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EVALUATION OF TILLAGE METHODS AND POTASSIUM EFFECT ON SOIL PROPERTIES AND GROWTH OF LESSER YAM

Essien, O. A.; Udoh, O. E.; Umoh, F. O. & Ntuen, E. S.
Department of Soil Science
Akwa Ibom State University, Mkpat Enin, Nigeria.
Email: otobongessien19@yahoo.com

ABSTRACT

The study was conducted to assess tillage methods and potassium effect on soil properties and yam yield on soils of southeastern Nigeria. A field experiment was set out at the Teaching and Research Farm of Akwa Ibom State University, Obio Akpa in 2019. A 2×4 factorial experiment was laid out in a randomized complete block design (RCBD). Tillage methods used were flat and mound, which constituted the main plots while the four (4) rate of muriate potash (0 kg ha^{-1}, 200 kg ha^{-1}, 400 kg ha^{-1}, and 600 kg ha^{-1}) occupied the sub plots. Tillage was done in the early planting season and yam tubers weighed 300g were planted. The initial and post-harvest soil samples were collected, processed and analyzed for soil physical and chemical properties. The result revealed that tillage methods improved soil properties significantly ($p < 0.05$). Flat tillage improved soil organic matter content by 4.37% and base saturation percentage by 89.49% over other systems. The interaction between tillage methods and potassium rate application showed that flat tillage with application of 200 kg ha^{-1} gave the highest mean of soil organic matter content by 46.49% above other rates of combination with tillage systems. While mound tillage with potassium application rate of 400 kg ha^{-1} improved tube weight by 1.83kg above other rates of potassium application. Therefore, mound tillage of 400 kg ha^{-1} of potassium is recommended for cultivation of lesser yam in the study area.

Keywords: Tillage methods, Mound and Flat Tillage, Potassium Application Rate, Soil Properties and Yam Yield .

INTRODUCTION

Mechanical manipulation of soil by practice that modify the state of the soil to create favorable conditions for crop growth is essential for sustainable food supply. According to Udo et al. (2017) and Ndaeyo et al. (2003), tillage is crucial for optimizing productivity by alleviating physical, chemical and biological constraints of soil, also it reduces soil compaction and control weeds and provides suitable tilts for improved seed germination, development and ultimately increased yield (Agboola, 2005). The utility of manual tillage systems for soil and water conservation is generally recognized worldwide (FAO, 2011), and the impact of tillage on crop production for plant emergence, development and unimpeded root growth (Licht Al-Kaisi, 2005). Tillage method affects necessary plant growth conditions in soil through it influence on soil physical properties (Licht and Al-Kaisi, 2005), proper tillage practices overcome edaphic constraints, whereas inappropriate tillage may cause undesirable outcomes for example soil structure destruction, accelerated erosion, loss of organic matter and fertility and disruption in cycle of water and plant nutrients (Lal, 1997). Umoh et al. (2020) explained that the aftermath of inappropriate tillage lead to accelerated erosion which will result in a degraded soil and consequent crop yield reduction.

Potassium is one of the most essential nutrients required for plant development. It plays a major role in energy transfer, stimulation of early growth and development, fruiting and seed formation (Osodeke 2005; Agbede, 2009). Phosphorus has been identified as one of the most limiting nutrient elements in crop production in tropical soils (Osodeke, 2000). Umoh et al. (2017) ascertain that Potassium exists in soil in different forms as structural (Mineral), nonexchangeable (fixed or difficulty available), exchangeable and water soluble forms (Dhahiwal et al., 2006), and that potassium forms are in dynamic equilibrium. Ano (2003) and Bangroo et al. (2012) view that potassium fixation and release in soil, depend on factors such as soil types, amount of potassium added in the soil, contact time, soil reaction and prevailing mechanisms of potassium reaction. Potassium plays vital role in several physiological processes such as photosynthesis, translation of photosynthesis, control of ionic balance, regulation of plant stomata, transpiration, activation of plant enzymes (Thompson, 2010). Potassium also enhances foliage growth (Marschner, 1995). In plant cells potassium maintains osmotic potential which enhances water uptake and root permeability, it also act as a guard cell and increases water use efficiency (Mehdi etal., 2007).

