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Relationship Between Measured and Calculated Yield of Cassava and Yam Under Peasant Farm Management System in Soils of Ibadan, Nigeria

Aiboni, V.U.

Department of Soil Science and Agricultural Mechanization

University of Agriculture Abeokuta

ABSTRACT

The relationship between measured and calculated yield of yam and cassava under peasant farm management in the soils of Ibadan area was investigated. Precambrian basement complex rocks underlie the area. A site heavily cultivated by peasant farmers and sufficiently represents the geology, soils, vegetation and land use pattern of Ibadan was selected for the study. Forty-five plots under cassava and yam cultivation were selected to cover the twelve series in the area. The soils have texture ranging from loamy sand t sandy clay with weak crumb and granular structure in the surface layer. The highly concretionary and gravelly surface layers of Gambari and low soil series constitute a problem for the tillage implements. The soils classified as Alfisols, Entisols and Inceptisols have high fertility indices 42.84 to 81.99 and very low to high productivity indices 3.77 to 60.91. Soil productivity was limited mainly by soil depth, drainage and surface stoniness. Crop yields were predicted from the relationship between the yield to productivity index using the measure yield value of one of the soils. Measured cassava yield fro 6.3 to 11.5t/ha. While calculated yield range from 2.69 to 11.5t/ha. Measured yam yield range from 1.2 to 5.Ot/ha while calculated yield range from 2.85 to 6.4 t/ha. Peasant farmers have been able to cultivate these soils by tilling with hoes machetes and making heaps for yams and cassava. Results indicate positive correlation between measured and cultivated yield r =0.81 for yam and 0.77 for cassava with good predictive values of Y =2.51 + 0.71X and Y = 1.36 + 0.74X for yam and cassava respectively. Chi-squared analysis showed the independence between measured and calculated yield.

INTRODUCTION

Proper soil conservation and management practice are important to maintain soil fertility for adequate food production; enhance the use of other agricultural land resources and for industrial development for youth employment and exportation of raw materials. In Nigeria, mainly peasant farmers produce food crops.

Cassava (Manihot esculenta) and Yam (Dioscorea sp.), the main source of carbohydrates in the Nigerian diet are tubers used for producing flour, garri, amala, starch and chips. Unless optimum yield of these food crops are obtained by farmers, importation of flour, starch and other cassava and yam products will continue to affect the industrial development and Nigerian economy, cassava and yam are tropical tubers requiring similar soil, landscape and climatic conditions for optimum production (Onwueme. 1978; Aiboni. 1985 and Aiboni and Ogunkunle. 1998).

In Ibadan area, the shifting cultivation system of farm management is dominantly practiced. In this system the land is cultivated for about 1 to 3 years and left to fallow for 2 to 5 years. The end of the fallow period is marked by burning of debris of a small piece of land at the end of dry season. The land is then tilled with hoes and machetes. Ridges and heaps are made within the top 5-10 cm of the soil for cultivation of food crops such as yam and cassava (Aiboni. 1985).

Intensive tillage and poor soil management often result in the deterioration of the granular and crumb structure of the surface soil to loose or massive structure, unfavourable to crop production (Wilson and Browning 1945 citing Karlen, et al. 1990).

Karlen, et al. (1990) indicated that various components of soil tilts are those that affect crop yield and these include soil structure, compaction, aeration, moisture, organic matter and biological properties.

Crop yield can therefore be used as an indicator of soil tilt/productivity as it integrates the combine effect of the soil, crop, climate and management. This study is therefore aimed at establishing a relationship between measured and calculated yield of yam and cassava under peasant farm management system with minimum input.

MATERIAL AND METHODS

The Study Site

The site, which is heavily created with arable crops by peasant farmers, covers an area of approximately 200 hectares along the northern boundary of IITA. Ibadan (Fig.1). The site sufficiently represents the geology, soils, vegetation and land use pattern of the area. It overlies the Pre-Cambrian basement complex rocks (Jones and Hocky. 1944). It is drained mainly by Odosa stream. Ibadan lies within the transitional zone between the humid and sub-humid tropical climate with mean annual rainfall of 788 to 1884 mm, mean temperature of 21.3^{0}C to 31.2^{0}C and relative humidity of 61 % to 83% (Moormann, *et al.* 1975).

