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# Changes in soil physical properties and Trifoliate yam (*Dioscorea dumetorum*) performance under different tillage methods in Southwestern Nigeria.

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**Abstract**— Research was conducted to evaluate the changes in soil physical properties and trifoliate yam (*Dioscorea dumetorum*) performance under different tillage methods in two locations of south western Nigeria. The study was carried out in 2013 cropping season at the Teaching and Research Farms of Ekiti State University (EKSU), Ado-Ekiti and the Federal University of technology, Akure (FUTA). The experiment was laid out in a randomized complete block design with three replications. The treatments were Ridge tillage (Rt), Mound tillage (Mt), Bed tillage (Bt) and Zero tillage (Zt). Data collected on soil physical properties and trifoliate growth and yield performance were subjected to analysis of variance (ANOVA) with the means separated using Duncan Multiple Range Test (DMRT). Results of this study indicated that Mt reduced soil bulk density which led to enhanced growth and tuber yield of trifoliate yam. Zt had high soil bulk density which could be substituted for the significant loss in yield of trifoliate yam. Relative to the Zt, Mt increased the tuber weight by 19% in Ado and 10% in Akure respectively. Compared with Rt and Bt in Ado, Mt improved tuber yield of trifoliate yam by 10% and 21%. The use of Mound tillage is therefore recommended because it was more effective in reducing soil bulk density and increasing nutrient use efficiency of crops and consequently enhancing better growth and yield of trifoliate yam.

Keywords: Physical properties, tillage, trifoliate yam, tuber yield

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## 1. INTRODUCTION

Trifoliate yam (*Dioscorea dumetorum*) is an under-utilized tropical tuber crop known for its great storage of starch which makes it the most nutritious out of all the yam species (Owuamanam et al., 2013; Agbor-Egbe and Teche, 1995). Though Nigeria is regarded as the largest producer of yams in the world, followed by Ghana, Cote D'Ivoire, Benin, Togo, and Cameroon (FAO, 2013), the cultivation of trifoliate yam has received little research attention in spite of its enormous potentials which may leads to its extinction in no distant future (Verter and Bečvařova, 2014). There has been a decline in the production of trifoliate yam over the years in Africa (Iwuchukwu and Onwubuya, 2012) due to some soil factors like decreasing soil fertility, soil degradation, as well as inappropriate tillage methods associated with its cultivation especially in Nigeria (Oladeji et al., 2016; IITA 2013; Lal, 1987).

Tillage is defined as the preparation of soil so as to improve its physical chemical or biological properties and consequently enhance the seedling establishment and performance of crops (FAO 1990). Soil tillage can carried out manually or mechanised and it is an important factor to be considered as it determines the loosening or compacting of soil structure, bulk density, pore size distribution and soil air which eventually affect plant growth (Lal, 1993). Therefore, Tillage is of great importance in determining the physical properties of some soils for better crop growth and yield (Ahmed 2000). Inappropriate use of tillage by farmers is a major factor affecting crop production in southwestern region of Nigeria (Aina, 1976; Ogbodo 2005) as farmers perform tillage operations without the knowledge of their effects on the soil and the crop (Ozpinar and Isik, 2004). Use of excessive and unnecessary tillage operations has led to low productivity of soil which may be associated with unfavourable physical conditions such as bulk density, infiltration rate, soil resistance to penetration, and water percolation and distribution. Different soil conditions created by different tillage methods may affect crop performances especially tuber crops like trifoliate yam. But there is scarcity of information on the effect of tillage methods on the performance of trifoliate yam in the forest zone of south west Nigeria. This study is therefore necessary, as previous studies on trifoliate yam in Nigeria especially in the eastern part, are concentrated on

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traditional food processing of trifoliate yam and not really on the production (Ukpabi, 2015) and few studies on tillage mainly compared the effect of mechanized tillage practices on yam yields. It is on this premise that the present study focus on evaluating the changes in soil physical properties and the performances of trifoliate yam under different tillage methods in Southwestern Zone of Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Site description

This trial took place at the Teaching and Research Farms of the Ekiti State University (Lat. 5° 13′ E, Long. 7° 37′ N) and Federal Universtiy of Technology, Akure (Lat. 5° 18′ E, Long. 7° 17′ N), Nigeria. The site is a well-drained deep red Alfisol in the tropical zone. There are two rainy seasons, one from March to July and the other from mid-August to November, with temperature ranging from 24 to 32°C and annual rainfall in Akure is about 1500mm. The study site had been under continuous cultivation of a variety of arable crops, among which was cassava, maize, melon, cocoyam, sweet potato, prior to the commencement of this study.