Lesser yam (Dioscorea esculenta) is a carbohydrate staple food. Yam are monocots which simple net-veined, leaves devoid of hair, and more or less heartshaped. Leaf arrangement on the stem is either opposite or alternate. Yams are dioeciovs producing male and female flowers on different plants and freshly harvested yam tuber contains 70% of water, 28% of carbohydrate, 1-2% of protein, and also contain small amounts of fat and sugar, as well as most of the essential minerals and vitamins (Udo and Ndon, 2016). Appropriate tillage system with combination of potassium fertilizer is expected to improve soil productivity and promote faster growth of lesser yam in a shortest period.

MATERALS AND METHODS

Description of the Study Area

The research was conducted under rain fed condition from may to October, 2019 at Teaching and Research Farm, Akwa Ibom State University, which lies between latitude 4° 30′ and 5° 30′ N and longitude 7° 30′ and 8° 30′ E. The area is in rainforest Zone, characterized by heavy rainfall ranging from 2500mm in land to over 3000mm along the coast. Temperature ranging between 26° c - 30° c with relative humidity of 75-80% within a year. The soil of the area are derived from highly weathered parent materials which are dominated by low activity of clay such as kaolinite and Amorphous of Al and Fe (Edem, 2007). The soil was sandy loam, characterized by low organic matter, low CEC and are highly leached.

Treatment and Experiment Design

The experiment field which has previously been fallowed was cleared and mapped out using a 2 × 4 factorial in RCBD, and was replicated 3 times. Two tillage types i.e. A_1 – Flat tillage (FT) and A_2 – Mound tillage (MT) were in the main plot. Four (4) fertilizer rates of application i.e B_1 – 0kg/ha (control), B_2 – 200kg/ha, B_3 – 400kg/ha, B_4 – 600kg/ha occupied the sub plot. Each block replicated had 32 plants at a spacing of 1m apart with 1m alleys between replications. Each plot measured 32m × 3m which gave a total area of 96m^2/plot. Average seed yam size weight 600g.

Soil Sampling and Handling

Soil samples were collected from 0-15cm depth at Pre-planting and Post-planting. The samples were air-dried and sieved through 2mm mesh and stored in a labeled cotton bag for laboratory analysis.

Laboratory Analyses

Particle size distribution was determined by the Bouyoucos Hydrometer Method as described by (Udo et al., 2009). Soil pH was determined using a glass electrode pH meter (JENWAY 3520 MODEL) in a ratio of 1:2.5 both I water and in 1.0m KCL. Total nitrogen was determined by Micro-Kjeldahl method (Udo et al., 2009). Organic carbon was determined by the wet oxidation method and Organic matter was determined by multiplying % OC by the Convention Van Bemmeller factor of 1.724. available phosphorus was determined by Colorimetric method after Bray-1 extraction (Udo et al., 2009). Exchangeable bases (K, Ca, Mg and Na) were extracted with IN ammonium acetate (IN NH_4 OA_c) solution, buffered at pH 7.0. The concentration of Ca and Mg were determined with Atomic Absorption Spectrophotometer and K and Na by the use of flame photometer. (Udo et al., 2009).

Plant Data Collection

Plant data collected was determines by measuring the length of the tuber using measuring tape and the weight of the tuber was gotten by measuring the weight of the Yam using measuring scale in gkg^{-1}. Tuber girth was determined by using strings tied around the Yam tuber and then read the length of the strings tied around the yam tuber and then read the length of the strings from the measuring tape in cm.

Statistical Analysis

Data obtained from the experiment were subjected to analysis of variance (ANOVA) and least significant difference (LSD) at 5% level of probability was used to compare Treatment means (Wahua, 1999).

