Performance of Cassava on Soil Amended with Spent Mushroom Substrate Under Varying Levels of Tractor Compaction

I. Fubara-Manuel [1] • C. Emeka [1] • E. Ikrang [2] • D. D. Davis [1] • O. P. Princewill [1]

[1] Department of Agricultural and Environmental Engineering, Rivers State University, PMB 5080, Port Harcourt, Nigeria
[2] Department of Agricultural and Food Engineering, University of Uyo, Uyo, Nigeria
fubara-manuel.isoteim@ust.edu.ng

Abstract. Cassava is an important and most widely consumed staple food in Southern Nigeria. However, its production especially in South-South, Nigeria, is mainly at the subsistence level. In order to boost production, mechanized farming and the use of fertilizers have always been advocated. Mechanized farming, however, involves the use of tractors that compact the soil. This study was therefore conducted to investigate the performance of cassava (manihot esculenta) on a sandy loam soil amended with spent mushroom substrate (SMS) under varying tractor passes, at the Institute of Agricultural Research and Training, Rivers State University, Port Harcourt, Nigeria. 92kg of SMS was mixed with the soil, ploughed and harrowed using a tractor. At the end of these operations, the tractor was allowed to run on the experimental plots without any hitched implement so as to compact the soil using 0, 2, and 4 tractor passes (0TP, 2TP and 4TP). The compaction levels arising from the several tractor passes were measured with a cone penetrometer. A similar plot of land which neither had SMS nor tractor passes was included as a control (C) making it a total of four Treatments in all. The randomized complete block design with three replications was used in establishing the experiment. Two cassava stems were planted per stand in each plot, at a spacing of 1m x 1m, with supplemental irrigation applied at a rate of 0.002m^3/s. The plant parameters measured were emergence rate, plant height, stem girth, and yield. The results showed that at 19 days after planting (19 DAP), the emergence rates were 100%, 100%, 42.8% and 28.6% for C, 0TP, 2TP and 4TP respectively. The highest average plant height was obtained from 0TP, followed by C, 2TP and 4TP in that order. The stem girth and yield also followed the same trend. On the whole, the highest mean yield (8833kg/ha) was obtained from 0TP, while mean yields from C, 2TP and 4TP were 8692kg/ha, 8292kg/ha and 4250kg/ha respectively. There was no significant difference between the plant growth parameters and yield at 5 % level. However, for stem girth, there was significant difference at the 5% level between 0TP and 2TP, 0TP and 4TP, and C and 4TP. Also, OTP and 4TP, and C and 4TP of the yield were significantly different at 5%. The results, however, suggest that the level of compaction arising from the number of tractor passes contributes significantly to the performance of cassava planted on sandy loam soil amended with SMS.

To cite this article
[Fubara-Manuel, I., Emeka, C., Ikrang, E., Davis, D. D. & Princewill, O. P. (2021). Performance of Cassava on Soil Amended with Spent Mushroom Substrate Under Varying Levels of Tractor Compaction. *The Journal of Middle East and North Africa Sciences*, 7(02), 6-13]. (P-ISSN 2412- 9763) - (e-ISSN 2412-8937). www.jomenas.org. **2**

Keywords: Spent Mushroom Substrate, Cassava, Tractor Passes, Yield.

1. Introduction:

Cassava plant (manihot esculenta) is one of the most widely consumed staple foods in the world. The crop is grown throughout the year with about 90% of the producers being small-scale farmers, as is the case with general agricultural production in the country (Igoni & Ayotamuno, 2016).Cassava is rich in vitamin A, B and C, carbohydrates, calcium and essential minerals, although nutrients composition differs according to variety and age of the harvested crop, soil condition, climate and other environmental factors during cultivation (Igoni and Fubara-Manuel, 2016). It is therefore of optimum importance to enhance the production of such staple crop.

In order to meet the demand of an increasing population, mechanized farming has always been advocated. There is also global movement from dependence on petroleum and its bye-products to agriculture with a view to enhancing sustainable economy, thus leading to soil compaction as a result of the use of agricultural machines (Berisso et al, 2012). Compaction of soil due to the weight of farm machines, especially tractors, has been recognized as a severe problem. Ramazan et al. (2012) found that plant height and yield of maize decreased with the number of tractor compaction, as well as influencing many soil properties and processes including crop yield (Servadio et al, 2005).

