EFFECTS OF COCOYAM (*Colocosia esculentus L.)* PLANTING DENSITIES ON SOIL LOSS AND YIELD IN ABAKALIKI, SOUTH-EASTERN NIGERIA

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ABSTRACT

An experiment was carried out on effects of cocoyam planting densities on soil loss and yield in Abakaliki. The field was laid out in Randomized Complete Block Design (RCBD) with four treatments of 44, 100 and 174 planting densities of cocoyam and control (bare plot). Samples were collected at 0-20cm depth for determination of soil properties. Soil lost after each rainfall was collected from each plot. Data were subjected to analysis of variance (ANOVA). Bare plot had significantly ($P<0.05$) higher soil loss than plots receiving different densities of cocoyam. Significantly ($P<0.05$) taller cocoyam plants were obtained in plot receiving 44 stands at 3WAP as well as mean yield of cocoyam which also showed significant differences among the planting densities. Whereas, bare plot had 53, 58 and 62% higher soil loss than other plots receiving different densities, cocoyam height at 3WAP was 32 and 37% higher in plot with 44 stands than Plots with 100 and 178 planting densities. Mean yield of cocoyam was 5 and 48% higher in plot having 44 stands when compared to plots with 100 and 178 cocoyam densities. Trend of soil loss, growth and yield of cocoyam according to treatments is in the order of bare soil >44>100>178 for soil loss and 44>100>178 for plant height and yield for the planting densities, respectively. Lower density of cocoyam is recommended for higher yield but for soil conservation against loss, higher density is advocated.

Keywords: Cocoyam density, effect, fertility, productivity, soil loss, yield

Introduction

Cocoyam (*Colocosia esculentus L.*) is one of the major root tubers produced in large quantity in Nigeria, which is the highest producer in the world. She produces 40% of the total world output, while Ghana which comes behind produces 31% (Nwite *et al.*, 2008). According to Eke-okoro *et al*. (2005), cocoyam is classified into 6 cultivars namely Coco-India (NCY004), Green Ede ofe (NCY005), Purple Ede ofe (NCY006), Giant Ede ofe (NCY007), Ukpong (NCY008), and Ghana (NCY009). Cocoyam contains easily digestible starch as well as vitamin c, riboflavin and thiamine. The leaves are also edible and used for delicacies in many families in Igbo land. Cocoyam is known to have so many therapeutic values in the treating of potentially allergic infants and persons with gastro-intestinal disorder and for diabetic patients (Eke-Okoro *et al.*, 2005). The crop requires 2-4 months of rainfall per annum, average temperature of about 21^{o}C and it grows on a wide range of soils. For instance, the Swamp Taro grows best in heavy soils and tolerates water-logging conditions (Nwite *et al*., 2008). Soil pH range of 5.5-6.5 is ideal for cocoyam (Purseglove, 1976; Ekeokoro *et al.,* 2005). Cocoyam does not seem to grow well on dry-loose soils except on hydromorphic soils often with good fertility status. The yield of cocoyam per hectare varies from place to place and cultivar to cultivar. Generally, the world average production is put at 5.5 tones per hectare (Nwite *et al.,* 2008). However, yield as high as 15-30 tones per hectare have been recorded with Ukong

(NCY008) cultivar giving the highest of 20-30t ha^{-1} (Eke-Okoro *et al*., 2005). Apart from rapid depletion of plant nutrients, low organic matter content (<2.0) according to Enwezor *et al.* (1990), which constitute strong limitations to crop production in Nigeria such as Abakaliki agroecological area, planting density of cocoyam could influence not only soil loss but its growth and yield. In Abakaliki soil loss is a common problem that can affect soil productivity due to fragile nature of some soils lying along the slope and severe loss can lead to degradation of top soil and removal of applied fertilizer or manure which in turn could affect soil fertility and yield of cocoyam (Adekiya and Ojeniyi, 2002). Cocoyam has unique floral pattern. The leaves are broad and the plant height ranges from low to medium which vary from variety to variety. These attributes make them effective protective vegetative cover of their immediate environment. Although soil loss and influence of vegetative cover had been studied, there is complete lack of information particularly on the cocoyam's protective cover on soil loss and as well as productivity. This necessitated this study. The major objective of this experiment was therefore to examine effects of cocoyam density on soil loss and its yield in Abakaliki.

