GROWTH AND YIELD OF CUCUMBER (*CUCUMIS SATIVUS L.)* AS INFLUENCED BY TRELLISING AND BIOCHAR IN THE NIGERIAN GUINEA SAVANNA

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Abstract. *A field trial was conducted during the wet season of 2020 at the research farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria; located at Samaru in the Northern Guinea Savanna of Nigeria. Treatments consisted of trellising; trellised and non-trellised and fertilization; control (0 t ha-1), Biochar (2 t ha-1) and NPK Fertilizer (100:50:50 ha-1). The treatments were factorially combined and laid out in randomized complete block design (RCBD) with three replications. The plots were marked out into 3 x 4 m in size with a spacing of 1.5 m and 2 m between plots and replicates respectively. Stand count, weed dry weight and leaf Area Index were not affected by trellising and fertilization at both sampling periods. Application of NPK at 100:50:50 kg ha-1 and biochar at 2 t ha-1 showed significant increase in number of branches and vine length with better results when influenced by trellising than control and non-trellised plants. There was no significant difference in the number of days to 50% flowering in cucumber with control showing the lowest days. Furthermore, Application of NPK at 100:50:50 kg ha-1 and biochar at 2 t ha-1 demonstrated significantly higher number of fruits, fruit length, fruit diameter, fruit weight and fruit yield with the best results as influenced by trellising. Data was collected on weed count, weed dry weight, vine length, number of leaves of plant, number of flowers, number of days to 50% flowering, plant length and plant weight. Data collected were subjected to analysis of variance (ANOVA), and means separated using Duncan Multiple Range Test.*

Keywords*: Cucumber, biochar and trellising*

INTRODUCTION

Cucumber (*Cucumis sativus L.*) is a member of the cucurbitaceae family comprised of 95 genera and 965 species (CHRISTENHUSZ ET AL, 2016). Cucumber originated from India and became popular throughout the Egyptian and the Greek Roman Empire (RENNER ET AL, 2007). It is botanically classified as pepo; it is a creeping vine which bears spiral tendrils and large leaves that form a canopy over the fruits. The color of the fruit is green, cylindrical and roughly shaped in size ranging from 8-62 cm depending on the variety. STATISTA (2017) reported that, 83.75 million metric tons of cucumbers and gherkins are produced globally after tomato and dry onion. China being the world's largest producer of cucumber with 80.6 million tons which is approximately 77 % of total global production followed by Russia and Turkey. A minimum temperature of 15°C is required for its development while the optimum night temperature is 18-21°C (MIHUT ET AL., 2018; MIHUT ET AL., 2022). Cucumbers also grows well in slightly acidic soils with optimum pH ranging from 5.5 – 7.0. The epicarp or outer covering that is melanin of cucumber is used or mixed with pomade or cream to control oily or fatty face (NWEKE ET. AL, 2013).

Biochar is a carbon-rich organic waste product obtained by heating biomass (pyrolysis) in a closed system under limited or no supply of oxygen. Increasing awareness of biochar production and its use on the field can increase yields and improve soils in the northern guinea savannah. Cucumber production in most part of Nigeria is fast becoming popular due to

its high nutritional importance and being a useful ingredient in the preparation of salad and liquor drink in canteens, hotels and homes as well as its medicinal and cosmetic value. In spite of all these wonderful attributes of cucumber, the production of the crop is still mainly in the hands of peasant farmers in Nigeria who lack information in some of the important cultural practices such as trellising and right spacing for optimum yield (NWEKE ET AL, 2013) leaving the crop still unranked in Africa. In view of the above, the trialwas conducted based on the following objectives: Sustainable and conservation agriculture using agricultural waste as biochar in weed suppression on the growth and yield of cucumber; and Improved knowledge in trellising on cucumber to curb pest and diseases incidence.

MATERIALS AND METHODS

Field trial was conducted during wet season of 2020 at the Institute for Agricultural Research, Ahmadu Bello University, Zaria; situated at Samaru (11º 10´ 35´´ N, 7º 36´ 40´´ E, 696.1 m above sea level) in the Northern Guinea Savanna. Soil samples were randomly collected prior to sowing using soil auger of 9cm diameter and were taken at a depth of 0-30 cm across the experimental site. Poultry litter biochar was produced through the process of pyrolysis using muffle furnace under limited oxygen condition (Baldock and Smernik 2002). The pre-processed poultry litter was taken into porcelain cup and kept into muffle furnace at 300 °C temperature. So, in this experiment the poultry litter biochar was produced by slow pyrolysis method (BROWNSORT, 2009).