The presence of soil amendment like spent mushroom substrate (SMS) is essential for agricultural production because it can promote soil drainage, increase soil microbial activity, provide substantial amount of plant nutrient and also a good source of organic matter and has a limiting effect on soil (Chong et al. 1997). Furthermore, SMS contains a wealth of micronutrients that are usually not present in standard NPK fertilizer. This paper, therefore, examines the performance of cassava when soil is amended with SMS under 0, 2 and 4 tractor compactions.

2. Materials and Methods:

2.1. Description of the study area

The study was conducted at the research farm of the Rivers State Institute of Agricultural Research and Training, located at Rivers State University, Port Harcourt, Nigeria, during the 2018 cropping season. Port Harcourt is characterized by tropical rainforest vegetation with a rainfall ranging from 2000-2484mm per annum of which 70% occurs between the months of May and August. The soil type is ultisol (USDA classification) and its soil texture is sandy loam (Ayotamuno et al, 2007).

2.2. Experimental design, layout, and treatment

The experiment was laid out in a randomized complete block design, with three replicates. Treatment consisted of spent mushroom substrate (SMS), irrigation water, and tractor passes. 92kg of weathered SMS was obtained from Dilomat Mushroom Centre at the Rivers State University, Port Harcourt, Nigeria. The SMS was incorporated into the experimental plot of size 10.4m x 6m, seven days before planting, followed by ploughing and harrowing. The plot was then divided into four subplots, each 2m x 6m with drain and alley constructed between each plot. The drains were constructed to prevent treatment from one plot flowing into adjacent plot either by surface runoff or interflow, while the alleys allowed free movement of personnel within plots. A tractor (SWARAJ 978 FE) was used to effect the required compaction level in each subplot. The treatment combinations were control, with no compaction and no SMS, which represented the natural condition of the soil, while SMS with zero tractor pass (0TP), two tractor passes (2TP), and four tractor passes (4TP) indicated the other combinations. Irrigation water was applied at a discharge rate of $0.002m^3$/s and distributed uniformly on each subplot at an interval of 7days.

2.3. Planting and cultural practices

Two stems of Pro-vitamin A variety of cassava, obtained from the Agricultural Development Project (ADP), in Port Harcourt, Nigeria, were planted per stand in a horizontal position at a depth of 10cm, with a spacing of 1m x 1m. The maturity period of this variety of cassava is about eight months after planting. There was no chemical or biological control of weeds. Weeds were manually removed twelve days after planting and whenever the need arose in order to prevent weeds from competing with the crops.

2.4. Determination of soil parameters

The penetration resistance of the soil (cone index) was determined, including other physico-chemical properties of the soil such as available phosphorus (P), total nitrogen (N), exchangeable bases (K, Ca, Mg, Na), p^H, particle size distribution, moisture content, organic matter, organic carbon, and electrical conductivity.

Cone index was determined using a cone penetrometer and the equation given below (Dopemu, 2016)

$$\text{Cone index } (\text{CI})_i = (\text{F})i/(\text{SA})i \ (\text{KN/m}^2) \quad (1)$$

$$\text{SA} = \pi\emptyset(\emptyset/2 + d_i)(\text{m}^2) \quad (2)$$

Where:

No. of tractor passes, i = 0, 2 and 4.
F = Probe resistance force reading (KN)
SA = Surface area (m^2)
d = Depth of penetration (m)
π = 3.142
Q = Diameter of probe (mm)

The physico-chemical properties were analyzed using the methods outlined by Hossner (1996), Jackson (1969), Olsen et al., (1982), Page et al. (1982), and Odu et al. (1985), while the moisture content was determined by the gravimetric method.

2.5. Determination of plant parameters

The average values of seven plants selected by simple randomization of each sub-plot were used to determine stem girth, plant height, and yield. Percentage emergence was also determined at four weeks after sowing.

2.6. Stem girth and plant height

The thickness of the cassava stem was measured using measuring tape. The height of the plant was also measured with a measuring tape as outlined by CIAT (1983)

2.7. Yield

The cassava yield of the fresh roots in kg/ha was calculated using the equation suggested by Abdul-Raziqshah, (2011), as given below.

