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Economic Analysis of the Effect of Fertilizer Application on the Performance of White Guinea Yam in Different Ecological Zones of Edo State, Nigeria

K.E. Law-Ogbomo and C.O. Emokaro

Department of Agriculture, Benson Idahosa University, P.M.B. 1100, Benin City, Nigeria

Abstract: Economic analysis of the effect of different rates of NPK 15:15:15 fertilizer application on the yield of yam in three different ecological zones of Edo State was investigated in this study with the aim of determing the optimal fertilizer application rate and the most profitable ecological zone for yam production in Edo State. This study involved the use of *Dioscorea rotundata* Poir, fertilized with NPK (15:15:15) at rates of 0, 100, 200, 300 and 400 kg/ha using a randomized complete block design with three replicates. The crop was planted early (April) 2004 and 2005 in each of the ecological zones (Derived Savanna (Ubiaja), Forest-Savanna transition (Sabongidda-Ora) and Forest (Evboneka)). Based on the objective function of profit maximization, the optimum returns were recorded at a fertilizer application rate of 300 kg/ha in the Derived Savanna zone with a gross margin of $18,577.38, net returns of $18,225.21 and a benefit-cost ratio of 5.10. In the Forest-Savanna transition zone, optimum rate of fertilizer application was also at 300 kg/ha with a gross margin of $13,794.78 and benefit-cost ratio of 3.76. Optimum rate of fertilizer application however dropped to 200 kg/ha in the Forest zone with a gross margin of $13457.39, net returns of $13110.61 and benefit-cost ratio of 3.73. This shows that farmers in the Derived Savanna and Forest-Savanna transition zones stand in a better position to make more profit from yam production through the application of higher rates of fertilizer than farmers in the forest zone. However, soils in the forest zones are naturally fertile and as such require lower fertilizer application rates than in the other zones.

Key words: Edo State % Optimum application rate % Resource-poor farmers % Staple food

INTRODUCTION

Nigeria is the main producer of yam (*Dioscorea species*) in the world with about 71% of world output, followed by Ghana, Cote d'lvoire, Benin and Togo in that order [1]. The white guinea yam (*Dioscorea rotundata* Poir) remains the predominant kind of yam in West Africa as a whole and is grown on a greater hectarage and produced in larger quantities than other species of yam in the world. Edo State falls within the yam producing areas in Nigeria.

Yam production in Nigeria has more than tripled over the past 40 years from 6.7 million tonnes per annum in 1961 to 27 million tonnes per annum in 2001 [2]. This increase is however, attributed to larger hectares of land planted to yam than to increased productivity as is the case in other climes. The decline in average yield per heater in Nigeria has been rather drastic, dropping from 14.9% in 1986 – 1990 to -2.5% in 1999 [2,3]. However, increase in annual average yield/ha of 28.4% was recorded between 2001 and 2006 [4]. Since yam remains a major staple food in Nigeria based on its cultural role [5] and contributing immensely to rural and regional economies [6], this has called for a concrete effort to curb this decline in yield/ha.

The major challenge before researchers therefore, is to evolve ways of increasing the yam yield/ha. This would not only ensure the continuous availability of yam for the ever increasing population, it would also improve the income earning capacity of the resource-poor farmers responsible for producing the bulk of the yam in Nigeria.

The average yam producer is highly rational in the economic sense, ever seeking ways of maximizing the returns from his lean resources which are not only scarce but have alternative uses. This study was thus designed to analyse the effect of the application of different rates of NPK 15:15:15 fertilizer on the performance of *Dioscorea*

Corresponding Author: Dr. K.E. Law-Ogbomo, Department of Agriculture, Benson Idahosa University, P.M.B. 1100, Benin City, Nigeria

rotundata pior in Derived savanna, Forest-Savanna transition and Forest ecological zones of Edo State. The main objective was to determine the optimum NPK 15:15:15 fertilizer application rate in each of the three ecological zones, based on the objective function of profit maximization. This would not only serve as a guide to local farmers, but also provide empirical evidence for other stakeholders and would-be investors in yam production and related ventures.