The treatments were factorially combined in randomized complete block design (RCBD) and replicated three times. Border spaces of 1.5 m between the plots and 2 m between replicates were marked out into plots. The treatments consist of one rate of biochar at 2 t ha-1 combined with half recommended rate of fertilizer, Full recommended rate of fertilizer at 100kg N, 50kg P_2O_5 and 50kg K_2O ha-1 and a control trellised and non-trellised crops assessed. Two weeks before sowing, biochar at the rate of 2.0 t ha-1 was incorporated on treatment basis by split opening the crest of the ridge to about 15cm depth and then covered with the soil after incorporation.

Inorganic fertilizer was applied through band application method at the recommended rate of 100kg N, 50kg P_2O_5 and 50kg K_2O ha-1 while plots with biochar was applied with half the recommended rate. First dose (basal) application was carried out at 10 days after sowing using compound fertilizer (NPK 15:15:15) to supply 50, 50 and 50kg of N, P_2O_5, and K_2O respectively. The remaining 50 kg N ha-1 (second dose) applied in the form of urea (46% N) at 3 weeks after the basal application. Hoe weeding was carried out at 4 and 6 weeks after sowing. Incidence of pest and disease was closely monitored and control measures was taken by spraying Imidaclorpid at 5.0 kg a.i ha-1 and lamdacyahalothrin at 25g a.i ha-1 first week after sowing. Fungicides such as ridomil gold at 1.2 kg a.i ha-1 and maneb at 2.0 kg a.i ha-1 as soon as fusarium wilt was observed on the cucumber plants.

RESULTS AND DISCUSSIONS

Weed cover score

The significant effects of fertilization and trellising on weed cover score of cucumber during the 2020 rainy season shown in Table 2. The plots that received no treatment (control) recorded the highest weed cover score followed by application of biochar at 2 t ha-1 and NPK fertilizer at the rate of 100:50:50 kg ha-1 had least values at both sampling periods. Alternatively, Trellised plants showed higher weed cover score in contrast to non-trellised at 4 and 6 WAS. Interaction of fertilization and trellising were not significant at both sampling periods.

Table 1

Physical, chemical and biological characteristics (0-30cm) of soils at the experimental site during the 2020 wet season.

Soil Characteristics	Values
Particle size distribution (g kg^{-1})	
Clay	120
Silt	420
Sand	480
Textural Class	Loam
Chemical Composition	
pH (1:2.5) in water	5.88
pH (1:2.5) in 0.01MCaCl2	24.96
Organic carbon (g kg^{-1})	15.61
Total Nitrogen (g kg^{-1})	1.81
Available Phosphorus (mg kg^{-1})	9.58
Exchangeable Bases (cmol kg^{-1})	
Calcium (cmol kg^{-1})	2.85
Magnesium (M)	0.51
Potassium (P)	0.18
Sodium (Na)	0.21
Aluminium Hydrogen (Al^{-} H)	0.22
Cation Exchange Capacity (C.E.C)	3.97

Analysed at the Department of Agronomy, Ahmadu Bello University, Zaria (2020).

Weed Dry Weight

Table 2 shows the effects of fertilization and trellising on weed dry weight of cucumber during the 2020 rainy season. Controlled plots recorded highest weed dry weight at 4 and 6 WAS, in the same vein, no significant difference with the application rate of biochar at 2 t ha-1 and NPK fertilizer at 100:50:50 kg ha-1 at 4 WAS which similarly decreased at 6 WAS with NPK fertilizer at 100:50:50 kg ha-1 showing the least weed dry weight. Furthermore, Trellised plants showed higher weed dry weight in relation to non-trellised plants at 4 and 6 WAS. The interaction of fertilization and trellising on weed dry weight were not significant at both sampling periods.

Table 2

Effects of Fertilization and Trellising on Weed dry weight and weed cover score of Cucumber during the 2020 rainy season at Samaru.

