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REPRODUCTIVE GROWTH RESPONSE OF SWEET PEPPER (*Capsicum annum* L) IN SOIL AMENDED WITH FALSE YAM (*Icacina oliviformis*) TUBER BIOCHAR

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Abstract

Biochar, carbon rich stable solid material, is used mostly for soil amendment. The main objective of this study was to assess false yam tuber biochar performance or effect on the vegetative growth of pepper. Pepper seeds were obtained at Wumpini agrochemical shop in Tamale which were sown, and growth parameters were assessed (germination percentage, plant height, number of leaves and leaf area index). The soil was amended with biochar produced from false yam tuber. The experiment consisted of seven treatments (T1, T2, T3, T4, T5, T6, T0) replicated three times including the control (soil only). The soil and biochar mixture were done in two different levels (6 g/pot and 12 g/pot) each at three different times (four weeks before planting (4WBP), two weeks before planting (2WBP) and at planting (DOP)) with control as soil only. Results obtained indicated that there were no significant differences in germination percentage among the treatments both at one week and two weeks after planting. The highest growth performance (plant height, number of leaves and leaf area index) was recorded in the control. The least growth performance was recorded in treatment T1 (6 g of biochar applied at 4 weeks before planting (4WBP)). The application rate of false yam tuber biochar (6 g/pot and 12 g/pot) as soil amendment might not be the right amendment for sweet pepper production.

Keywords: biochar, growth parameter, time of application, false yam, sweet pepper

Introduction

Biochar is prepared from biomass through pyrolysis. This carbon rich stable solid material is used mostly for soil amendment but it can also be used for other purposes such as water treatment in fish production, detoxification, used as insulation in building and many more (Schmidt, 2012). To understand the function of biochar in the soil, one needs to look at the physiochemical properties of biochar (Gao & DeLuca, 2016). Its large surface area and highly porous nature makes it appropriate to hold and retain nutrients and serves as a habitat for useful microbes to thrive. Biochar has the ability to retain a large part of its carbon content (Weber & Quicker, 2018), this property makes it a good material for carbon sequestration leading to climate change mitigation.

False yam (*Icacina oliviformis*) is a wild drought-resistant erect woody herb which has scandent nature. It typically thrives in the Savannah region, mostly West and Central Africa, in countries like Ghana and Nigeria (Dei et al., 2011). It is a tuber crop of the family Icacinaceae. In Ghana, it is mostly found in the Northern part of the country. Despite its rich nutritional contents, it is very poisonous to both human and animal consumption (Fay, 1991). It is rich in carbon and the fleshy tuberous root contains 80% carbohydrate (Fay, 1991). In human history, its tubers have been used as a source of starch during severe famine. Also, research reveals that this yam tuber contains a lot of agronomic and nutritional properties which can be very supportive during plant growth.

Vegetables have assumed a significant role in human nourishment. They provide most of the vitamins and minerals needed in human diet. Pepper (*Capsicum annum* L) has proven to be one of the most important vegetable crops in the diet of humans. It fits in the family Solanaceae which is grown extensively almost in every country (Gebhardt, 2016) due to its benefits and economic importance. Aside its nutritional needs, it is used hugely in industrial fields, medicine and even in security, it is used in making tear gas.

Materials and Methods

Experimental Site

This experiment was done in the Plant House of the University for Development Studies, Nyankpala Campus, Tamale. The site is found on latitude 90 25' 45" N and longitude 00 58'42" W at latitude 183 m above sea level (Savannah Agricultural Research Institute [SARI], 2001).

Experimental Design

Pot experiment was setup in a three by seven (2 x 3) factorial arranged in randomised complete block design (RCBD) with three replicas. Two different levels of biochar were applied to the soil at different times (4WBP, 2WBP and DOP).

The soil used for the experiment was obtained at the experimental site, the plant house of the University for Development Studies, Nyankpala Campus. The pots (buckets) used for this work, each of volume 6 litres, were perforated to enable excess water to flow out the set up during the planting. The application of the biochar to the soil was done at two different rates, which was half rate of 6 g/pot and full rate of 12 g/pot. This was done at three different times; four weeks before planting (4WBP), two weeks before planting (2WBP) and at the time of planting (DOP). There was a control treatment with no biochar application, this added up to the other treatments making seven treatments which were replicated three times. Thus, twenty-one experimental units were obtained (Table 1).

