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Resaerch Application Summary

Effects of organic mulch on soil properties and yield composition of groundnut on a typical latosol

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Abstract

Given the deficient nature of the Liberian soil (low N, P, K and acidic soil condition), a field experiment was conducted in 2016 and 2017 at the College of Agriculture and Sustainable Development Experimental Field using Biochar, Sawdust and Straw as organic mulches at different rates, 800 g/ha and 1200 g/ha each and a control in a Randomised Complete Block Design (RCBD) with three replications. The aim was to determine the effect of organic mulch application on the physico-chemical properties of the soil and its impact on the yield of groundnut. Results indicated that sawdust, Biochar and straw enhanced the physico-chemical properties of the soil with increase in NPK (55.6 - 61.75 N; 12.4 – 61.75 P and 0 – 160.55 K) which positively impacted soil moisture, organic matter contents, soil bulk density, soil pH (5.46-6.8) and soil temperature which favor groundnut growth. Thus, application of sawdust, Biochar and straw as organic mulches have the potential to significantly impact the physico-chemical properties of the deficient Liberian soil.

Key words: Biochar, genotype, groundnut, organic mulch, Latosol, Liberia, Sawdust, Straw

Résumé

Compte tenu de la nature déficiente du sol libérien (faible teneur en N, P, K et sols acides), une expérience sur le terrain a été menée en 2016 et 2017 au College of Agriculture and Sustainable Development Experimental Field en utilisant du biochar, de la sciure de bois et de la paille comme paillis organiques à différents taux, 800 g / ha et 1200 g / ha chacun et un contrôle dans une conception de blocs complets randomisés (RCBD) avec trois répétitions. L'objectif était de déterminer l'effet de l'application de paillis organique sur les propriétés physico-chimiques du sol et son impact sur le rendement de l'arachide. Les résultats ont indiqué que la sciure de bois, le biochar et la paille amélioraient les propriétés physico-chimiques du sol avec une augmentation du NPK (55,6 - 61,75 N; 12,4 - 61,75 P et 0 - 160,55 K), ce qui avait un impact positif sur l'humidité du sol, le contenu en matière organique, la densité apparente du sol, le pH du sol (5,46-6,8) et la température du sol qui favorisent la croissance des arachides. Ainsi, l'application de sciure de bois, de biochar et de paille en tant que paillis organiques peut avoir un impact significatif sur les propriétés physico-chimiques du sol libérien déficient.

Mots-clés: Biochar, génotype, arachide, paillis organique, Latosol, Libéria, sciure de bois, paille

Introduction

Groundnut (*Arachis hypogaea* L.) also called peanut is native to the Western Hemisphere and is grown in rain-fed areas of West Africa including Liberia and in the irrigated areas of the Central and Eastern parts of Sudan (Abd El-Kader *et al.,* 2010). Several authors (Brady *et al.,* 1996; Gandhi and Banis, 2006; Edyta *et al.,* 2014) have indicated that the type of soils used predominantly for groundnut production is oxisols, characterized by their coarse texture and low organic matter contents. They are equally low in cation exchange capacity (CEC), with little or no mineral reserves, low water retention capacity, low pH and are highly leached and structurally unstable (Guerena *et al.,* 2008).

However, with the removal of vegetation cover through anthropogenic activities such as intensive cropping, soil fertility maintenance becomes a serious problem. This is usually evidenced by the rapid decline of organic matter contents and soil nutrients, high soil acidity and erosion which culminate in sharp decline in groundnut yield (Kshurshid *et al.,* 200). Moreover, different types of materials such as grass straw, sawdust, wood chips, and/ or biochar may be used as mulch for increasing water use efficiency and weed control in crop fields (Norman *et al.,* 2002; Khurshid *et al.,* 2006; Komla, 2013). Mulch provides a better growth environment, moderates soil temperature, increases soil porosity and water infiltration rate during rainy seasons, controls run-off, erosion as well as suppresses weed growth to create a perfect condition for optimum crop yield (Guerena and Winter, 2008).