### 2.2 Field layout and treatments

Treatments were Ridge tillage (Rt), Mound tillage (Mt), Bed tillage (Bt) and Zero tillage (Zt). The treatments were laid out in a randomized complete block design and replicated three times. Each plot size planted with white variety of trifoliate yam at a spacing of 1m x 1m. Manually made Mounds and Ridges of about 0.75 m high and 0.75 m wide at the base were used. Bed tillage of about 0.75 m high was manually ploughed and harrowed while Zero tillage plot was left untilled using contact herbicide (Clearweed @ 3 litres/ha) to get rid of the weeds. The size of each of the 12 plots was 2 x 2 m, giving a plant population of 4 plants per plot. Blocks were 1 m apart and the plots were 0.5m apart.

### 2.3 Treatments application and crop husbandry

One seed yam weighing 0.4 kg of white trifoliate yam (*Dioscorea dumentorum*) obtained from the Agricultulral Development Programme (ADP) in Ekiti State was planted per hole. Stakes were installed after sprouting. Weeding was done manually with a hoe once at 4, 6, 11, 17 and 20 weeks after planting at each experimental plot.

### 2.4 Soil sampling and analysis

Before the start of the experiment (after land clearing), soil samples, randomly collected from 0-30 cm depth were thoroughly mixed inside a plastic bucket to form a composite which was later analysed for physical and chemical properties. The soil samples were bulked, air-dried and sieved using a 2-mm sieve for routine chemical analysis, as described by Carter (1993). Particle-size analysis was carried out for textural class using the hydrometer method (Sheldrick and Hand Wang 1993). Soil pH was determined in a soil/water (1: 2) suspension using a digital electronic pH meter. Soil organic carbon was determined by the Walkley and Black procedure by wet oxidation using chromic acid digestion (Nelson and Sommers 1996). Total N was determined using micro-Kjeldahl digestion and distillation techniques, available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry. Exchangeable K, Ca and Mg were extracted with a 1 M $NH_4OAc$, pH 7 solution. Thereafter, K was analysed with a flame photometer and Ca and Mg were determined with an atomic absorption spectrophotometer (Okalebo et al. 2002).

### 2.5 Data collection

Soil samples were collected randomly at 0–15 cm depth at three sites per plot for physical analyses. Soil bulk density (BD), and soil moisture content was also determined at crop harvest. The soil bulk density on dry basis was determined for each treatment. For this test 3 undisturbed samples were taken from the plots by core sampler and dried 24 h at 105°C in an oven. soil porosity was calculated using the formula: Soil total porosity = [(1− BD)/ soil particle density] where soil particle density is assumed to be 2.65 g $cm^{-3}$. Soil temperature was determined with a soil thermometer inserted to 5 cm depth at 15.00 h. Three plants were randomly selected per plot for determination of number of leaves and vine length at 5 months after planting when the yam plant formed a full canopy. Number of leaves was determined by counting the number of leaves on each yam plant, Vine length was determined by meter rule and leaf area was determined graphically. Tuber yield was determined at harvest (8 months after planting) by recording the weight of fresh tuber from two plants selected randomly from each plot using a top loading balance to determine their weights and tuber length was determined by meter rule.

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**2.7 Data analysis**

Data collected on soil physiical properties, growth and yield of trifoliate yam were subjected to analysis of variance (ANOVA) using SPSS 15.0 software package, and means separated using Duncan Multiple Range Test (DMRT).

## 3. RESULTS

The data presented in Table 1 is the result of the physico-chemical analyses of the experimental sites before the start of the experiment and the amendments used. The pre crop physical analysis of the site carried out showed the textural classes to be sandy clay loam in Ado and was sandy loam in Akure. The bulk density was 1.32 g/cm$^3$ in Ado and 1.28 g/cm$^3$ in Akure respectively. The initial soil analyses showed slightly acidic and low N and K values in both locations.

Table 1: Pre-cropping Soil Physicohemical Properties and nutrient composition of amendments used

| Property/Nutrient | Physico-chemical values in Ado | Physicochemical values in Akure |
|---|---|---|
| Sand (%) | 63.50 | 62.50 |
| Silt (%) | 12.00 | 19.00 |
| Clay (%) | 24.50 | 18.50 |
| Textural class | Sandy clay loam | Sandy loam |
| Bulk density (g cm$^{-3}$) | 1.32 | 1.28 |
| Total porosity (%) | 48.85 | 52.38 |
| pH ($H_2O$) | 5.97 | 4.85 |
| Carbon (OC) | 3.45(%) | 1.70(%) |
| Nitrogen (N) | 0.49(%) | 0.13(%) |
| Phosphorus (P) | 9.32 (mg kg$^{-1}$) | 3.92 (mg kg$^{-1}$) |
| Potassium (K) | 0.13 (cmol kg$^{-1}$) | 0.10 (cmol kg$^{-1}$) |
| Calcium (Ca) | 2.93 (cmol kg$^{-1}$) | 2.29 (cmol kg$^{-1}$) |
| Magnesium (Mg) | 1.93 (cmol kg$^{-1}$) | 0.97 (cmol kg$^{-1}$) |
| Sodium (Na) | 0.13 (cmol kg$^{-1}$) | 0.14 (cmol kg$^{-1}$) |

