781.49^{a}	18.02^{a}	12.91^{a}	8.33	69.50^{a}	3706.86^{a}
Haricot Contender	15.41^{b}	12.26^{b}	8.55^{a}	61.29^{b}	3285.80^{b}	15.72^{b}	11.86^{b}	8.47	61.54^{b}	3667.36^{b}
SE±	0.191	0.103	0.089	0.727	42.200	0.131	0.137	0.067	0.583	30.200
Interaction										
CT x V	0.0001	0.233	0.864	0.252	0.101	0.072	0.535	0.418	0.697	0.294

Means followed by a different letter(s) differ significantly at $p < 0.05$ using Student Newman Keuls (SNK). BUK = Bayero University Kano. FCE = Federal College of Education Katsina.

Table 4. Effects of Interaction of Compost tea with variety on the number of pods per plant of green bean at BUK.

Treatments	Number of pods per plant
$0V_1$	16.36^{b}
$50V_1$	17.47^{ab}
$100V_1$	18.27^{a}
$0V_2$	14.91^{d}
$50V_2$	15.44^{cd}
$100V_2$	15.89^{bc}
SE±	0.331

Means followed by a different letter(s) differ significantly at $p < 0.05$ using Student Newman Keuls (SNK). V_1 = Bean Cora, V_2 = Haricot Contender.

CONCLUSION

Based on the results of this study, the use of compost tea improved the productivity of green beans through the bio-stimulation effects of the tea. The study also showed that Bean Cora resulted significantly in greater green pod yield than Haricot Contender. This may result from the adaptability of the variety to the growing environment and its genetic superiority. It is recommended that further research should be carried out using compost tea at different rates to ascertain the optimum level for higher green bean production. Bean Cora is also recommended for production in this region.

DISCLOSURE STATEMENT

No any potential conflict of interest was reported by Authors.

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