Yield (kg/ha) = [Crop weight per subplot(kg)/Area of subplot(m^2)]x10000m^2/ha (3)

2.8. Percentage emergence

The data was recorded on the basis of number of days after planting to emergence. The percentage of emergence was calculated as

$$\%\,\text{E} = [\text{Number of Emergence/Total Planted}] \times 100\% \quad (4)$$

2.9. Statistical analysis

The analysis of variance (ANOVA) was used to compare the variability in the growth parameters at different levels of tractor compaction.

3. Results and Discussion:

Table 1 shows the chemical properties of the spent mushroom substrate before it was added to the soil.

It had however been observed that soil P^H was not significantly affected by different doses of organic and inorganic fertilizers (Mahendra et al, 1988; Lund and Doss, 1980).

It is also worth mentioning that cassava yields are not normally affected until the soil P^H is below 4.2 (FAO, 2013).

Table 1. *Chemical Properties of the Spent Mushroom Substrate*

pH	EC (μ/cm}	OM (%)	Organic C (%)	Total N (%)	C/N Ratio (%)	Available P (%)	Ca (%)	Mg (%)	K (%)	Cu (%)	Zn (%)	Fe (%)	Mn (%)
6.82	246	53.2	8.1	0.84	9.64	0.00006	0.0787	0.148	0.0562	-	0.0139	0.04:	0.0363

There is dearth of literature on the range of values of the properties of SMS suitable for the optimum growth and yield of cassava. There are recommendations for SMS selection for the production of turf. According to Landschoot and McNitt (1995), pH is recommended to be between 6.0 and 8.0, organic matter should be greater than 40%, carbon: nitrogen ratio should be below or equal to 30:1 for the production of turf. It can be seen from Table 1 that these parameters fall within the recommended ranges.

Table 2 presents the average values of cone index at 0, 2 and 4 passes of tractor wheel

The soil EC before compaction was 15.51µs/cm but increased to 91.73µs/cm after incorporating SMS and compacting.

The EC then reduced to 16.37µs/cm at harvest. This agrees with the findings of Maher (1994). The reason for the increase in EC may be due to the large quantities of soluble salts and HCO_3 contained in the organic fertilizer (Wong et al, 1999).

The reduction in EC at harvest may be attributed to plant uptake or leaching effect of the irrigation water (Fubara-Manuel et al. 2005; Maher, 1994).

Table 2. Mean Values for Cone Index at different Passes of Tractor.

				Cone Index (MN/m^2)				
Tractor Passes	After Compaction	IMAP	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
0	0.027	0.026	0.027	0.023	0.029	0.021	0.021	0.021
2	0.042	0.043	0.042	0.042	0.044	0.043	0.042	0.040
4	0.063	0.063	0.066	0.066	0.054	0.054	0.057	0.052

*MAP means Months after Planting.

The physicochemical properties of the soil before adding SMS and compaction, after adding SMS and compaction, and at harvest are presented in Table 3.

Table 3 shows that the pH of the soil increased from 5.57 before the experiment to 5.87 after addition of SMS and compacting, and then reduced further to 5.00 at harvest.

This trend did not however alter the acidic nature of the soil. The decrease in soil pH may be due to the fact that organic carbon acts as a source of energy for soil micro-organism which, upon mineralization, releases organic acids (Adediran et al, 2005; Bokhtiar & Sakurai, 2005).

Available Phosphorus increased by 17.6% after addition of SMS and compaction. It however reduced by 27.9% at harvest when compared with the initial status of the soil. The increase is in conformity with the findings of Wisniewska and Pankiewiecz (1989), who observed that soil treatment with SMS elevates the P, K, Ca and Mg contents in the soil. However, uptake by plants has the capacity to reduce these parameters (Fubara-Manuel et al, 2012).