The results of the study in table 2 showed significant ($p \leq 0.05$) effects of tillage on the physical properties (moisture content, bulk density, porosity and temperature). Moisture content (MC) and Porosity (PR) were significantly ($p \leq 0.05$) higher in Mt than Zt. Conversely, bulk density (BD) was significantly reduced ($p \leq 0.05$) in Mt than Zt. However, tillage effect was not significant on temperature.

Table 2: Effect of tillage methods on soil physical properties in southwestern Nigeria.

| Tillage | Moisture content (%) | | Bulk Density (gcm$^{-3}$) | | Porosity (%) | | Temperature ($^{o}$c) | |
|---|---|---|---|---|---|---|---|---|
| | Ado | Akure | Ado | Akure | Ado | Akure | Ado | Akure |
| Rt | 23.39a | 23.32ab | 1.37bc | 1.26bc | 47.61ab | 52.51ab | 28.17a | 28.18a |
| Mt | 25.09a | 25.18a | 1.35c | 1.24c | 48.42a | 53.39a | 28.38a | 28.15a |
| Bt | 23.18a | 22.51ab | 1.40ab | 1.27b | 47.06b | 51.87bc | 28.11a | 28.18a |
| Zt | 21.91a | 21.51b | 1.42a | 1.30a | 45.83c | 50.97c | 28.00a | 28.18a |

Values followed by similar letters under the same column are not significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT). Rt= Ridge tillage; Mt = Mound tillage; Bt = Bed tillage; Zt = Zero tillage

The effect of tillage methods on the growth performance of trifoliate yam is shown in Table 3. All Tillage methods (Rt, Mt and Bt) significantly ($p \leq 0.05$) increased the values of growth parameters when compared with Zero Tillage (Zt). However, Zt gave lower values of number of leaves and vine length than Mt in both locations. Leaf area values significantly attained the highest in Mt (2.76cm$^2$ and 2.64cm$^2$) among all the other tillage treatments.

Table 3: Effect of tillage methods on the growth performance of trifoliate yam

| Tillage | Number of Leaves | Vine length (m) | Leaf area (cm$^2$) |
|---|---|---|---|

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| | Ado | Akure | Ado | Akure | Ado | Akure |
|---|---|---|---|---|---|---|
| Rt | 736.42a | 784.17a | 3.28ab | 2.87ab | 2.68b | 2.55b |
| Mt | 788.92a | 814.92a | 3.34a | 2.92a | 2.76a | 2.64a |
| Bt | 731.50a | 772.17a | 3.19b | 2.76b | 2.58bc | 2.50c |
| Zt | 684.58b | 578.58b | 2.98c | 2.57c | 2.49c | 2.45d |

Values followed by similar letters under the same column are not significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT). Rt= Ridge tillage; Mt = Mound tillage; Bt = Bed tillage; Zt = Zero tillage

Table 4: Effect of tillage methods on the yield performance of trifoliate yam.

| **Tillage** | **Tuber weight (t/ha)** | | **Tuber length (cm)** | | **Tuber Girth (cm)** | |
|---|---|---|---|---|---|---|
| | **Ado** | **Akure** | **Ado** | **Akure** | **Ado** | **Akure** |
| Rt | 8.08b | 7.44a | 16.14a | 13.75b | 16.29b | 14.87b |
| Mt | 8.87a | 7.41a | 16.99a | 14.24a | 18.58a | 16.82a |
| Bt | 7.35b | 7.19a | 15.23b | 12.57b | 16.35b | 14.12bc |
| Zt | 7.49b | 6.75b | 15.37b | 11.58c | 14.63c | 12.91c |

Values followed by similar letters under the same column are not significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT). Rt= Ridge tillage; Mt = Mound tillage; Bt = Bed tillage; Zt = Zero tillage

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The effect of tillage methods on the yield of trifoliate yam is shown in Table 4. Tillage methods significantly ($p \leq 0.05$) had increased yield parameters values than when compared with Zero tillage (Zt). Mt had higher values of tuber weight, tuber length and tuber girth than Zt. However, tuber weight and girth were significantly higher in Mt than other tillage methods (Rt and Bt) in Ado. Relative to the Zt, Mt increased the tuber weight by 19% in Ado and 10% in Akure respectively. Compared with Rt and Bt in Ado, Mt improved tuber yield of trifoliate yam by 10% and 21%.