Field Study

Yam and cassava plots were selected to cut across the major soil series in the 200 ha area, this was achieved by auger examination of 120 cm depth in the farm plots. A total of 45 plots were selected spreading over 11 soil series. Plot size ranged from 0.04-0.8 ha.

Soil profiles were dug at auger points and were described following FAO guidelines (1977). Soil samples were collected by horizons for laboratory analysis. Soil series were identified according to Smyth and Mont-gomery (1962). The slope gradient (%) in each profile site was determined with Abeney level.

Yield of mature local cassava and white yam were determined as the weight of tubers in a 4m2 at the centre of each plot. The slash and burn system of agriculture was practiced by all farmers, without the use of modern inputs as fertilizer, herbicide, insecticides, irrigation and improved crop varieties.

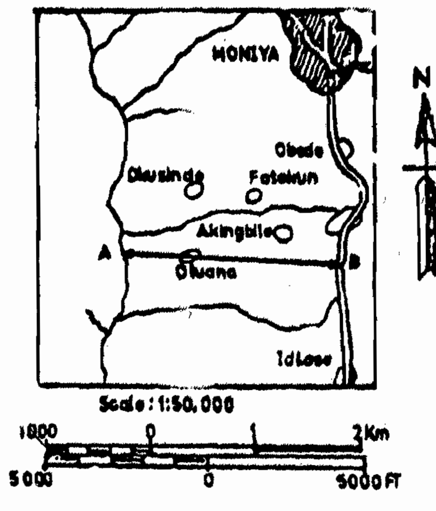
Laboratory Analysis

Particle size of air-dried soils passed through 2 mm sieve, determined by hydrometer method (Day, 1965). Soil pH was determined in 1:1 soil to water ratio with glass electrode. Organic carbon was determined by wet oxidation method of Walkley and Black (Allison, 1965). Exchange-able cations were extracted with 1N ammonium acetate. Ca, Mg, K and Na in the extract were analyzed with Perkin Elmer 420 atomic absorption spectro-photometer. Exchangeable acidity was extracted with 1N KCL and determined by titration with 0.1N NaOH. Effective cation exchange capacity was computed by summation of exchangeable bases and acidity. Base saturation was calculated by dividing exchange-able base by the cation exchange capacity and expressed as percentage. Available phosphorus was determined by the Bray No. I Method (Bray and Kurtz, 1945). Total nitrogen was determined by Kjeldahi distillation method. Clay mineralogy was determined by X-ray diffraction. The soil series were classified at higher level according to USDA (Soil Survey Staff 1994) with corresponding FAO-UNESCO method (FAO, 1994).

Soil Productivity Index and Calculation of Yield of Cassava and Yam

The soil productivity evaluation procedure adopted is a parametric method in line with the principles of the FAO (1976) framework. First the diagnostic criteria were identified and then rated numerically using some mathematical equations (Aiboni, 1985).

In developing the productivity ratings, soil conditions considered optimum for the cultivation of cassava in the area were well-structured, deep, well-drained, non-stony sandy loam soils with high nutrient status (> 0.2%, N, > 9 ppm p > 0.4 me/100g k, >3% organic matter), high base satu-ration (> 75%), high cation ex-change capacity (20-40 me/100g clay in top soils and 10 me/100 g clay in subsoils), high mineral reserve



Contour Map of Ibadan Site

Source: 150,000Topographic Map Sheet No. 241 OYO, S.E.

Fig. 1 Cross section from tributary of the river Ona across Oluana to the Ibadan/Oyo road

(>30% weatherable min-erals in profile) with average annual rainfall between

1,000-2,000mm well distributed through-out the year.