RESULTS AND DISCUSSION

Soil physical and chemical properties of the study area before treatment.
The result of Soil properties in Table 1 Shows that Sands, Silt and Clay fraction recorded average total of 741 gkg^{-1}, 152 gkg^{-1} and 107 gkg^{-1}, respectively. The pH of the soil had a mean value of 6.09, total nitrogen had 0.07%, organic matter, available phosphorus, electrical conductivity, exchangeable Mg, Na and K were 2.92%, 6.80 Mg kg^{-1}, 0.22 dsm^{-1}, 3.00 cmol kg^{-1}, respectively. The total nitrogen, organic matter, cation exchange capacity, fall within the critical value of 2 cmol kg^{-1}, proposed by Aduayi et al. (2002), for the soils of South Eastern Nigeria.

Table 1: Mean Soil Physical and Chemical Properties before treatment application

Soil Properties	Value
Sand (gkg^{-1})	741
Silt (gkg^{-1})	152
Clay (gkg^{-1})	107
Textural class	Sandy Loam
pH (H_2O)	6.09
EC (ds/m)	0.22
Organic matter (%)	2.92
Total Nitrogen (%)	0.07
Available Phosphorus (Mg Kg^{-1})	6.80
Mg (cmol kg^{-1})	3.00
Na (cmol kg^{-1})	0.07
K (cmol kg^{-1})	0.28
Exchangeable acidity (cmol kg^{-1})	1.20

The result reveals that tillage methods on selected soil chemical properties at yam harvest (6 months after planting) shown in Table 2, improve soil organic matter content generally. The highest organic matter content was obtained in flat tillage (4.37%), followed by mound tillage with a mean of 4.04%. Base saturation was significantly affected by tillage method, with highest value of 89.49% recorded on flat tillage while mound tillage recorded 89.13%. The result indicated that bonding and adhension properties of organic matter that retarded the rate at which water flowed through the soil were not disturbed in line with (Bot and

Benites, 2005), which means that absence of tillage protects structural integrity of the soil, unlike those that were tilled. However, tillage method had no significant effect on soil pH, exchangeable acidity, exchangeable sodium, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium and exchangeable magnesium.

Table 2: Effect of tillage methods on Soil chemical properties of yam harvest (Six months after planting)

Tillage method	pH	Organic Matter (%)	Total N (%)	Av.P	Ca	Mg	Na	K	EA	ECEC	Base saturation(%)
				mg kg^{-1}	←		→ cmol kg^{-1}				
Flat tillage	5.58	4.37	0.17	65.06	13.11	5.62	0.08	0.18	2.6	21.50	89.49
Mound tillage	5.43	4.04	0.10	61.55	12.08	4.95	0.08	0.18	2.15	19.51	89.13
LSD (<0.05)	NS	1.47	NS	NS	NS	NS	NS	NS	NS	NS	3.41

Application of K at different rates on selected soil chemical properties at yam harvest (Six months after planting) Shown in Table 3, significantly improves soil organic matter content generally. The highest organic matter content was obtained in 200 kg ha^{-1} of 4.61%, followed by 600 ha^{-1}. of 4.54%. However, K-rates had no significant effect on soil pH, exchangeable potassium, exchangeable calcium, exchangeable magnesium, total nitrogen and available phosphorus.

Table 3: Effect of K-rates on selected chemical properties at yam harvest (Six months after planting)

K- rate kg ha-1	pH	Organic Matter (%)	Total N (%)	Av.P	Ca	Mg	Na	K	EA	ECEC	Base saturation (%)
				mg kg^{-1}	←			cmol kg^{-1} →			
0	5.35	3.67	0.21	67.62	11.82	4.63	0.08	0.18	2.34	19.05	87.20
200	5.47	4.61	0.21	63.63	13.58	5.40	0.09	0.18	1.96	21.18	91.13
400	5.63	4.00	0.10	62.59	12.25	5.43	0.09	0.19	2.17	20.26	89.82
600	5.58	4.54	0.12	59.38	12.73	5.69	0.07	0.17	2.34	21.51	89.09
LSD	NS	1.47	NS	NS	NS	NS	NS	NS	NS	NS	NS