MATERIALS AND METHODS

The study was conducted in 2004 and 2005 in three ecological zones of Edo State; Evboneka (forest), Ubiaja (derived savanna) and Sabongidda-Ora (forest-savanna transition). These zones lie between longitude 5°04' and 6°45'E and between latitude 5°45' and 7°30'N. Weather data during the trial period were obtained from the Nigerian Institute for Oil Palm Research (NIFOR), Benin City. The data are presented in Table 1.

Prior to land preparation and after harvest, composite samples of top soil (0–30 cm depth) were collected from each of the three sites with an auger. The samples were air-dried for two weeks, sieved and routinely analyzed for their soil physical and chemical properties, using standard laboratory procedures described by Mylavarapu and Kennelley [7]. Data obtained are presented in Table 2. Although the sites were cultivated in the last two years, there was no evidence of fertilizer use.

A randomized complete block design with three blocks was utilized at each year for the different location. Each block comprised five plots, each of which measured 7x 6 m. The treatment consisted of five fertilizer levels viz. 0, 100, 200, 300 and 400kg/ha of NPK 15:15:15 compound fertilizer.

Planting was done with *D. rotundata* cv "Obiaoturugo" yam sett of 250 g size buried in the soil at a spacing of 100cm within row to given a population of 10000 plants per hectare (ppp). Planting was done on 24th of April in each of the two years. The plots were weeded when necessary. Basal application of five levels (0, 100, 200, 300 and 400 kg/ha) of NPK fertilizer at six weeks after planting (WAP). Staking was done by using one stake per stand.

The yams were harvested at 33 WAP when all the leaves (leaf senescence) and vines had withered and there was no more vegetative growth. Twelve yam stands in each plot were harvested and data collected on tuber yield per hectare.

Analysis of variance was carried out on each of the data collected after estimating the mean for two years with GENSTAT programme, version 8.1 and means were compared using Least Significant Different (LSD).

Table 1: Climatic data at Evboneka (Forest zone)

	2004							2005						
			Relative humidity (%)			Temperature (%)				Relative humidity (%)		Solar	Temperature (%)	
	Rainfall	Sunshine	900H	1500H	Solar radiation	Max.	Min.	Rainfall	Sunshine	900H	1500H	Radiation	Max.	Min.
Month	(mm)	(hours)						(mm)	(hours)					
January	35.20	224.80	78.40	50.70	365.10	33.30	21.60	0.00	NA	61.70	45.00	NA	33.30	19.60
February	13.50	101.70	72.80	50.40	406.80	35.60	22.50	15.70	NA	79.80	52.40	NA	35.10	24.10
March	55.30	33.00	72.60	50.60	392.20	30.60	24.40	167.20	NA	81.70	65.20	NA	33.70	22.00
April	104.40	109.20	83.30	69.00	369.90	33.50	22.60	114.40	NA	81.80	67.10	NA	34.60	22.00
May	323.40	139.50	84.80	67.00	384.90	31.50	23.00	132.90	NA	83.40	68.20	NA	31.90	20.90
June	355.70	126.60	89.80	65.20	359.60	30.70	22.80	292.76	NA	85.90	75.50	NA	31.60	2..8
July	214.30	83.40	87.50	79.30	294.30	30.70	21.60	409.80	NA	86.40	81.00	NA	27.40	19.90
August	298.60	41.00	90.00	85.20	294.80	29.80	21.80	80.90	NA	89.00	68.00	NA	27.70	20.90
September	251.10	67.10	86.10	75.10	324.60	30.40	21.50	177.30	NA	86.30	73.80	NA	29.40	21.60
October	247.00	111.50	82.90	70.30	379.30	31.30	22.10	167.20	NA	84.80	69.10	NA	32.30	19.60
November	28.30	162.10	82.50	64.80	386.00	32.40	22.70	33.90	NA	80.10	56.40	NA	32.00	20.90
December	0.00	154.70	82.90	56.30	396.10	33.70	22.80	0.00	NA	83.40	61.50	NA	32.90	21.10
Total	1928.80	1493.80	991.60	783.90	4353.60	383.50	270.00	1595.00	NA	984.00	794.00	NA	381.90	253.40
Mean	160.70	124.50	82.60	65.30	362.80	32.00	22.5	132.90	NA	82.03	66.20	NA	31.80	21.10

Source: Documentation and Information Department, Nigerian Institute for Oil Palm Research, NIFOR.