Considering the above, there is a dearth of information on the important roles and uses of organic mulches by local farmers in Liberia. Organic mulches are however, widely available and its uses are cost effective, and contribute immensely to moisture retention during dry spell. This study was therefore undertaken to evaluate the impact of sawdust, biochar and straw (organic mulches) on the physico-chemical properties of the soil and its impact on growth as well promotes their use among smallholder farmers.

Materials and Methods

Study site. This study was conducted in Liberia at the Upper Highland Tropical Forest Agro-Ecological Zone (UHTF AEZ) in Suakoko District, Bong County at the College of Agriculture and Sustainable Development (CASD) experimental farm from December 2016 to April 2017. The soil at the site is well-drained loamy sand referred to as Latosol. Climatic data from the study site are presented in Table 1.

Soil physico-chemical characteristics. Soil samples were collected from the field before layout of the experiment for the determination of the soil physico-chemical properties. The soil samples were collected from 0-30 cm depth and were dried in the Lab, pounded to pass through 2 mm sieve. The pre-planting and post-harvest soil physico-chemical analysis was done and results are presented in Table 2.

Table 1. Climatic data during the experimental period

Month	Rainfall (mm)	Temperature (°C)	
		Maximum	Minimum
December 2016	12	30.4	24.3
January 2017	10	30.8	24.8
February 2017	30	31.9	24.6
March 2017	13	30.6	25.1
April 2017	162.1	33	25

Source: CASD Local Weather Station, 2017

Table 2. Physico-chemical properties of soil at the study site and organic mulches used

Parameter	Pre-plant test	Post-planting test	Biochar	Sawdust	Straw
pH	5.46	6.87			
Temperature (°C)	31	30			
Organic matter content (%)	15.4	59.9			
Nitrogen (kg/ha)	55.6	61.75	6.175	9.88	6.175
Phosphorus (kg/ha)	12.4	61.75	247	24.7	24.7
Potassium (kg/ha)	0	160.55	111.15	0	0
Bulk density (DB (g/cm3))	1.47	1.22			
Moisture content (g)	10.4	25.3			
% Sand	80.4	95.1			
% Silt	13.8	3.25			
% Clay	5	0.5			

pH = power of hydrogen; % sand = percentage of sand; % silt = percentage of silt; % clay = percentage of clay

Field layout and experimental design. Interplot and interblock distances (walkway) was 0.2 m; 45 cm between row and 45 cm within column was selected as planting distance. There were six (6) plants per sub plot with total of 378 plants on the field. Three plants in the middle portion of the plot were randomly selected and tagged for data collection totaling 189 plants. The Randomised Complete Block Design (RCBD) was used with three (3) replications. The dimensions of the experimental field was 4.9 m x 25 m, with three (3) blocks, each block consisted of 21 sub plots and each measuring 1 m x 1.5 m.

Data collection and analysis. The first and second data were collected after the first and second months, respectively. Data were taken on days to 50 % germination; days to 50 % flowering; plant height; number of branches; number of leaves per plant; number of leaflet; number of pods per plant; number of seeds per plant; 100 seed weight; pod weight per plant; soil pH; soil bulk density; total organic matter; NPK level in the soil; and soil moisture content; soil temperature was analyzed in the lab.

Analysis of Variance (ANOVA) was performed ($P \leq 0.05$) to ascertain variability in the three genotypes of peanut under organic mulch application. Correlation analysis was performed to determine the level of association between major characters studied as affected by the organic

application. Least Significant Difference (LSD) was used to separate treatment means using the SAS-JMP statistical package (version 11).

Results and Discussions

Effect of organic mulch application on soil physico-chemical properties. There were significant differences in soil temperature with an increase in the total organic matter and moisture contents, percentage of sand but with reduction in percentage of silt and clay (Table 2). Soil bulk density varied from 1.47-1.22. This confirms that the soil was loosened by the application of these organic mulches, thus soil structure was improved. Similary, Sinkevičienė *et al.* (2008) reported that organic mulches significantly decrease soil temperature. Additionally, Sinkevičienė *et al.* (2008) reported that mulched plots improved soil moisture content which is consistent with the findings of this study. Thus, organic mulches significantly increase soil moisture retention capacity, impact soil bulk density and reduced temperature.