Table 3. Physicochemical Properties of the Soil

S/No.	Sample Parameters	Before (Addition of SMS and compaction)	After (Addition of SMS and compaction)	At Harvest
1	Soil P^H	5.57	5.87	5.00
2	Electrical Conductivity (µs/cm)	15.51	91.73	16.37
3	Moisture Content (%)	14.08	14.00	11.86
4	Organic Carbon (%)	0.57	0.73	0.44
5	Organic Matter (%)	0.98	0.92	0.76
6	Total Nitrogen (%)	0.013	0.013	0.28
7	Available Phosphorus (mg/kg)	39.77	46.78	28.66
8	Exchangeable K (cmol/kg)	0.22	0.24	0.06
9	Exchangeable Na (cmol/kg)	0.30	0.36	0.34
10	Exchangeable Ca (cmol/kg)	0.53	0.87	1.53
11	Exchangeable Mg (cmol/kg)	0.28	0.40	1.17
12	Sand (%)	80.00	82.00	80.50
13	Silt (%)	6.20	6.00	3.10
14	Clay (%)	13.93	14.20	16.37
15	Textural Class	Sandy Loam	Sandy Loam	Sandy Loam

Figure 1 presents the variation of plant height with time for control plot, 0, 2, and 4 tractor passes. The regression equation and line for each treatment are also shown.

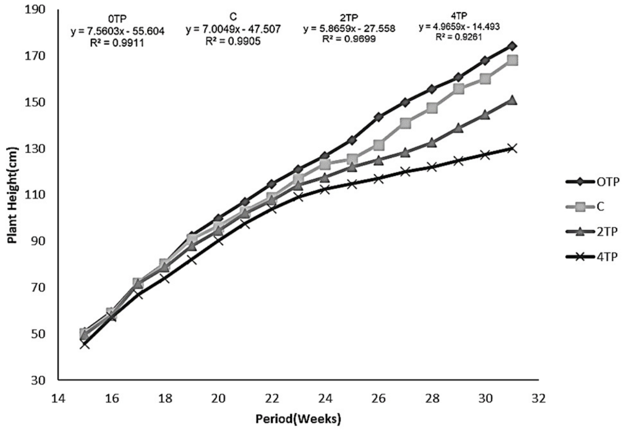

Figure 1. Plant height versus time for control plot, 0, 2 and 4 Tractor Passes.

The relationship between plant heights after seven months of planting (7MAP) shows that the correlation value at 0TP of plant height was higher than that of control plot ,while control plot was greater than 2TP. Furthermore, 2TP was higher than that of 4TP (0TP>C>2TP>4TP).This could be attributed to the effect of tractor wheel on agricultural soil, as this agrees with the findings of Stone (1988), Hettiaratchi (1990), Batey (2000), Batey and Mckenzie (2006) which state that crop growth, yield and quality may be adversely affected by soil compaction, as a result of restrictions in the root depth.

Figure 2 presents the relationship between stem girth and time for the various treatments, including the regression equations and lines.

The relationship between stem girth and time (7MAP) shows that the correlation value at 0TP of stem girth was higher than that of control plot, while control plot was greater than 2TP.However, 2TP was higher than that of 4TP, with the trend (0TP>C>2TP>4TP). This could also be attributed to the improvement of soil physicochemical properties with organic fertilizer (SMS), irrigation water and the impact of tractor wheel within the subsoil during the plant growth and development period.

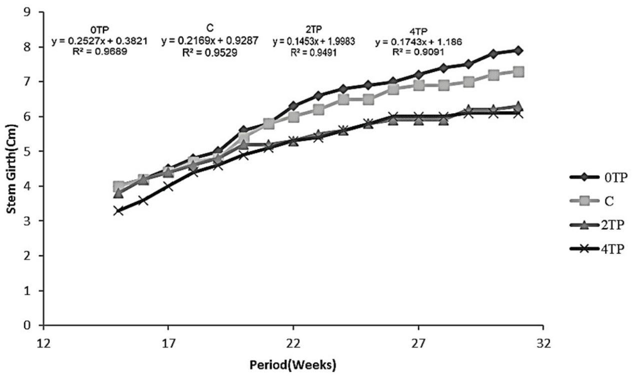

Figure 2. Stem Girth versus time for control plot, 0, 2, and 4 Tractor Passes.

Table 4 shows the emergence percentage at control plot, 0, 2 and 4 tractor passes at different intervals after planting.