Materials and methods

Experimental site

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The site is located by latitude 06^o $4^/$N longitude 08^0 $65^/$E in the derived savannah of the south east agro-ecological zone of Nigeria. The area experiences a bimodal pattern of rainfall (April-July and September-November) with short spell in August referred to as "August break" by the indigenes. The total annual mean rainfall ranges between 1700 mm and 2000 mm. The minimum and maximum temperatures are 27^OC and 31^OC, respectively for rainy and dry seasons. The relative humidity in dry and rainy seasons is 60% and 80%. The soil is formed from sedimentary deposits from cretaceous and tertiary periods and belongs to the Order Ultisol which is classified as Typic Haplustult (FDALR, 1985.)

Experimental Design and layout

The land area which measured 12.5 m x 15 m approximately 0.08ha was used for the experiment. The site was cleared with cutlass and debris removed. The field was laid out in a Randomized Complete Block Design. The plot size measured 4 m x 4 m with spacing of 0.5 m in-between plots and 1 m spaces between the blocks. The treatments were population densities of cocoyam at four rates replicated five times to give a total of twenty experimental plots. The plots were prepared manually with hand hoe. The treatments were control, cocoyam planted at 60 cm x 60 cm, 40 cm x 40 cm and 30 cm x 30 cm respectively representing 44,100 and 178 planting densities for the treatments. This treatments were designated $T_{0,}$ $T_{1,}$ T_2 and T_3 for control, cocoyam density of 60 cm x 60 cm, 40 cm x 40 cm and 30 cm x 30 cm. The variety of cocoyam used is the swamp Taro. The cormels were planted at a depth of 15 cm depth. The corms and cormels were sourced from Ebonyi State Agricultural Development Programme (EBADEP) Onuebonyi Izzi, Abakaliki. They were planted after preparing the beds. Weeds were removed at 3 weekly intervals with hand hoe till harvest.

Soil Sampling

Soil Samples were collected with auger from the site at twenty five points from the site before bed preparation and planting of corms at 0–20 cm depth and composited for determination of soil properties before planting. Soil samples were air dried, sieved with 2 mm sieve and used for laboratory determinations.

Agronomic Data

Data collection on plant height started one month after planting. The plant height was estimated by measuring the height of sampled plants with meter rule at weekly internals. Yield data were determined at the time of harvest where the weight of the corms and cormels were estimated on plot basis. Harvest was taken when cocoyam leaves had shriveled and dried. Yield was expressed on average basis for corms and cormels for each treatment.

Estimation of Soil Loss

Polythene was procured and placed round each plot to track soil loss after rainfall. The soil deposited inside the polythene in each occasion after rainfall was emptied into a bucket. The soil in the bucket with the soil was then weighed with a weighing balance. Soil loss after removing the weight of bucket was calculated based on Universal Soil Loss Equation (USLE) as described by Wischmeier and Smith (1965). The expression is A = RKLSCP

where

A = Estimated annual average soil loss (t ha^{-1})

R=Rainfall factors which is a measure of the erosive power of a specific rainfall (j ha^{-1})

K= Soil erodibility factor *i.e.* soil loss per unit of rainfall (mm)

LS=Slope length and Steepness factor combined into a single index (dimensions less)

C= Crop management factor (dimension les)

P= Control supporting practices (dimension less)