## 4. DISCUSSION

The significant higher soil moisture content in Mt might partly be due to the increase in water holding capacity of the soil particles while the lower soil moisture content of Zt might partly be attributed to the enhanced vapour movement thereby resulting in moisture evaporation. These results are also in agreement with those of Gordon *et al.* (1993) and Kashif *et al.* (2006), who concluded that ridge and mound soils contained a greater amount of water in the soil profile than minimally tilled soils. Zt gave relatively high soil bulk density when compared with Mt and Rt plots could be attributed to non-tillage and compaction. This observation implies that continuous exposure of untilled soil to rainfall without tillage will increase the bulk density of the soil. These results are in conformity with the works of Agbede and Ojeniyi (2003) and Agbede and Adekiya (2011) who earlier reported higher bulk density for zero tillage compared with tilled soils in southwest Nigeria. Findings from this study indicate tillage did not significantly ($p \leq 0.05$) influenced temperature. This observation implies that continuous exposure of soil particles to the atmosphere do not affect temperature. Similar studies confirmed that tillage and amendments did cause significant difference in absolute soil temperature (Ojeniyi, 1990; Adekiya and Ojeniyi, 2002). Findings from the study showed that Zt gave the lowest growth and yield parameters of trifoliate yam, when compared with yam grown on tilled soils most especially Mt. This could also be caused by higher bulk density, which adversely affected nutrient uptake and easy penetration. The results are in agreement with Agbede and Adekiya (2013), who found that the low values of growth performance of yam from untilled soils compared with values from tilled soils could be attributed to mechanical impedance to root and tuber growth, and lack of effective soil depth for tuber formation as a result of its high bulk density. Increase in soil bulk density is also known to reduce root elongation at low water contents (Adekiya and Ojeniyi 2009). Values of yield attributes were higher in Mt than in Zt. The observed significant variations in all yield indices of trifoliate yam was similar to the finding of Mohammadi and Shamabadi (2012) who showed that tillage practices had significant influence on yield forming processes like number of tubers per plant, tuber length and tuber weight which attained the maximum values in tilled soils. Ogbodo (2005) also reported that dry matter yield of potato was significantly higher on the tilled plots by 27 - 39% when compared with the untilled plots.

## 5. CONCLUSION

Results from the study have indicated that tillage was crucial for trifoliate yam cultivation. Among all the measured soil physical properties like moisture content, bulk density and porosity when compared, soil bulk density dictated the growth and tuber yield of trifoliate yam. Mound tillage reduced soil bulk density and which to enhanced nutrient uptake, growth and tuber yield of trifoliate yam. Zero tillage had high soil bulk density and could not be substituted for tilled soils due to significant loss in yield of trifoliate yam.

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## References

[1] Adekiya, A. O. and S. O. Ojeniyi. "Evaluation of tomato growth and soil properties under method of seedling bed preparation in an Alfisol in the rainforest zone of southwest Nigeria". *Soil Tillage Research*. (2002). 64:275-279.

[2] Agbor-egbe, T. and Treche, S.. "Evaluation of the chemical composition of Camerounian yam germplasm". *Journal of Food Composition and Analysis*, (1995) **8**:274-283.

[3] Agbede T. M. and A. O. Adekiya. "Evaluation of sweet potato performance and soil properties under tillage methods and poultry manure levels". *Emirate Journal of Food Agriculture*. 2011. 23 (2): 167-177..

[4] Agbede T. M. and Adekiya A. O.. "Soil properties and yam yield under different tillage systems in a tropical alfisol". *Archives of agronomy and Soil Science* 2013. 59 (4): 505-519**.**

[5] Agbede, T. M. and S. O. Ojeniyi. "Effect of land preparation methods on soil properties and yield of yam grown on Alfisols". *Nigeria Journal of Soil Science* (2003)13:68-75.

[6] Agbede, T. M. and Ojeniyi, S. O.. "Tillage and Poultry Manure Effects on Soil Fertility and Sorghum Yield in Southwestern Nigeria". *Soil Tillage Research*; (2009) 104:74-81.

[7] Ahmed, B. M. "Performance of chisel and disc implements and their effects on sorghum and maize in Gezira vertisols". M.Sc. (Agric.) thesis. University of Khartoum, Khartoum, Sudan; 2000.