Table 1: Treatments

Biochar levels (per pot)	Weeks before planting	Treatment code
6 g	4	T1
12 g	4	T2
6 g	2	T3
12 g	2	T4
6 g	0	T5
12 g	0	T6
Control	0	T0

***Source**: Field Experiment (2020).*

Source and Preparation of Test Crop

Pepper was used as the test crop. The seeds were obtained from Wumpini agrochemical shop in Tamale, Northern region of Ghana. All foreign materials and non-viable ones in the seeds were removed.

Production of Biochar

False yam tubers were harvested using cutlass, pick ass and hoes. The tubers were cut into smaller pieces about 2 cm and dried for one week in the sun. When the pieces of tuber were completely dried, they were packaged in a sack and kept in a dried place to avoid contact with moisture.

False yam tubers were placed in a barrel with holes under and a chimney on top which served as a pyrolizer. Dried grass was lighted on top of the false yam tubers for a few minutes and covered with a chimney to allow charring or incomplete burning of the cut tubers to form biochar. It is a slow process which took about 3 - 6 hours but very efficient when done in small quantities. A mallet was used to reduce the biochar into smaller particles about 20 - 60 mm before it was applied to the soil.

Data Collection and Statistical Analysis

Data was collected during the experiment and this included germination percentage of the pepper seeds, plant height, leaf area, number of leaves per plant. Data obtained was analysed using Microsoft Excel and Genstat 18th Edition. These tools helped to perform the analysis of variance, standard error of means and average means.

Results and Discussion

Germination Percentage

It was observed on the first week that T2 and T0 recorded the highest mean germination percentage with germination percentage of 33.33% followed by treatments T1, T4, T6, T3 with T5 recording the least average germination percentage (Table 2). Although this was recorded, there were no significant differences ($P > 0.05$) among the treatments. Garnett et al. (2004) showed that biochar that contains unwanted compounds may not be suitable for soil amendments since they might inhibit seed germination and initial roots growth. Gaskin et al. (2008) stated that biochar may contain traces to high concentration of compounds that could impact seed germination depending on biomass from which biochar is produced. And this may explain why in week one none of the treatments had a germination percentage above 50%.

Also, statistically, there was no differences ($P > 0.05$) among the treatments. With the germination percentage recorded in week two after planting, all treatments had either 50% or above germination percentage (Table 2). This may be because there was enough moisture content in the soil for germination. This is in line with the finding of Ibrahim (2016) who mentioned that water availability in soil presents a good medium for seed germination. Two most significant stages in the life cycle of plants are germination and emergence which determine nutrient and water resources availability to plants (Shaban, 2013).

Table 2: Average Germination Percentage after a Week and Two Weeks of Sowing

Treatments Levels	Average Germination Percentage (%)	
	1WAP	2WAP
T1	25.00 ± 0.000	50.00 ± 0.578
T2	33.33 ± 0.333	50.00 ± 0.578
T3	8.33 ± 0.333	91.67 ± 0.333
T4	16.67 ± 0.333	75.00 ± 0.578
T5	0.00 ± 0.000	58.33 ± 0.202
T6	8.33 ± 0.333	58.33 ± 0.667
T0	33.33 ± 0.882	66.67 ± 0.667
P-value (0.05) LSD (0.05)	0.226 1.267	0.633 2.128

***Source**: Field Experiment (2020).*

Plant Height

After the seeds had been sown, data on plant height were collected from the third week to the fifteenth week (Table 3) and the following were observed. Data recorded for the first seven weeks after planting (7WAP) showed that there was no significant difference ($P > 0.05$) among the treatments and the control. However, T0 recorded the highest average mean whereas T1 recorded the least average mean. There was a significant difference ($P < 0.05$) between the treatments in the eighth week after planting (8WAP). T1 was significantly different from T0, treatments T3, T2 T6, T4 and T5 were not significantly different from each other but were different from T1 and T0. Also, T0 recorded the highest mean whereas T1 recorded the least (Table 3). No significant differences ($P > 0.05$) were seen in the data recorded afterwards from week nine to fifteen (9WAP-15WAP).