Table 4. Percentage Emergence (% E) at Different Passes of Tractor Wheel

Days After Planting (DAP)	*0TC*	*C*	*2TC*	*4TC*
12	28.6	14.3	0	0
14	42.8	28.6	14.3	0
16	71.4	42.8	28.6	14.3
19	100	100	42.8	28.6
21	100	100	85.7	71.4
25	100	100	100	100

The table indicates that increase in the passes of tractor wheel on soil leads to lower emergence percentage, which conforms with the findings of Botta et al., (2006). They stated that multiple passes with a tractor (I ton maximum wheel load) had deleterious effects in direct drilled top soil, rendering it unsuitable for crop emergence. Furthermore, Håkansson (2005) states that compaction implies a decrease in total pore volume and particularly affects the larger pores and voids between aggregates, thus impairing the continuity of the macro-pore system, leading to poor aeration, infiltration and transport of water, which leads to reduced crop root growth and poorer uptake of water and nutrients.

Table 5. presents the summary of analysis of variance on plant height and stem girth between experiment plots.

Table 5 shows that there was no significant difference between the plant height, stem girth and yield at $P \leq 0.05$. However, for stem girth, there was significant difference between 0TP and 2TP, 0TP and 4TP, and C and 4TP at $P \leq 0.05$, while for yield, 0TP and 4TP, and C and 4TP were significantly different at $P \leq 0.05$. This can be attributed to the effect of tractor wheels on the soil.

Table 6 presents the mean values of cassava yield at control plot, 0, 2, and 4 tractor compactions,7MAP.

Table 6. Values of average Cassava yield at control plot, 0, 2 and 4 Passes of Tractor Wheel

Cassava Yield (Kg/ha)			
0TP	C	2TP	4TP
8,833	8,692	8,292	4,250

Table 6 indicates that increase in the number of tractor wheel passes resulted in a decrease in yield. Furthermore, the yield at C was less than that of 0TP, indicating that the addition of SMS to the soil enhanced crop growth.

Table 5. Summary of analysis of variance (ANOVA)

Parameter	**Source of Variation**	**Degree of Freedom**	**Sum of Square**	**Mean Square**	**F-Value**
Plant Height					
0TP & C	Between Groups	1	0	0	0
	Within Groups	12	9647.637	803.9698	
	Total	13	9647.637		
C & 2TP	Between Groups	1	0	0	0
	Within Groups	2	221.87	110.935	
	Total	3	221.87		
2TP & 4TP	Between Groups	1	0	0	0
	Within Groups	4	493.1483	123.2871	
	Total	5	493.1483		

Table 5. Summary of analysis of variance (ANOVA)

Parameter	**Source of Variation**	**Degree of Freedom**	**Sum of Square**	**Mean Square**	**F-Value**
Plant Height					
0TP & 2TP	Between Groups	1	0	0	0
	Within Groups	12	5996.974	499.7479	
	Total	13	5996.974		
0TP & 4TP	Between Groups	1	0	0	0
	Within Groups	13	5525.837	425.0644	
	Total	14	5525.837		
C & 4TP	Between Groups	1	0	0	0
	Within Groups	13	5525.837	425.0644	
	Total	14	5525.837		
Stem Girth					
0TP & C	Between Groups	1	0.690312	0.690312	0.544813
	Within Groups	30	38.01188	1.267063	
	Total	31	38.70219		
C & 2TP	Between Groups	1	2.88	2.88	3.790305
	Within Groups	30	22.795	0.759833	
	Total	31	25.675		
2TP & 4TP	Between Groups	1	0.125	0.125	0.229008
	Within Groups	30	16.375	0.545833	
	Total	31	16.5		
0TP & 2TP	Between Groups	1	6.390313	6.390313	6.766562
	Within Groups	30	28.33188	0.944396	
	Total	31	34.72219		
0TP & 4TP	Between Groups	1	8.302813	8.302813	7.884444
	Within Groups	30	31.59188	1.053063	
	Total	31	39.89469		
C & 4TP	Between Groups	1	4.205	4.205	4.841681
	Within Groups	30	26.055	0.8685	
	Total	31	30.26		
Yield					
0TP & C	Between Groups	1	0.005513	0.005513	0.018561
	Within Groups	6	1.781975	0.296996	
	Total	7	1.787488		
C & 2TP	Between Groups	1	0.017633	0.017633	0.057187
	Within Groups	10	3.083433	0.308343	
	Total	11	3.101067		
2TP & 4TP	Between Groups	1	1.650208	1.650208	3.880941
	Within Groups	10	4.252083	0.425208	
	Total	11	5.902292		