Note: bare fallow 9% slope

Laboratory Methods

Soil pH was determined using glass electrode pH meter at 1:2.5 soil to water solution ratio as described by Mclean (1982). Organic carbon determination was done using modified Walkely and Black method (Nelson and Sommers, 1982). Total Nitrogen was determined by Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus determination was by the method described in Page *et al.* (1982). Exchangeable bases were extracted by the process described by Tel and Hagarty (1982). Exchangeable acidity determination was by titration method as described by Juo (1979) while cation exchange capacity was obtained by using 0.IN NH_4OAC method (Jakson, 1958). Base saturation was calculated using the formular.

$$\% BS = \frac{TEB}{CEC} \times \frac{100}{1} \quad \text{---} \; 1$$

where

TEB = Total exchangeable bases (cmol kg^{-1})

CEC = cation exchange capacity (cmol kg^{-1})

Data Analysis

Data collected from the field during the experiment and from laboratory analysis were subjected to Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD). Test for significance among treatment means was carried out using Fisher's Least Significant Difference (F-LSD) and accepted at 5% probability level (Obi, 2012).

Results and Discussion

Table 1 shows soil properties before planting. The result shows that particle size distribution varied but with sand dominating. The textural class was sandy loam. Soil pH was 5.3 while organic carbon content was moderate (15.50 g kg^{-1}) but very low percent content (1.40 g kg^{-1}) of nitrogen. Available phosphorus content (25.90 mg kg^{-1}) was moderate. Exchangeable Ca and Mg dominated exchange complex of soil. Cation exchange capacity was very low. Base saturation (70%) was high but with a low exchangeable acidity.

Table 1: Properties of Soil before Planting

Soil properties	value
Sand (g kg^{-1})	760
Silt (g kg^{-1})	142
Clay (g kg^{-1})	980
Textural	sandy loam
pH (KCL)	5.3
Organic carbon (g kg^{-1})	15.50
Nitrogen (g kg^{-1})	1.40
Available phosphorus (mg kg^{-1})	25.90
Calcium (cmol kg^{-l})	1.60
Magnesium (cmol Kg^{-1})	0.40
Sodium (cmol Kg^{-1})	0.15
Potassium ($cmolkg^{-1}$)	0.04
Cation exchange capacity (cmol Kg^{-1})	3.15
Exchangeable acidity (cmol Kg^{-1})	0.96
Base saturation (%)	70.00

The results in Table 2 Shows effect of cocoyam densities on soil loss. Bare plot had significantly (P>0.05) higher soil loss when compared to other plots receiving cocoyam treatments. There were significant (P<0.05) differences in soil loss among different treatments as well as in cocoyam densities. The bare plot was higher in soil loss by 53,58 and 62% when respectively compared to plots receiving 44, 100 and 178 stands of cocoyam densities. The plot with 44 stands of cocoyam had 10 and 18% increments in soil loss compared to their counter parts with 100 and 178 stands of cocoyam. The order of soil loss in plots with different densities of cocoyam and control is bare plot >44>100>178 stands.

Table 2: Effect of Cocoyam density on soil loss

Treatments	soil loss (t ha^{a-1})
T_0	2.68
T_1	1.25
T_2	1.13
T_3	1.03
FLSD (P<0.05)	0.39

T_0= control (bare plot), T_1 =44 stands of cocoyam; T_2=100 stands of cocoyam, T_3= 178 stands of cocoyam; Fisher's Least Significant Difference

Table 3 shows effect of cocoyam density on plant height at 3, 6 and 9 weeks after planting (WAP). The plot with 44 cocoyam planting density significantly (P<0.05) differed in cocoyam height at 3 WAP from plots receiving 100 and 178 cocoyam densities. Furthermore, there was no significant effect of cocoyam density on plant height at 6 and 9 WAP. Cocoyam height at 6 and 9 WAP. Cocoyam height at 6 WAP was 32 and 37% higher in plot with 44 planting density compared to heights obtained in plots with 100 and 178 densities, respectively. Similarly, cocoyam was taller respectively by 10% in plots treated with 44 and 100 densities compared to height recorded in plot with 178 planting density.