Plants growing in soil amended with false yam tuber biochar did not perform well as compared to the control in the early stages of the plant growth, but they were seen doing better at the stage of flowering as compared to the control. This may be associated with the fact that biochar is able to improve soil quality and also keep the soil nutrients stable for a longer time (Chan et al., 2007). This result is in agreement with the work of El-Tohamy et al. (2006) who reported the increase in plant height is mostly due to improved soil structure with nutrients available in the growing areas such as Nitrogen and Phosphorus having enhancing impact on vegetative growth of plants.

Table 3: Average Plant Height at Different Growth Stages

Treatments	Mean plant height at different growth stages (cm)						
Levels	3WAP	5WAP	7WAP	9WAP	11WAP	13WAP	15WAP
T1	5.080±0.000	6.690± 1.184	7.70±1.0410	10.43±2.126	16.65±0.087	21.25±0.606	27.70±1.155
T2	6.290±0.578	8.573± 2.237	11.3±3.522	17.00±5.485	24.85±7.015	32.40±7.852	38.50±6.351
T3	6.097±0.667	7.663± 1.147	10.43±1.027	13.40±1.852	21.03±3.417	31.77±3.289	41.13±3.560
T4	7.113±0.667	9.700± 0.558	14.13±1.017	20.47±3.115	29.37±3.565	39.97±4.278	44.10±2.950
T5	6.983±0.000	9.713± 1.504	15.55±2.338	22.00±3.580	30.75±3.608	41.15±4.821	44.25±3.897
T6	5.633±0.667	7.753± 0.765	14.80±2.577	16.50±3.372	21.20±5.239	28.53±7.665	42.93±1.485
T0	7.947±0.333	13.550± 2.690	18.27±1.927	25.63±0.570	31.40±1.815	36.97±4.142	40.83±4.343
P-value (0.05)	0.569	0.140	0.051	0.065	0.148	0.175	0.089
LSD (0.05)	3.242	4.879	6.424	9.74	12.42	15.81	11.42

Source: *Field Experiment (2020).*

Table 4: Average Number of Leaves at Different Growth Stages

Treatment	Average number of leaves at different growth stages						
Levels	3WAP	5WAP	7WAP	9WAP	11WAP	13WAP	15WAP
T1	2.000± 0.000	3.333±0.667	4.333±0.333	6.333±0.882	5.67±1.026	11.00±0.000	11.33±0.333
T2	3.000± 0.578	5.000±0.578	6.333±1.453	9.333±2.028	9.00±2.028	19.33±3.756	19.00±4.041
T3	2.667± 0.667	4.000±0.578	6.000±0.578	7.333±0.667	10.00±0.578	14.00±1.155	16.00±1.732
T4	2.667± 0.667	4.000±0.578	7.000±0.578	10.000±1.155	13.00±1.528	17.33±3.333	21.67±3.283
T5	4.000± 0.000	5.000±0.578	7.333±0.882	11.000±1.155	9.33±1.732	21.33±4.333	26.33±6.642
T6	2.667± 0.667	4.000±0.000	6.333±1.202	9.000±1.528	10.00±5.234	12.00±3.055	16.00±0.578

T0	4.333± 0.333	6.333±0.333	8.667±0.333	11.333±0.882	13.67±1.815	15.00±0.578	16.33±2.186
P-value (0.05) LSD (0.05)	0.060 1.529	0.021 1.576	0.086 2.620	0.116 3.821	0.625 9.380	0.163 8.500	0.127 10.220