Specifically, each characteristic was rated for cassava and yam (Aiboni, 1985 and Aiboni and Ogunkunle, 1998). Land produc-tivity indices were then obtained as the product of the percentage ratings using a modified version of the storie index of Aiboni (1985). The ratings were used as decimals in computing the productivity index which is expressed again as percentage to make the calculation simple and easy to follow.

The actual land productivity index (p) was estimated by the equation:

P = d.t.s.f.w .... (1)

Where: d is soil depth, t = soil texture and surface stoniness; s = the gradient', f is multiple factor of soil fertility, consisting of rating for primary nutrients, organic matter content, base saturation, CEC and mineral reserve in the fine sand fraction; w = the average annual rainfall distribution/soil moisture.

The soil fertility index (f) was calculated separately as:

F = pn.o.n.c.m ....(2)

Where pn = rating (%) for level of primary nutrients; o=rating for organic matter; n=rating for base saturation; c=rating for nature of clay mineral and m=rating for mineral reserve in the fine sand fraction.

The ratio of measured yield to soil productivity index of soil A is expressed to be equal to that of soil B and is expressed as:

$$YA = YB.X\ {}^{PA}/_{PB} \quad ....(3)$$

Where YA is the yield of Soil A; YB the yield of soil B; PA the productivity index of Soil A and PB the productivity index of Soil B.

Thus, yields of the crops (cassava and yam) on each pedon were calculated from the parameters described in the preceding equation using measured yields of Egbeda series obtained from benchmark soils studies (Amon, 1965). For cassava, the yield was 11.5 t/ha while it was 9.89 t/ha (Aiboni and Ogunkunle, 1989).

Stepwise multiple regression was used in analyzing the inter-relationship among the soil and crop yield variables. The relationships between measured and calculated yields of yam and cassava were established using both the chi-square and correlation coefficients.

RESULTS AND DISCUSSION

Soil Characteristics

As a result of previous erosional and depositional processes, the sea is characterized by complex distribution of soil along slope, recent colluvial and alluvial deposits in the middle and lower slope sites (Aiboni, 1989). The distribution of soils from hill-top to valley bottom include: Shallow hill-creep soils (Okemesi series; upper slope highly weathered sedimentary soils (Mamu, Egbeda, Olorunda and Iwo series); middle to lower colluvial soils (Apomu, Iregun, Oba and Gambari series) and valley bottom colluvial and alluvial soils (Adio and Lago series). Soil pH range from 5.0 to 7.9, organic mater 0.05 to 5.6 percent; available phosphorus 0.8 to 13.7 $mgkg^{-1}$ and cation exchange capacity for the top soil 3.98 to 11.22 Cmol Kg^{-1}. The clay mineral is dominated mainly by kaolinite and sesquioxides with some hydrous mica in the middle slope and montmorillonite and allophane in the valley bottom.

The soil fertility index is high 50.22 to 91.9 while the productivity index is very low to high 3.77 to 60.91 (Tables 1,2 and fig. 2) soil productivity is limited mainly by soil depth. surface stoniness and drainage. The soils were classified in the order of Alfisols. Entisols and Inceptisols of the USDA (1994) classification with corresponding FAO (1994) Classification as Luvisols, Regosols and Luvisols (Aiboni, 1985).

Table 1: Percentage ratings for individual factors of soil fertility index in Ibadan Site