Furthermore, there were significant increases in the Nitrogen (N), Phosphorus (P) and Potassium (K) contents of the soils of the study site. In K level was more than doubled (from 0 to 160.55 kg/ha) after the organic mulch application on all plots. Our results are consistent with those of Saroa and Lal (2004) who reported that mulching increased total P and K concentrations in soils after four years of mulching from 601–658 mg kg^{-1} and 491–694 mg kg^{-1} after 11 years of mulching, respectively. Organic matter was also significantly increased for all plots indicating the direct impact of the treatments.

Effect of organic mulch application on agronomic performance of groundnut genotypes. There was no significant difference in percent germination among all treatments. 800 g Biochar applied on Runner genotype recorded the longest days to germination with 800 g Straw mulch + Valencia, 1200 g straw + runner as well as 800 g of sawdust applied to runner recording the earliest germination rate (Table 3). However, since temperature influences germination, straw emits heat and sawdust in similar fashion affected germination of the groundnuts. This is consistent with the findings of Norman *et al.* (2011) who reported that organic mulch significantly increased soil moisture while decrease soil temperature impeded early germination.

All the groundnut genotypes supplied with the different treatments flowered between 30-39 days which shows that number of days to 50 % flowering were not influenced by organic mulching. A study conducted by Komla (2013), indicated that all treatments of mulching during dry season failed to significantly influence number of days to 50 % flowering of vegetables. It can therefore be concluded that the presence of untimely rainfall influenced the days to 50% flowering. The delayed 50 % flowering by plants from mulched plots could be attributed by the fact that the mulch materials extended the vegetative growth period of the crops by increasing soil moisture content, weed growth and reducing soil temperature, and thus, paving the way for subsequent outbreak of nematodes.

Soil physico-chemical characteristics. Soil samples were collected from the field before layout of the experiment for the determination of the soil physico-chemical properties. The

soil samples were collected from 0-30 cm depth and were dried in the Lab, pounded to pass through 2 mm sieve. The pre-planting and post-harvest soil physico-chemical analysis was done and results are presented in Table 2. There were significant differences among all treatments with respect to the total number of leaflets and leaves (Table 3). Spanish groundnut variety treated with 1200 g of straw recorded the highest number of leaflets (n = 209) while Runner with same treatment recorded the least number of leaflets (n = 70.9) among all treatments. Also, under the same condition, 1200 g sawdust +Spanish groundnut variety yielded the highest number of leaves (n = 431); while 800 g biochar + runner had the least amount of leaves per plant (n = 113) (Table 3).

Effect of organic mulch application on key reproductive traits of groundnut. The number of pods per plant, pod weight per plant, 100 seeds weight per plant and number of seeds per plant were differently influenced by the treatments. On the contrary, there were slight changes among all treatments observed under the same condition for number of pods per plant, which was contrary to the findings of Sanchez *et al.* (1999).

Overall, the observed decrease in yield and yield components of all treatments was an indication that the mulch materials provided an unfavourable environment, i.e., provided wet condition and hide out for the presence, survival, multiplication and attack of by nematode. The high rainfall of (162.1 mm) during the month of April, 2017 and low temperature of (25˚C) over the same period may have favored the activities of the Soil-borne nematodes which substantially affected all yield components.

Conclusion

This study indicates that number of leaves, number of leaflets and number of flowers are significantly influenced by mulches. However, the organic mulches had less effect on the growth and yield of the groundnuts during the study period due to an unexpected high rainfall which provided favorable environment (wet condition) for survival, multiplication and subsequent attack by soil-borne nematodes. Furthermore, the soil physico-chemical properties (pH, soil bulk density, soil moisture holding capacity, total organic matter content, soil temperature, percent sand, clay and silt; NPK.) were significantly impacted by the organic mulch application. The application of organic mulch (sawdust, biochar and straw) was strongly correlated with soil properties which reduced the acidic nature of the Liberian soil while improving nitrogen, phosphorus and potassium levels.