[8] Aina P. O.. "Soil changes resulting from Long-Term Management Practices in Western Nigeria". *Soil Science Society of American* Journal (1976)44:827-837

[9] Carter MR. "Soil sampling and methods of analysis". *Canadian Society of Soil Science*. Boca Raton (FL): Lewis. 1993. 823 pp.

[10] FAO. Agricultural engineering in development: tillage for crop production in area of low rainfall. Food and Agriculture Organization, United Nations, Rome, Italy; 1990.

[11] Gordon, W. B., D. H. Rickerl, D. R. Sorensen and P. K. Wieland. "Tillage and nitrogen effects on growth, nitrogen content, and yield of corn". *Communications in Soil Science and Plant Analysis*, (1993) 5-6: 421.

[12] International Institute for Tropical Agriculture (IITA) Yams (*Dioscorea* spp). 2013; Retrieved Nov. 28, 2013.

[13] Iwuchukwu JC, Onwubuya EA. "Trends in production of selected species of yam (*Diosorea* spp) In Enugu North Agricultural Zone, Enugu State Nigeria":

ISSN 2229-5518

Implication for Food Security and Bio Diversity Conservation. *International Journal of Agricultural Science and Research*. 2012;2(3):97-115.

[14] Kashif, K., Muhammad I., Muhammad S. A. and Allah N.. Effect of tillage and mulch on soil properties and growth of maize. *International Journal of Agric and Biology* (2006) 8: 5. 593-596.

[15] Lal, R. "Managing the soils of Sub-Saharan Africa". *Science* 1987. 236:1069-1076.

[16] Lal R.. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. *Soil and Tillage Res*. 1993, 51: 61-70.

[17] Mohammadi A. and Shamabadi Z . "Evaluation the effect of conservation tillage on potato yield and energy Efficiency". *Inter. Journal Agr. Crop Sci*, (2012) 4(23):1778-1785.

[18] Nelson D. W, Sommers L. E. "Total carbon, organic carbon and organic matter". In: Sparks DL, editor. Methods of soil analysis. Part 3. 2nd ed. SSSA Book Series No. 5. Madison (WI): ASA and SSSA 1996. p. 961–1010.

[19] Ogbodo E. N. "Effect of depth of tillage on soil physical conditions, growth and yield of sweet potato in an ultisol at Abakaliki, southeastern Nigeria". JASR, (2005). 5(1): 41-47

[20] Okalebo JR, Gathua KW, Woomer PL. "Laboratory methods of soil and plant analysis. A working manual". 2nd ed. Nairobi (Kenya): TSBF-CIAT, SACRED Africa, KARI, SSEA 2002. 128 pp.

[21] Oladeji, A.E., Bussie, M.-D., Roman, F.-M., Ibironke, P., Robert, A., Therese, G., "Characterization and classification of the provitamin a carotenoids of deep yellowfleshed bitter yam (Dioscorea dumetorum) varieties". *J. Food Nutr. Res.* (2016) 4, 640–645.

[22] Ojeniyi, S. O.. "Effect of bush clearing and tillage methods on soil physical and chemical properties of humid tropical Alfisol". *Soil Tillage Res*. (1990) 15:269-277.

[23] Onweremadu EU, Ibeawuchi II, Duruigbo CI. "Land evaluation and productivity of organically-fertilized crop mixtures in a degraded tropical soil". *Nat Sci.* 2008. 6(1):34–42.

[24] Ozpinar, S. and Isik, A. "Effects of tillage, ridging and row spacing on seedling emergence and yield of cotton". *Soil and Tillage Research*. (2004). 75 (1): 19–26.

[25] Owuamanam CI, Iwuoha CI, Onuegbu NC, Ogueke CC, Nwosu JN. "Quality characteristics of processed flours from trifoliate yam (*Dioscorea dumetorum*) as influenced by steeping and boiling in varying concentration of trona solution over time". Am. J. Food Technol. 2013;8:162- 172.

[24] Sheldrick B, Hand Wang C. "Particle-size distribution. In: Carter MR, editor. Soil sampling and methods of analysis". Ann Arbor (MI): *Canadian Society of Soil Science*/Lewis 1993. 499–511.

[25] Ukpabi Joseph Ukpabi "Traditional Food Processing Techniques of *Dioscorea dumetorum* in Nigeria". *American Journal of Food Science and Nutrition*. (2015).Vol. 2, No. 3, pp. 21-30.

[26] Verter, N. and Bečvařova, V.. "Yam production as pillar of food security in Logo Local Government Area of Benue State, Nigeria". *European Scientifi c Journal*, 2014:10(31): 27–42.

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