	Weed cover score		Weed dry weight (g)	
	4 WAS	6 WAS	4 WAS	6 WAS
Fertilization (F)				
Control	6.00a	4.50a	45.13a	29.717a
Biochar (2 t ha^{-1})	5.00b	3.67b	29.20b	20.53b
NPK (100:50:50 kg ha^{-1})	3.83c	3.00c	20.08b	13.18c
SE±	0.255	0.161	3.134	1.657
Trellising (T)				
Trellised	5.89a	4.45a	42.41a	28.49a
Non-trellised	4.00b	3.00b	20.53b	13.80b
SE±	0.208	0.132	2.559	1.353
Interaction				
F x T	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment group are not significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT), NS= Not Significant, WAS= Weeks After Sowing and SE± = Standard Error

Vine Lengths

Vine Lengths were not significantly affected by fertilization at 2 WAS as shown in Table 3. However, at 4 WAS the effect of biochar at 2 t ha-1 and NPK fertilizer at 100:50:50 kg ha-1 were statistically at par and significantly higher than control. Nonetheless at 6 WAS, NPK fertilizer at 100:50:50 kg ha-1 was observed to have the highest vine length in sequence to biochar at 2 t ha-1 and controlled plots exhibited the lowest vine length. The effects of trellised plants were significantly higher than the non-trellised plants in all the sampling periods with the exception of 4 WAS which was not significant. Similarly, the interaction between the factors was not significant.

Table 3

Effects of Fertilization and Trellising on Number of branches and Vine length of Cucumber during the 2020 rainy season at Samaru.

	Vine length(cm)		**Number of branches**	
	4 WAS	6 WAS	4 WAS	6 WAS
Fertilization (F)				
Control	45.75b	66.42c	4.42b	5.00c
Biochar (2 t ha^{-1})	92.46a	139.58b	6.29a	8.03b
NPK (100:50:50 kg ha^{-1})	112.50a	186.67a	7.75a	9.71a
SE±	8.476	3.017	0.464	0.364
Trellising (T)				
Trellised	93.72	163.11a	8.14a	10.53a
Non-trellised	73.42	98.67b	4.17b	4.67b
SE±	6.920	2.634	0.379	0.297
Interaction				
F x T	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment group are not significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT), NS= Not Significant, WAS= Weeks After Sowing and SE± = Standard Error

Number of branches

Table 3 shows the significant effects of fertilization and trellising on number of branches during the 2020 rainy season at Samaru. Application of NPK fertilizer at 100:50:50 kg ha-1 showed the highest number of branches at 2 and 4 WAS which was statistically at par with 2 t ha-1 Biochar applied treatment. While at 6 WAS, the application of NPK fertilizer at 100:50:50 kg ha-1 significant higher than biochar at 2 t ha-1 and the controlled plots recorded the least values for number of branches in all the sampling periods. Similarly, the trellising plant recorded higher values than the non-trellising in all the sampling periods. There was no interaction between fertilization and trellising on number of branches.

Number of fruits

Table 4 shows the effect of fertilization and trellising on number of fruits of cucumber during the 2020 rainy season. NPK fertilizer at 100:50:50 kg ha-1 recorded the highest number of fruits followed by biochar at 2 t ha-1 and plots without fertilizer (control) having the least values. The significant difference on trellised plants indicated more number of fruits than non-trellised plants. No significant interaction was observed on the factors.

Table 4.
Effects of Fertilization and Trellising on Number of fruits, Fruit length, Fruit weight and Fruit Yield of Cucumber during the 2020 rainy season at Samaru.

	Number of fruits	Fruit length		Fruit weight		Fruit Yield
Fertilization (F)						
Control	4.17c	10.83c	163.50c	3.63c		
Biochar (2 t ha-1)	10.33b	17.17b	446.17b	11.03b		
NPK (100:50:50 kg ha-1)		13.50a	19.50a	497.00a	12.49a	
SE+	0.350	0.350	8.510	0.209		
Trellising (T)						
Trellised	10.33a	17.56a	372.67	9.17		
Non-trellised		8.33b	14.11b	362.11	8.94	
SE+	0.286	0.286	6.948	0.171		
Interaction						
F x T	NS	NS	NS	NS		

Means followed by the same letter(s) within a column in each treatment group are not significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT), NS= Not Significant, WAS= Weeks After Sowing and SE± = Standard Error

Fruit length

The influence of fertilization and trellising treatments of cucumber during the 2020 rainy season are presented on table 4. The plots that received NPK fertilizer at 100:50:50 kg ha-1 recorded the highest values than biochar at 2-ton ha-1 and the controlled plots. Similar trend was found in trellising than the non-trellising treatments. However, no significant interaction was observed.

Fruit yield

The fruit weight and yield as influenced by fertilization and trellising of Cucumber during the 2020 rainy season is showed on table 4. Where plots that received NPK fertilizer at 100:50:50 kg ha-1 exhibited the higher values than biochar applied plots at 2 t ha-1 while the controlled plots were observed to have the least values. The effects of trellising as well as the interaction were between the two factors not significant in both parameters.