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Table 3. Variation in key vegetative traits of groundnut under organic mulch application in Liberia

Treatments	DFPG	DFPF	#LLPP	#LPP	#BPP	#FPP	MPH(cm)
Runner + Control	6.67^{ab}	39.00^{a}	56.3^{efg}	190.33^{def}	9.33^{bcd}	19.67^{abcd}	12.83^{ab}
Runner + 800g Biochar	8.00^{a}	33.00^{c}	44.00^{g}	113.33^{f}	7.33^{d}	14.67^{de}	9.38b
Runner + 800g sawdust	5.67^{b}	33.00^{c}	86.3^{bcdef}	268.00^{abcdef}	13.33^{abcd}	22.33^{abc}	16.72^{a}
Runner + 800g Straw	6.33^{ab}	32.67^{c}	62.3^{ef}	219.00^{def}	11.33^{bcd}	18.00^{bcde}	14.43^{ab}
Runner + 1200g Biochar	6.67^{ab}	33.00^{c}	63.7efg	216.33^{def}	9.67^{bcd}	15.33^{cde}	13.78^{ab}
Runner + 1200g sawdust	6.00^{ab}	32.67^{c}	67.0^{efg}	213.00^{def}	11.33^{bcd}	15.67^{bcde}	15.77^{a}
Runner + 1200g straw	5.67^{b}	32.67^{c}	70.0^{defg}	230.67^{cdef}	10.00^{bcd}	19.67^{abcd}	17.12^{a}
Spanish + Control	6.33^{ab}	34.33^{bc}	110.0^{bcd}	385.00^{abc}	16.67^{ab}	16.00^{bcde}	12.55^{ab}
Spanish + 800g Biochar	7.67^{ab}	32.67^{c}	56.00^{efg}	197.00^{def}	11.00^{bcd}	12.33^{e}	13.92^{ab}
Spanish +800g sawdust	7.33^{ab}	32.33^{c}	125.3^{b}	410.33^{ab}	20.00^{a}	18.00^{bcde}	13.37^{ab}
Spanish + 800g straw	7.33^{ab}	33.33^{c}	59.3^{efg}	188.67^{def}	9.33^{bcd}	12.33e	14.15^{ab}
Spanish + 1200g Biochar	6.67^{ab}	33.67^{c}	98.3^{bcde}	341.33^{abcd}	14.67^{abcd}	19.00^{abcde}	13.43^{ab}
Spanish + 1200g sawdust	7.33^{ab}	38.33^{ab}	114.3^{bc}	431.00^{a}	15.67^{abc}	15.33^{cde}	15.95^{a}
Spanish + 1200g straw	6.67^{ab}	32.67^{c}	209.0^{a}	310.33^{abcde}	12.00^{bcd}	19.33^{abcde}	15.82^{a}
Valencia + Control	7.33^{ab}	32.67^{c}	75.7^{cdefg}	255.00^{bcdef}	11.67^{bcd}	17.67^{bcde}	14.83^{a}
Valencia + 800g Biochar	7.33^{ab}	33.00^{c}	70.3^{defg}	241.33^{cdef}	9.67^{bcd}	12.67^{de}	14.32^{b}
Valencia + 800g Sawdust	6.67^{ab}	32.67^{c}	52.3^{fg}	158.67^{ef}	8.33^{cd}	14.00^{de}	11.77^{ab}
Valencia + 800g Straw	5.67^{b}	33.00^{c}	60.3^{efg}	207.67^{def}	10.00^{bcd}	15.00^{de}	14.33^{ab}
Valencia + 1200g Biochar	7.00^{ab}	34.00^{bc}	80.3^{cdefg}	256.00^{bcdef}	12.33^{abcd}	17.00^{bcde}	13.32^{ab}
Valencia + 1200g sawdust	6.00^{ab}	31.67^{c}	93.3^{bcde}	312.67^{abcde}	14.00^{abcd}	25.67^{a}	13.97^{ab}
Valencia + 1200g straw	7.00^{ab}	33.00^{c}	70.0^{defg}	233.67^{cdef}	11.00^{bcd}	22.67^{ab}	16.18^{a}
TCV	0.5908	0.2665	<0.001	0.0290	0.3213	0.0409	0.6159
BCV	0.039*	0.059*	<0.001	<0.001	<0.001	0.254	0.194
LSD (5%)	ns	Ns	sig	Sig	ns	sig	ns