Table 3: Effect of cocoyam density on plant height

	Cocoyam heights at different sampling periods (cm)		
Treatments	**3WAP**	**6WAP**	**9WAP**
T_0	0	0	0
T_1	18.60	14.97	24.12
T_2	12.63	14.19	24.12
T_3	11.63	13.64	21.83
FLSD (P<0.05)	1.18	1.83	NS

T_0= control (bare plot), T_1=44 stands of cocoyam; T_2=100 stands of cocoyam, T_3= 178 stands of cocoyam; FLSD= Fisher's Least Significant Difference, WAP= weeks after planting

Result (Table 4) showed that while there was significantly (p>0.05) higher effect of cocoyam density on mean yield of cocoyam in plot receiving 44 stands compared to plots with 100 and 178 densities, significant differences were obtained in mean cocoyam yields among the planting densities. The plot that received 44 cocoyam stands had 5 and 48% higher mean yield than their counter parts with 100 and 178 stands. Furthermore, plot treated with 100 stands of cocoyam was 45% higher in mean yield compared to the one with 178 stands. Trend of mean yield of cocoyam is in the order of 44 >100>178 stands for the planting densities.

Table 4: Effect of cocoyam density on mean yield of cocoyam

Treatments	**Mean yield (t h_a^{-1})**
T_0	0
T_1	17.31
T_2	16.50
T_3	9.05
FLSD (P<0.05)	0.66

T_0= control (bare plot), T_1=44 stands of cocoyam; T_2=100 stands of cocoyam, T_3=178 stands of cocoyam; FLSD= Fisher's Least Significant Difference, WAP= weeks after planting

Results demonstrated that bare plot had high potential for loss of soil more than soil under cocoyam vegetative cover. This could be attributed to exposure of soil to hazards of impacts of rainfall drop impacts which increased erodability of the soil. Plant covers intercept rainfall drops and thereby protect the surface of the soil from being washed away by runoff water (Martinez *et al.*, 2006). The finding also agrees with the report of khisa *et al.* (2002) that highest soil loss of 3.30 t ha^{-1} was obtained from a bare plot while the lowest of 0.35 t ha^{-1} was recorded in plot with vegetative cover. Cocoyam densities further demonstrated their relative potentials to checkmate and preserve soil resource from loss and degradation. This could increase soil fertility and its productivity. Dada and Rayimminana (2010) observed that number of cocoyam stands on a plot affected relative losses of soil and so reduced its degradation. The result further showed relative increments in cocoyam heights due to its densities. This could be attributed to competition of cocoyam stands for space and exploitation of nutrients for growth and development. Significant increase in cocoyam height in plot having 44 stands when compared to other plots with higher densities could be attributed to more space and availability of higher nutrients as well as low competition for nutrients for use for photosynthetic processes. These observations agree with the reports of Ademiliyi (2013) and Hanison *et al*. (2014) that cocoyam density affected its height due to competition for available space and nutrients. Generally, as plant densities increased, height of cocoyam decreased indicating that soil loss was not only the factor responsible for fertility degradation and low productivity but other factors such as low nutrient content, space, sunlight and competition also affected the plant's growth. It could be deduced that effect of cocoyam densities diminish with periods of growth of the crop as shown in Table 3 since there was no significant of planting densities on height at 6 and 9 WAP. The result on mean yields of cocoyam indicated that its densities affected the yield. This finding agrees with the result of cocoyam height (Table 3) where increase in planting densities decreased growth. Decreased yield with increase in planting densities could be attributed to competition for mineral nutrients and lack of space to intercept and maximize sunlight for physiological process. This resulted to poor yield with increase in planting densities even though soil loss was minimal.

Conclusion

From the result of the study, it could be concluded that cocoyam densities affected rate of soil loss, plant height and mean yields. The finding further showed that rate of soil loss does not have much influence on height and yield of cocoyam, as planting densities although this was not tested statistically. In terms of soil loss, higher density of cocoyam is recommended while farmers are advised to practice planting of lower densities for higher and sustainable productivity.

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