***Source**: Field Experiment (2020).*

Number of Leaves

Except for week five, data obtained during the experiment showed no significant difference ($P > 0.05$), meanwhile, T0 recorded the highest mean and T1 recorded the least. Data obtained from week five after planting (5WAP) showed a significant difference ($P < 0.05$). T1 was different from T0 whilst treatments T3, T4, T6, T2 and T5 were not significantly different from each other though they differed slightly from T1 and T0 (Table 4). Number of leaves recorded increased slowly among all the treatments which may be associated to effects of several factors especially intensity of nutrient availability to plants which leads to leaf initiation (Elad et al., 2011). Plant growth and development such as growth of leaf mostly depend on availability and concentration of nutrients in the soil. From the experiment, soil treated with biochar such as treatments T5 and T4 performed well when biochar lasted for a longer time. This is in agreement with a report from Liang et al. (2006), aged biochar particles is concentrated with negative charges that preserves soil aggregation and ensure nutrient availability to plant roots.

Leaf Area Index

Collection of data on leaf area started on week six (6WAP). Data collected on the leaf area revealed that there was significant difference ($P < 0.05$) among the treatments. T1 was significantly different from T0 whilst treatments T3, T4, T2, T5 and T6 were not significantly different but were different from T1 and T0. Similar results were observed from week seven to week ten, where T1 recorded the least mean, T0 recorded the highest score in most weeks (Table 5). This could be attributed to climatic factors such as light intensity, humidity, temperature and nutrient availability (Li et al., 2013). Treatments T4, T5 and T3 as compared to the control (T0) performed very well in response to biochar application and this could be due to the fact that application of biochar enhances soil moisture by increasing available soil water content up to 97% and saturated water contents up to 56% (Uzoma et al., 2011).

Table 5: The Average Leaf Area of Test Crop at Different Growth Stage

Treatment	Average leaf area at different growth stages (cm^2)					
Levels	6WAP	7WAP	9WAP	11WAP	13WAP	15WAP
T1	1.940±0.585	2.210±0.782	3.57±1.026	7.97±0.320	15.74±1.524	30.07±2.601
T2	5.147±2.208	5.317±2.243	10.09±4.610	24.52±8.603	40.30±12.999	58.44±9.068
T3	3.783±0.596	4.353±0.674	6.86±1.978	19.96±6.066	49.34±9.725	68.10±9.094
T4	5.123±0.142	5.953±0.353	12.89±2.543	35.98±9.280	68.29±10.696	77.41±8.426

T5	7.220±2.067	8.240±2.171	14.76±4.157	40.50±7.015	56.43±14.702	68.23±10.655
T6	7.593±1.450	6.027±1.783	8.08±1.687	13.76±4.207	30.53±12.073	54.19±11.888
T0	10.370±1.623	12.087±1.309	19.80±1.711	35.22±3.853	52.77±10.848	54.19±13.721
P-value (0.05)	0.021	0.011	0.021	0.019	0.074	0.087
LSD (0.05)	4.381	4.561	8.56	19.14	33.62	30.02

***Source**: Field Experiment (2020).*

Conclusion

There were no major differences among the treatments for the germination percentage taken after a week of planting (1WAP) and two weeks after planting (2WAP). The highest growth performance (plant height, number of leaves and leaf area index) was recorded in the control. The least growth performance (plant height, number of leaves and leaf area index) was recorded in treatment T1 (6 g of biochar applied at 4 weeks before planting (4WBP)). In conclusion, the use of biochar as soil amendment has a lot of potential benefits, increase growth in some circumstances but the application rate of false yam tuber biochar (6 g/pot and 12 g/pot) as soil amendment might not be the right amendment for sweet pepper production, since the control, plants in soil only performed better than plants in treated soil.

It may be appropriate to investigate the compounds in the false yam tuber that inhibit the growth performance of sweet pepper and the experiment should be repeated to confirm the effects of false yam tuber biochar under different conditions such as field planting.