Yield					
0TP & 2TP	Between Groups	1	0.035208	0.035208	0.096406
	Within Groups	10	3.652083	0.365208	
	Total	11	3.687292		
0TP & 4TP	Between Groups	1	2.1675	2.1675	5.278003
	Within Groups	10	4.106667	0.410667	
	Total	11	6.274167		
C & 4TP	Between Groups	1	2.009008	2.009008	5.678346
	Within Groups	10	3.538017	0.353802	
	Total	11	5.547025		
*** Significant at 5% Level**					

4. Conclusion:

Application of SMS enhanced the growth of cassava on a tractor compacted sandy loam soil, though the passes of tractor wheel on the soil adversely affected growth parameters such as plant height, stem girth and cassava yield as well as emergence percentage. The 0TP gave the best result in all the parameters considered, followed by control plot that had no SMS and tractor compaction, and 2TP, while 4TP had the lowest.

Corresponding Author:
I. Fubara-Manuel, Ph.D.
Department of Agricultural and Environmental Engineering, Rivers State University, PMB 5080, Port Harcourt, Nigeria.
E-mail: fubara-manuel.isoteim@ust.edu.ng

References:

1. Adbul-Raziqshah, S., Muhammed, S., Abdur-Rab, N. A., Masorod, A., Facai, W., and Gohers, S. 2011. Response of germination, growth and yield of okra (Abelmoschus esculentus) to seed priming duration and p-source in Northern Pakistan. African Journal of Plant Science. 5(11),663670
2. Adediran, J. A., Taiwo, L. B., Akande, M. O., Sobulo, R. A., & Idowu, O. J. (2005). Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria. Journal of plant nutrition, 27(7), 1163-1181.
3. Ayotamuno, J. M., Zuofa, K., Ofori, S. A., & Kogbara, R. B. (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. African Journal of Biotechnology, 6(5).
4. Batey, T. (2000). Soil profile description and evaluation. Soil and environmental analysis, physical methods. 2nd edn (Eds KA Smith, CE Mullins)(Marcel Dekker: New York).
5. Batey, T., & McKenzie, D. C. (2006). Soil compaction: identification directly in the field. Soil Use and Management, 22(2), 123-131.
6. Berisso, F. E., Schjønning, P., Keller, T., Lamandé, M., Etana, A., de Jonge, L. W., ... & Forkman, J. (2012). Persistent effects of subsoil compaction on pore size distribution and gas transport in a loamy soil. Soil and Tillage Research, 122, 42-51.
7. Bokhtiar, S. M., & Sakurai, K. (2005). Integrated use of organic manure and chemical fertilizer on growth, yield, and quality of sugarcane in high Ganges river floodplain soils of Bangladesh. Communications in soil science and plant analysis, 36(13-14), 1823-1837.
8. Botta, G. F., Jorajuria, D., Rosatto, H., & Ferrero, C. (2006). Light tractor traffic frequency on soil compaction in the Rolling Pampa region of Argentina. Soil and Tillage Research, 86(1), 9-14.
9. Chong, S., Mersha, F. B., Comb, D. G., Scott, M. E., Landry, D., Vence, L. M., ... & Xu, M. Q. (1997). Single-column purification of free recombinant proteins using a self-cleavable affinity tag derived from a protein splicing element. Gene, 192(2), 271-281.
10. CIAT (Centro International De Agriculture Tropical), 1983.Morphology of the cassava plant. Study guide series 04EC 02.03. Cali, Colombia 44
11. Domínguez O, C. E., Fuentes de Piedrahíta, C. L., Ceballos, L. F., & Fernández, F. O. (1983). Morphology of the cassava Plant.
12. FAO (Food and Agriculture Organization) **(**2013**)**. A guide to sustainable production intensification, United Nations, Rome. Retrieved from www.fao.org .
13. Fubara-Manuel, I. (2005). Scheduling irrigation in an area transiting from rain-fed to irrigated agriculture using water balance approach. Proceedings of the 6th International global change. Global Change Journal, 12, 303-322.Saikia, M. K. (1978) Assam-Muslim Relation and its Cultural Significance. Golaghat: Luit printers. Printed.