Discussions

The crop performed well under the influence of trellising than non-trellised. Trellised crops revealed larger and marketable fruits, good number of branches, lengthy vines than non-trellised crops that revealed small number of branches, shorter vines, non-marketable fruits. This could be as a result of trellised crops having more access to better sunlight exposure that lead to adequate photosynthetic activities, necessary for growth requirements, aeration, less competition to weeds and less exposure to certain diseases and finally appreciable fruit yield, whereas the non-trellised plants observed serious competition of weeds and with some other factors. Similarly, the non-trellised crops were also affected by high humidity that attracted pathogens and other pests such as insect and rodents. These results are in line with the findings of NWEKE ET AL. (2013) who reported that, farmers allow cucumber vines to be over-crowded on ground that lead to the attack by mold due to high humidity that produce fruits with yellow bellies. Furthermore, OKONMAH (2011) recommended raised platform staking for increasing pod yield and enhanced marketable value for cucumber and fluted pumpkin. Trellising as a factor is a good influence on the growth and yield of vine crops especially on perishable crops like cucumber. Therefore, Farmers should implement the use of trellising on their farms for the

production of healthy crops. Plots treated with NPK fertilizer recorded low population of weed than poultry litter biochar treated plots. The reason for this result might be due to the high potential of biochar used to have the affinity to release its total nitrogen at a go while NPK takes a few weeks to release its total nitrogen in steps. Weed count was higher in plots of Poultry litter bio-char which reveals that bio-char does not limit the growth of weed but rather boosts it. Weed dry weight was also higher in plots applied with 2 t ha-1 of biochar than that of NPK fertilizer at 100:50:50 kg ha-1. The result contradicts the findings of Arif et al. (2012) who reported that, the slow release of nutrient by biochar denies the weed of some nutrient especially at the early growth stage and making it more available for the crop at later growth stage which boost. This therefore reveals that farmers cannot rely on fertilizer whether synthetic or non-synthetic to control weed as it's just a catalyst for growth and a soil fertility reviver.

The crops that received biochar performed similar to the application of NPK fertilizer at the rate of 100:50:50 kg ha-1. The poultry litter biochar applied treatments performed good in term of plant height, vine length, number of branches, etc. could be because of the high content of nitrogen from the biochar material ready for potential release to the crop. The result of the current study tends to reaffirm the postulation of OSAJI ET AL. (2017) who stated that improvement in soil properties following application of biochar led to increase in vine length, number of fruits, fruit length and yield of cucumber relative to the control.

Under other circumstances, poultry litter biochar applied at 5 t ha-1 will be able to produce more yield. It was confirmed different rates of biochar application added as soil amendment has the potential of improving soil quality and boosting productivity of cucumber in a degraded ultisol (OSAJI ET AL, 2017). This supplement should be used by farmers because of its organic and potential source which will lead to healthy and high yield of marketable crops. Poultry litter bio-char should also be used in farms because of its swift release of necessary elements of growth and its easy availability to man. This result is in accordance with the findings of LEHMANN ET AL. (2006); LEHMANN (2009); SARKAR ET AL. (2015) who proved that production of stable biochar from organic wastes and its use in soil can play a vital role to solve the current problem in agriculture and also can contribute to mitigate the raising greenhouse gas emission. Applied NPK fertilizer at 100:50:50 kg ha-1 demonstrated the best growth and yield, healthy and marketable fruits than all the other treatments. This finding is similar to the result of CHOUDHARI AND MORE (2002) who confirmed that NPK fertilizer at 150:90:90 kg ha-1 applied through fertigation gave maximum number of fruits per vine, fruit weight (g), yield per plant (kg) and yield ha-1 (tons) of cucumber plant. This result might be due to the availability of the essential nutrients in the soil necessary for growth and development at the time of vegetative, flowering and fruiting of crop. This resulted in the development of the crop and its photosynthetic apparatus and therefore enhancing assimilate production and accumulation. This was in consonance with the findings of LAWAL (2000) who reported significant response of cucumber fruit weight per plant and total yield to applied inorganic fertilizer. A significant increase in vine length, number of leaves, leaf area and number of branches was recorded with increase in fertilizer application (LAWAL, 2000).

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CONCLUSIONS

In conclusion, trellising produced healthier fruits and higher yields than non-trellised. NPK application at 100:50:50 kg/ha gave the highest yields and biochar produced similar

yields to NPK which can perform better with increasing rate. Biochar poses as an organic sustainable agricultural product that can revive and conserve the soil while also acting as a fertilizer but does little on weed suppression. Trellising is also a profitable cultural practice that can ensure healthy fruits and high yields.

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