Table 2: Soil physical and chemical properties of the experimental sites before cropping with yams in 2004 and 2005

	Experimental sites					
Soil properties	Evboneka 1	Evboneka 11	Sabongidda-Ora 1	Sabongidda-Ora 11	Ubiaja 1	Ubiaja 11
pH (H_2O)	5.00	4.80	5.70	6.30	6.32	6.36
Organic carbon (%)	0.76	0.79	1.62	1.66	1.90	1.54
Total nitrogen (%)	0.09	0.07	0.18	0.18	1.20	0.15
Available phosphorus (mg/kg)	4.67	3.85	7.30	1.10	6.50	2.80
Calcium (cmol/kg)	0.80	0.70	7.80	5.75	0.45	4.93
Magnesium (cmol/kg)	0.60	0.60	0.60	1.75	0.34	1.31
Potassium (cmol/kg)	0.15	0.15	0.40	0.27	0.14	0.23
Clay (%)	25.00	31.00	11.00	22.60	10.90	17.60
Silt (%)	17.00	22.00	11.00	23.40	8.60	12.40
Sand (%)	58.00	47.00	78.00	54.40	80.50	70.40
Textural class	Sandy loam	Sandy Loam	Loam sand	Sandy loam	Loam sand	Sandy loam

Keys: Evboneka I - NPK fertilizer trial site 2004 (Forest zone)
Evboneka II - NPK fertilizer trial site 2005 (Forest zone)
Sabongidda-Ora - NPK fertilizer trial site 2004 (Forest-savanna transition zone)
Sabongidda-Ora - NPK fertilizer trial site 2005 (Forest-savanna transition zone)
Ubiaja 1 - NPK fertilizer trial site 2004 (Derived savanna)
Ubiaja 11 - NPK fertilizer Trial site 2005 (Derived savanna)

In order to determine the profitability of tuber yield produced from the different fertilizer rate, the following parameters were estimated:

(I) GM = TR – TVC [8]
Where GM = Gross margin (US $/ha)
TR = Total revenue (US $/ha)
TVC = Total variable cost (US $/ha)
(iii) Return/$ invested = GM/Total fixed cost [8]
(ii) NR = GM – TFC
Where NR = Net return (US $/ha)
TFC = Total fixed cost (US $/ha)
(iii) TCP = TVC + TFC
Where TCP = Total cost of production
(iv)Benefit-cost ratio = NR / TCP [8].

RESULTS AND DISCUSSION

The highest yield of 24.07 t/ha was recorded in the derived savanna zone at the NPK 15:15:15 application rate of 300 kg/ha, followed by a yield of 20.23 t/ha at 200 kg/ha application rate (Table 3). The fertilizer application rate of 300 kg/ha in the forest-savanna transition zone gave the next highest yield of 19.16 t/ha, followed by the application N rate of 200 kg/ha which gave a yield of 19.12 kg/ha in the forest zone (Table 3). The respective yield followed the same sequence at an output price of $869.57 per tonne. This suggests that the derived savanna zone exhibited the best response to NPK fertilizer application in Edo State with respect to the yield of yam.

In terms of cost, the highest total variable cost of $3276.52 was incurred under the fertilizer application rate of 400 kg/ha in all the zones (Table 3) with cost of planting material (yam sett) accounting for about 66% of the total variable cost, while labour cost accounted for about 25%. This compares favourably with findings of Kalu and Erhabor [6], who reported that the bulk of the total variable cost was spent on planting materials and labour. This is further corroborated by Wilson [9] and IITA [10], who listed the cost of labour and materials among the major constraints of yam production.

The total fixed cost did not vary much across the zones, ranging from $334.26 at the unfertilized plots to $357.56 under 400 kg NPK/ha N fertilizer application rates (Table 3). This reflected on the economic parameters of gross margin, net returns and benefit-cost ratio with the highest of $18577.38, $18225.21 and 5.10, respectively coming from the derived savanna zone at the N fertilizer application rate of 300 kg/ha (Table 3). This was followed by $14422.60, $14075.83 and 4.0, respectively at the N fertilizer application rate of 300 kg/ha as the optimum fertilizer application rate at the derived savanna zone of Edo State with respect to profit maximization.