References

Chan, K. Y., Van Zwieten, L., Meszaros, I., Downie, A., & Joseph, S. (2007). Agronomic values of greenwaste biochar as a soil amendment. *Australian Journal of Soil Research*, *45*(8), 629–634. https://doi.org/10.1071/SR07109

Dei, H. K., Bacho, A., Adeti, J., & Rose, S. P. (2011). Nutritive value of false yam {*Icacina oliviformis*) tuber meal for broiler chickens. *Poultry Science*, *90*(6), 1239-1244. DOI: 10.3382/ps.2010-01107

El-Tohamy, W. A., Ghoname, A. A., & Abou-Hussein, S. D. (2006). Improvement of pepper growth and productivity in sandy soil by different fertilization treatments under protected cultivation. *Journal of Applied Sciences Research*, *2*(1), 8–12. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1090.9485&rep=rep1&type=pdf

Elad, Y., Cytryn, E., Meller Harel, Y., Lew, B., & Graber, E. R. (2011). The biochar effect: Plant resistance to biotic stresses. *Phytopathologia Mediterranea*, *50*(3), 335–349. DOI:10.14601/Phytopathol_Mediterr-9807

Fay, J. M. (1991). *Icacina oliviformis* (Icacinaceae): A close look at an underexploited food plant. II. Analyses of food products. *Economic Botany*, *45*(1), 16–26. https://doi.org/10.1007/BF02860046

Gao, S. & DeLuca, T. H. (2016). Influence of biochar on soil nutrient transformations, nutrient leaching, and crop yield. *Advances in Plants & Agriculture Research*, *4*(5). https://doi.org/10.15406/apar.2016.04.00150

Garnett, E., Jonsson, L. M., Dighton, J., & Murnen, K. (2004). Control of pitch pine seed germination and initial growth exerted by leaf litters and polyphenolic compounds. *Biology and Fertility of Soils*, *40*(6), 421–426. https://doi.org/10.1007/s00374-004-0801-z

Gaskin, J. W., Steiner, C., Harris, K., Das, K. C., & Bibens, B. (2008). Effect of low-temperature pyrolysis conditions on biochar for agricultural use. *Transactions of the ASABE*, *51*(6), 2061–2069. https://doi.org/10.13031/2013.25409

Gebhardt, C. (2016). The historical role of species from the Solanaceae plant family in genetic research. *Theoretical and Applied Genetics*, *129*(12), 2281–2294. https://doi.org/10.1007/s00122-016-2804-1

Ibrahim, E. A. (2016). Seed priming to alleviate salinity stress in germinating seeds. *Journal of Plant Physiology*, *192*, 38–46. https://doi.org/10.1016/j.jplph.2015.12.011

Li, Y.-M., Elson, M., Zhang, D., Sicher, R. C., Li, H., Meinhardt, L. W., & Baligar, V. (2013). Physiological traits and metabolites of cacao seedlings influenced by potassium in growth medium. *American Journal of Plant Sciences,4* (5), 1074-1080 . https://doi.org/10.4236/ajps.2013.45133

Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J. O., Thies, J., Luizão, F. J., Petersen, J., & Neves, E. G. (2006). Black carbon increases cation exchange capacity in soils. *Soil Science Society of America Journal*, *70*(5), 1719–1730. https://doi.org/10.2136/sssaj2005.0383

Savannah Agricultural Research Institute (2001). *Annual report*. CSIR-Savanna Agricultural Research Institute (SARI).

Schmidt, H.-P. (2012). 55 Uses of biochar. *Ithaka Journal*, *25*(1), 13–25. https://www.researchgate.net/publication/257939693_55_Uses_of_Biochar

Shaban, M. (2013). Effect of water and temperature on seed germination and emergence as a seed hydrothermal time model. *International Journal of Advanced Biological and Biomedical Research*, *1*(12), 1686–1691. http://www.ijabbr.com/article_7963_4f37c8e5e1bfa0fe7c5b27342c7144ed.pdf

Uzoma, K. C., Inoue, M., Andry, H., Fujimaki, H., Zahoor, A., & Nishihara, E. (2011). Effect of cow manure biochar on maize productivity under sandy soil condition. *Soil Use and Management*, *27*(2), 205–212. https://doi.org/10.1111/j.1475-2743.2011.00340.x

Weber, K., & Quicker, P. (2018). Properties of biochar. *Fuel*, *217*(1), 240–261. https://doi.org/10.1016/j.fuel.2017.12.054

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