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K-rate application significantly affected lesser yam yield (big and small tuber weight, tuber length, tuber girth, number of tubers/stand and big tuber dry matter), when compared with control shown in Table 4, however application of different rate of K does not produce significant effect on small tuber dry matter. Application of different rate of K significantly increased small tuber weight with increase rate of K, when compared with control. K-rate at 400 kg ha^{-1} produced the highest mean number of small tuber weight 1.77 kg, followed by 600 kg ha^{-1} with mean value of 0.71 kg and least value of 0.77kg was produced by application of 200kg ha^{-1}.

Application of different rate of K significantly increased small tuber length with increase rate of K when compared with control. This indicates that phosphorus is needed in large quantity for the process of biological nitrogen fixations. There was a significant yield response of lesser yam to phosphorus fertilizers. Similar trend has been reported by researchers such as Osodeke (2005) and Ugese and Avan (2005). K-rate at 400 kg ha^{-1} produced the highest mean value of small tube length of 8.42 followed by 200 kg ha^{-1} with mean value of 4.90 and least value of 4.17 produced by application of 600 kg ha^{-1}. K-rate application significantly increased small tuber length when compared with control. K-rate at 400 kg ha^{-1} produced the highest mean value of small tuber length, followed by 200 kg ha^{-1} and 600 kg ha^{-1} (8.42, 4.90 and 4.17), respectively. Big tuber length and Big tuber girth were significantly affected by 400 kg ha^{-1}, 600 kg ha^{-1} and 200 kg ha^{-1} of K-rate of application (23.80, 12.86, 9.55 and 21.10, 20.13 and 11.40), respectively. Application of different rate of K significantly increased small tuber girth with increase rate of K when compared with control. K-rate at 600 kg ha^{-1} produced the highest mean value followed by 400 kg ha^{-1} and 200 kg ha^{-1} (19.98, 13.78, 5.22), respectively. Application of different rate of K significantly increased number of small tubers/stand and big tubers/stand with increase rate of K when compared with control. K-rate at 600 kg ha^{-} produced the highest mean value followed by 400 kg ha^{-1} and 200 kg ha^{-1} (53.83, 43.00 and 21.00 and 47.33, 38.17 and 23.00), respectively.

Application of different rate of K significantly increased big tuber dry matter with increase rate of K when compared with control. K-rate at 400 kg ha^{-1} produced the highest mean value, big tuber dry matter of 77.83 followed by 200kg ha^{-1} with mean value of 64.17 and least value of 62.00 was produced by application of 600 kg ha^{-1}.

Table 4: Effect of K-rate on Lesser Yam Yield parameters

Kg ha-1	Small tuber wt (kg)	Big tuber wt	Small tuber lenght (cm)	Big tuber length	small tuber girth	big tuber girth	No. of small tuber stand	No. of big tuber stand	Big tuber dry matter	small tuber dry matter
Control	0.18	0.93	3.07	6.65	3.46	7.68	12.83	11.17	62.00	14.8
200	0.77	1.73	4.90	9.55	5.22	11.40	21.00	23.00	64.17	9.50
400	1.77	4.95	8.42	23.80	13.78	21.10	43.00	38.17	77.83	17.50
600	0.71	1.97	4.17	12.86	19.98	20.13	58.83	47.33	62.00	11.50
LSD	1.47	1.23	1.47	3.14	2.64	4.07	8.77	6.07	38.61	NS

CONCLUSION

To improve Soil fertility for production of Lesser Yam (Dioscorea esculenta), potassium fertilizer and tillage methods should be applied. This research revealed that the application of different rates of K and tillage methods significantly improved Soil chemical properties for better yam yield. K-rate uptakes, tuber yield as well as other performance parameters of Yam were found in the study area to be high when K-rates and mound tillage were applied at 400 kg ha^{-1} (6 months after planting). The research has exposed the potentials of different K-rates as nutrient sources for improving Soil condition for yam yield.

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