14. Fubara-Manuel, I., Nwonuala, A., & Davis, D. D. (2012). Growth response of fluted pumpkin (Telfairia occidentalis Hook. F) to combinations of irrigation intervals and spent mushroom substrate in the Niger Delta region of Nigeria. African Journal of Biotechnology, 11(14), 3346-3351.
15. Håkansson, I. (2005). Machinery-induced compaction of arable soils.
16. Hettiaratchi, D. R. P. (1990). Soil compaction and plant root growth. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 329(1255), 343-355.
17. Hossner, L. R. (1996). Dissolution for total elemental analysis. *Methods of Soil Analysis: Part 3 Chemical Methods*, *5*, 49-64.
18. Igon, A. H., & Ayotamuno, J. M. (2016). Maize yield response to induced compaction in a sandy-loam soil. *Sustainable Agriculture Research*, *5*(526-2016-37881).
19. Igoni, A. H., & Fubara-Manuel, I. (2016). Size dependence of energy required for cassava grating. Energy and Environment Research, 6(2), 1-9.
20. Jackson, M. L. (1969). Soil Chemical Analysis-Advanced Course. Soil Chemical Analysis-Advanced Course., (Edition 2).
21. Landschoot, P., & McNitt, A. (1995). Using spent mushroom substrate (mushroom soil) as a soil amendment to improve turf. Staff paper, Pennsylvania State University USA.
22. Lund, Z. F., & Doss, B. D. (1980). Residual Effects of Dairy Cattle Manure on Plant Growth and Soil Properties 1. Agronomy Journal, 72(1), 123-130.
23. Mahendra S. B., Kenneth S. D., Venkateswura R, Vincent EP (1988). Application of poultry manure influences on Thampson Seedless Grape production and Soil properties.
24. Maher, M. J. (1994). The use of spent mushroom substrate (SMS) as an organic manure and plant substrate component. Compost Science & Utilization, 2(3), 37-44.
25. Odu, C. T. I., Esurosu, O. F., Nwaboshi, I. C., & Ogunwale, J. A. (1985). Environmental study (Soil and Vegetation) of Nigeria Agip Oil Company Operation Area. A report submitted to Nigeria agip oil company limited, Lagos, Nigeria, 102-107.
26. Olsen, S. R., Sommers, L. E., & Page, A. L. (1982). Methods of soil analysis. Part, 2(1982), 403-430.
27. Page, A. L., Miller, R. H., & Keeney, D. R. (1982). Methods of soil analysis. Part 2. American Society of Agronomy. Soil Science Society of America, Madison, WI, USA.
28. Ramazan, M., Khan, G. D., Hanif, M., & Ali, S. (2012). Impact of soil compaction on root length and yield of corn (Zea mays) under irrigated condition. Middle East Journal of scientific research, 11(3), 382-385.
29. Save, F. A. O. (2013). grow: Cassava. A guide to sustainable production intensification. Rome: Food and Agriculture Organization of the United Nation.
30. Servadio, A., D. Ario, L., Galeoto, G., Sanso, M. L., and Souchard, E. (2005). Conservative treatment of idiopathic scoliosis through the global postural re-education. J Clin Case Rep 5: 630.
31. Shah, A. R., Sajid, M., Ara, N., Ahmad, M., & Shafi, G. (2011). Response of germination, growth and yield of okra (Abelmoschus esculentus) to seed priming duration and p-sources in Northwest Pakistan. African Journal of Plant Science, 5(11), 663-670.
32. Stone, D. A. (1988). Subsoil strength and yield of vegetable crops. Soil use and management, 4(1), 10-14.
33. Wismewska, G. and Pankiewicz, T. (1989). Evaluation of the suitability of spent mushroom substrate. Prace inst.sad.kwi.14:7-13.
34. Wong, J. W. C., Ma, K. K., Fang, K. M., & Cheung, C. (1999). Utilization of a manure compost for organic farming in Hong Kong. Bioresource Technology, 67(1), 43-46.

Received December 28, 2020; reviewed January 16, 2020; accepted January 26, 2021; published online February 01, 2021