In the forest-savanna transition zone, the optimum fertilizer application rate was also 300 kg/ha with gross

Table 3: Profitability analysis of the effect of NPK 15:15:15 fertilizer application on the performance of *D. rotundata* cv "Obiaoturugo"

		Fertilizer rate (kg/ha)				
Site	Item	0	100	200	300	400
Evboneka	Output (t/ha)	10.36	17.72	19.12	19.16	11.55
(Forest)	Revenue ($869.57/t)	90088.70	15408.70	16626.09	16660.90	10043.48
	Total variable cost ($)	3060.87	3114.78	3168.96	3222.61	3276.52
	Total fixed cost ($)	334.26	340.80	346.78	352.17	357.57
	Total cost ($)	3395.13	3456.17	3515.00	3574.78	3634.09
	Gross margin ($)	5947.83	12295.65	13457.39	13438.26	6723.48
	Return/$invested	1.94	3.95	4.25	4.97	2.03
	Net return ($)	5613.57	11954.26	13110.61	12999.13	6365.91
	Benefit-cost ratio	1.65	3.46	3.73	3.64	1.75
Sabongidda-Ora	Output (t/ha)	10.10	14.63	16.20	19.57	13.00
(Forest-Savanna	Revenue ($869.57/t)	8782.61	12721.74	14086.96	16660.87	10043.48
transition)	Total variable cost ($)	3060.87	3114.78	3168.96	3222.61	3276.52
	Total fixed cost ($)	334.26	340.80	346.78	352.17	357.57
	Total cost ($)	3395.13	3456.17	3515.00	3574.78	3634.09
	Gross margin ($)	5721.74	9606.96	10918.26	13794.78	8027.83
	Return/$invested	1.87	3.08	3.45	4.28	2.45
	Net return ($)	5387.47	9266.16	10571.48	13442.60	7671.13
	Benefit-cost ratio	1.59	2.68	3.01	3.76	2.11
Ubiaja	Output (t/ha)	11.80	18.57	20.23	24.07	17.02
(Derived Savanna)	Revenue ($869.57/t)	10260.87	16147.83	17591.30	20930.43	14800.00
	Total variable cost ($)	3060.87	3114.78	3168.96	3222.61	3276.52
	Total fixed cost ($)	334.26	340.80	346.78	352.17	357.57
	Total cost ($)	3395.13	3456.17	3515.00	3574.78	3634.09
	Gross margin ($)	7200.00	13033.04	14422.60	18577.38	11523.48
	Return/$invested	2.35	4.18	4.55	5.76	3.82
	Net return ($)	6865.74	12691.65	14075.53	18225.21	11165.91
	Benefit-cost ratio	2.02	3.67	4.00	5.10	3.07

margin, net returns and benefit-cost ratio of 13794.78, 13442.60 and $3.76, respectively (Table 3). However, the optimum fertilizer application rate at the zone was lower (200 kg/ha) with a gross margin, net margin and benefit-cost ratio of 13457.39, 13110.61 and $3.73, respectively (Table 3). The implication of this is that, though the benefit-cost ratio is positive at all the levels of fertilizer application in all the zones, the best returns would be achieved at an application rate of 300 kg/ha for both derived savanna and forest-savanna transition zones and 200 kg/ha for the forest zone. The local farmers in Edo State, who are assumed to be rational, must maintain these levels for optimum returns.

CONCLUSION

It has been shown in this study that the optimum rate of NPK 15:15:15 N fertilizer application is 300 kg/ha for the derived savanna and forest-savanna transition zones and 200 N kg/ha for forest zone in Edo State. This study also showed that the bulk of the total variable cost was expensed on planting materials and labour. Effort should be geared towards encouraging local farmers to maintain these optimum N application rates so as to remain at the economically relevant stage of production. This study should also be geared towards the development of cheaper planting materials and labour saving devices that are cost effective.

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