DFPG = days to 50% germination; DFPF= days to 50% flowering; #LLPP = number of leaflet per plant; LPP = number of leaf per plant; #BPP = number of branches per plant; #FPP = number of flowering per plant; PH = maximum plant height

Table 4. Effect of organic mulch application on key reproductive traits of groundnut in Liberia

Treatment	#PPP	PWPP(g)	100SWPP(g)	#SPP
Runner + Control	33.33^{bcd}	56.17^{abc}	25.3^{abc}	55.10^{bcde}
Runner + 800g Biochar	33.67^{bcd}	55.50^{bc}	27.8^{ab}c	59.47^{abcde}
Runner + 800g Sawdust	51.00^{ab}	85.43^{ab}	41.4^{a}	80.57^{ab}
Runner + 800g Straw	41.33^{abcd}	59.20^{abc}	27.6^{abc}	56.10^{bcde}
Runner + 1200g Biochar	26.33^{cd}	42.10^{c}	20.0^{bc}	40.77^{de}
Runner + 1200g Sawdust	35.33^{abcd}	65.90^{abc}	28.0^{abc}	50.37^{bcde}
Runner + 1200g Straw	34.67^{abcd}	55.83^{abc}	31.0^{abc}	62.90^{abcde}
Spanish + Control	40.33^{abcd}	61.83^{abc}	32.8^{abc}	67.77^{abcd}
Spanish + 800g Biochar	31.00^{bcd}	52.17^{bc}	22.4^{bc}	47.77^{cde}
Spanish + 800g Sawdust	54.67^{a}	94.53^{a}	41.8^{a}	88.57^{a}
Spanish + 800g Straw	31.67b^{cd}	57.07^{abc}	19.4^{bc}	47.67^{cde}
Spanish + 1200g Biochar	35.67^{abcd}	63.63^{abc}	31.7^{abc}	63.10^{abcde}
Spanish + 1200g Sawdust	40.33^{abcd}	71.07^{abc}	21.0^{bc}	44.37^{de}
Spanish + 1200g Straw	50.33^{ab}	88.33^{ab}	37.1^{ab}	71.47^{abcd}
Valencia + Control	41.33^{abcd}	67.93^{abc}	28.7^{abc}	61.13^{abcde}
Valencia + 800g Biochar	34.00^{bcd}	55.00^{bc}	22.5^{bc}	48.67^{bcde}
Valencia + 800g Sawdust	24.33^{d}	37.77^{c}	15.2^{c}	35.43^{e}
Valencia + 800g Straw	37.67^{abcd}	55.90^{abc}	29.4^{abc}	58.67^{abcde}
Valencia+ 1200g Biochar	37.33^{abcd}	67.37^{abc}	31.9^{abc}	64.00^{abcde}
Valencia + 1200g Sawdust	54.67^{a}	85.57^{ab}	2.5^{abc}	76.70^{abc}
Valencia + 1200g Straw	46.00^{abc}	84.90^{ab}	34.2^{ab}	62.23^{abcde}
TCV	0.1582	0.2581	0.2612	0.1752
BCV	0.0149*	0.1424	0.2509	0.1288
LSD (5%)	ns	ns	ns	ns

#PPP = number of pod per plants; PWPP = pod weight per plant; 100SWPP = 100 seed weight per plot; #SPP = number of seeds per plant

References

Abd, El-Kader, A. A, Shaaban, S. M. and Abd El-Fattah, M. S. 2010. Effect of irrigation level and organic compost on okra (*Abelmoschus esculentus* L.) grown in sandy calcareous soil. *Agriculture and Biology Journal of North America* 1 (3): 225 – 231

Brady, N. C. and Weil, R.R.1996. The nature and properties of soil (11th ed.). Prentice Hall Inc. New Jersey, USA, 740pp.