Soil Series	Pn			O		N A			M				Soil fertility Index
	%N	Me 100gK	(ppm)P	R%	%OM.	R%	Base saturation	R%	Nature of Clay	R%	Mineral reserve	R%	
Egbeda	0.28	0.69	11.0	100	5.57	100	99	100	K & S	90	Low	90	72
Olorunda	.07	.09	4.2	70	1.5	85	85	100	K & S	80	Low	80	42.84
Iwo	.11	.67	13.6	94	2.01	90	96	100	K & S	85	Low	85	64.72
Manu	.18	.42	12.8	95	3.56	95	97	100	K & S	80	Low	80	65.68
Iwo (Sandy)	.15	.27	13.7	96	2.96	92	95	100	*MIX	90	Fair	90	70.79
Apomu	.05	.18	5.6	78	0.98	78	97	100	MIX	95	Fair	90	52.02
Gambari	.06	0.20	2.7	66	1.99	89	95	100	MIX	95	Fair	90	50.22
Iregun	.11	.22	4.0	84	2.01	90	97	100	MIX	95	Fair	90	64.64
Oba	.19	.24	5.8	92	3.78	96	97	100	MIX	95	Fair	90	75.51
Adio Profile 9	.11	.11	3.9	75	1.93	88	96	100	Mont	100	Great	100	66.0
Adio profile 11	.07	.52	6.1	91	1.96	89	97	100	Mont	100	Great	100	80.99
Jago	.11	.23	5.8	90	2.18	91	96	100	*Mont	100	Great	100	81.9

%R=Percent rating; K & S = Soils with mainy Kaolinite and sesquioxides; Mix = Soils with mixture of clays of hydrous micas; Mont= Soils with mainly montmorillonite and allophane; Pn = Primary nutrient

Relationship between measured and calculated yield of yam cassava

Table 3 presents the measured and calculated yield of yam and cassava in Ibadan area. The measure yield of cassava range from 6.3 to 11.5 t/ha while the calculated range from 5.69 to 11.5t/ha. The measured yield of yam range from 1.2 to 6.0 t/ha while the calculated yield range from 2.85 to 6.4 t/ha.

The relationship between calculated and measured yield of cassava and yam are presented in Table 4 and Figs 3 and 4:

Results indicate positive correlation between measured and calculated yields of yam and cassava; r=0.81 and 0.77 with good predictive values of Y = 2.51 + 71X and Y = 1.36 + 0.74X for yam and cassava, respectively.

The slight difference between the measured and calculated yield of both crops could be due to over estimation of the effect of soil management on the calculated values and experimental error. For a more reliable data it might be necessary to conduct the experiment under controlled management conditions.

Table 2: Percentage rating of individual factors of land productivity index for Ibadan Area

Soil Series	A		B				S		Y		Land productivity Index
	Depth/drainage	R%	Texture*	%Gravel	R%	Degree slope	R%	%X	Annual rainfall	%Y	
Okemesi	Shallow W.D.	85	LS	60	10	18-20	75	68.68	1285mm with 5 dry mts	90	3.77
Monu	Deep W.D.	100	SL	60	16	16-18⁰	75	65.68	-do-	90	7.09
Egbeda	Deep W.D.	100	SL	7.9	94	2-3⁰	100	72.00	"	90	60.91
Olorunda	Deep W.D.	100	SL	25	75	3-4⁰	98	42.84	"	90	28.34
Iwo	Deep W.D.	100	SL	28.2	70	3-5⁰	98	64.72	"	90	39.96
Iwo (Sandy)	Deep E.D.	85	LS	20	74	6-7⁰	95	70.79	"	90	38.07
Apomu	Deep E.D.	83	SL-LS	8.3	90	8-9⁰	86	52.02	"	90	30.1
Gambari	Deep M.W.D.	90	SL	36	48	10-11⁰	90	50.22	"	90	17.57
Iregun	Deep M.W.D.	90	SL	20	78	8-10⁰	90	64.64	"	90	35.76
Oba	Deep M.W.D.	90	SL/SCL	20	80	8-9⁰	90	75.51	"	90	44.04
Adio (9)	Deep P.D.	70	SL	11.2	89	3-5⁰	98	66.0	"	90	36.27
Adio (11)	Deep P.D.	70	SL-SCL	29.8	70	3-4⁰	98	80.99	"	90	35.01
Jago	Deep PDS.	40	SL	12.8	87	2-4	100	81.9	"	90	25.65

*WD-Well drained; MWD=Moderately well drained; LS = Loamy sand; ED=Excessively drained; SL=Sandy loam; PDS= Poorly drained/Swamp; SCL= Sandy Clay Loam