Edyta, K. 2014. The effect of different types of straw mulches on weed-control in vegetables cultivation.

Journal of Ecological Engineering (15): 109–117. Doi: 10.12911/22998993.1125465.

Gandhi, N. and Bains, G.S. 2006. Effect of mulching and date of transplanting on yield contributing characters of tomato. *Journal of Research. Punjab Agriculture* 43 (1): 6-9.

Gill, K.S., Gajri, P.R., Chaudry, M.R. and Singh, B. 1996. Tillage, mulch and irrigation effects on corn (*Zea mays* L.) in relation to evaporative demand. *Soil and Tillage Research* 39 (3–4): 213–227.

Iftikhar, A., Zahoor, H., Shuaib, R., Noor-Un-Nisa, M. and Summar, A.N. 2011. Response of vegetative and reproductive components of chilli to inorganic and organic mulches. *Pakistan Journal of Agricultural Science* 48 (1): 19-24.

Khurshid, K., Iqbal, M., Arif, M. S. and Nawaz A., 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *International Journal of Agriculture and Biology* 8 (5): 593-596.

Komla, A.N. 2013. Effect of organic mulch on growth and yield of sweet pepper (*capsicum annuum* L.). Master's Thesis, University of Ghana, Ghana. pp. 37-57.

Norman, J.C., Opata, J. and Ofori, E. 2011. Growth and yield of okra and hot pepper as affected by mulching. *Ghana Journal of Horticulture* 9: 35-42.

Norman, J.C., Asante, I. and Nartey, I.T. 2002. Mulching effects on growth, partitioning and yield of sweet corn. *Ghana Journal of Horticulture* 11: 16-20.

Ravinderkumar, K.K. and Srivatsava, B.K. 1998. Influence of different mulches on flowering and fruit setting of winter tomato. *Crop Research* 12: 174-176.

Saroa, G.S. and Lal, R. 2004. Mulching effects on phosphorus and sulfur concentrations in a Miamian soil in central Ohio, USA. *Land Degradation and Development* 15: 351–365.

Sanchez, P.A., Stoner, E.R. and Pushparajah, E.D.1999. Management of acid tropical soils for sustainable agriculture. Proceedings of IBSRAM Inaugural Workshop. Bangkok, Thailand. 107pp.

Seyfi, K. and Rashidi, M. 2007. Effect of drip irrigation and plastic mulch on crop yield and yield components of cantaloupe. *International Journal of Agriculture and Biology* 9:247-249.

Sharma, R.R. and Sharma, V.P. 2003. Mulch influences fruit growth, albinism and fruit quality in strawberry. *Fruits* 58: 221–227.

Singh, R.S., Sharma, R.R. and Goyal, R.K. 2007. Interacting effects of planting time and mulching on "Chandeler" strawberry (Fragaria x ananassa Duch.). *Scientia Horticultura*e 111: 344–351.

Sinkevičienė, A., Jodaugienė, D., Pupalienė, R., Urbonienė, M. 2009. The influence of organic mulches on soil properties and crop yield. *Agronomy Research* 7 (1): 485–491.

Sønsteby, N.A. and Måge, F. 2004. Effects of bark mulch and NPK fertiliser on yield, leaf nutrient status and soil mineral nitrogen during three years of strawberry production. *Acta Agriculturae Scandinavia. Sect. B, Soil and Plant* 54: 128-134.

Thakur, P.S., Thakur, A. and Kanaujia, S.P. 2000. Reversal of water stress effects: mulching impact on the performance of *Capsicum annuum* under water deficit. *Indian Journal of Horticulture* 57(3): 250-254.

Unger, P.W. and Ji, S. 2001. Soil water accumulation under different precipitation, potential evaporation and straw mulch conditions. S*oil Science Society of America Journal* 65: 442-448.

Uwah, D.F. and Iwo, G.A. 2008. Effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth. *The Journal of Animal and Plant Sciences* 21(3): 525-530.