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EFFECT OF FERTILIZER AND INTERCROPPING WITH PIGEON PEA (*Cajanus cajan*) ON THE PRODUCTIVITY OF YAM MINISETT (*Dioscosrea rotundata*) BASED SYSTEM.

BY

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ABSTRACT

A study was conducted at the National Root Crops Research Institute, Umudike to determine the effect of fertilizer and intercropping with pigeon pea*(Cajanus cajan)* on the productivity of yam minisett based system. Fertilizer application at 200 kg ha $^{-1}$ NPK 20:10:10 compared to other levels (0, 400, 600 kg/ha) significantly increased yam *(Dioscorea rotundata cv obiaoturugo)* tuber yield and productivity of the sole yam minisett cropping system. No significant effect of fertilizer was observed on yam tuber yield in the yam minisett/pigeon pea intercrop. However fertilizer application at 200 kg ha $^{-1}$ NPK 20:10:10 resulted in significantly higher total calorie yield over no fertilizer in both cropping systems (sole and intercrop) and significantly improved the nutrient content (N, P, K, Ca) of pigeon pea biomass in the yam/pigeon pea intercrop. Intercropping yam with pigeon pea significantly increased the productivity of yam based system over sole cropped yam.

INTRODUCTION

Yam tuber yield per hectare is declining in the traditional farming systems of Nigeria due to declining soil fertility (Ano and Ikwelle, 2000). Yam production leads to soil nutrient mining as over 90% of the dry matter is harvested in the form of yam tuber and taken out of the farm (Ano *et al* 2003). Obigbesan and Agboola (1978) reported that an average of about 155 kg N, 12.2. kg P, 176 kg K, 3.9 kg Ca and 10.7 kg Mg per hectare are lost from the soil when yam (*Dioscorea rotundata*) tubers were harvested and taken out of the farm. In the time past the lost nutrients are replenished through long fallowing (Agboola and Unamma, 1994). Fallow periods are now very short and most often non-existent especially in the southern part of Nigeria where population density is high. The future of yam production in the country depends on the development of systems that could stabilize short fallows and thus improve their productivity. Such production systems should ensure that adequate amount of nutrients are in the soil during the growth period of yam and also that large quantity of biomass or residues of other crops which have high nutrient content are left on the soil at the end of the cropping season. Effective utilization of the biomass will make it possible for a farmer to crop his land to another crop in the next cropping season after yam harvest without first allowing the land to rejuvenate under long fallow. Such a system could be achieved through the application of fertilizer and intercropping with compatible crops. The addition of nutrient input from inorganic fertilizer should however be based on the result of scientific investigations since indiscriminate fertilizer use would cause nutrient imbalance in the soil. Appropriate intercrops for yam should not only be able to increase the productivity of yam based

system but should also conserve the soil resource base by ensuring that a large quantity of plant biomass with high nutrient content is left on the soil after crop harvest (Ano *et al*, 2003). Pigeon pea (*Cajanus cajan*) is a legume that grows well in the yam belt of Nigeria. There is no literature on yam minisett/pigeon pea intercropping system. It therefore follows that if pigeon pea is found to be compatible with yam minisett, the system (yam minisett/pigeon pea) will easily be adopted by Nigerian farmers since both crops are already existing in the Nigerian farming systems. The objective of this study was to determine the effect of fertilizer rate and pigeon pea intercrop on the productivity of yam minisett based system.

MATERIALS AND METHODS

The trial was conducted at the research farm of the National Root Crops Research Institute, Umudike, Nigeria (05° 29' N, 07° 33' E) during the 2000/2001 and 2001/2002 cropping seasons. The soil was an Ultisol and had a pH in water of 5.2, 1.47% organic matter, 0.10% total nitrogen, 4.5 Mg kg^{-1} Bray I P and effective cation exchange capacity (ECEC) of 4.5 cmol kg^{-1}

The experiment was a randomized complete block design with four replications and was established in May of each cropping season. The plot size was 6 m x 4 m. The treatments comprised two cropping systems (sole yam minisett and yam minisett/pigeon pea intercrop) and fertilizer rates (0, 200, 400, 600 kg ha-1 of NPK 20:10:10).

Cropping system:

Sole yam minisett

Forty gram yam minisett (*Dioscorea rotundata* cv Obiaoturugo) was planted on the crest of tractor made ridges at 1.0 m x 0.5 m to give a plant population of 20,000/ha.

Yam minisett/pigeon pea intercrop:

Forty gram yam minisett (*Dioscorea rotundata* cv Obiaoturugo) was planted on the crest of tractor made ridges at 1.0 m x 0.5 m to give a plant population of 20.000/ha. Local variety of pigeon pea *(Cajanus cajan)* was planted on the foot of the ridges, one seed per hole at 1 m x 4 m to give a plant population of 2,500/ha. Both crops were planted on the same day in May of each year.

Fertilizer rates:

In 2000/2001 fertilizer rates were three namely 0, 200, 400 kg ha^{-1} of NPK 20:10:10., results obtained from that year (first season) showed that the yam in yam/pigeon pea intercrop did not show any response to fertilizer application. The fertilizer rate was therefore increased to four (0, 200, 400 and 600 kg ha^{-1} NPK 20:10:10) in 2001/2002 cropping season (second season).

Fertilizer was applied at 8 weeks after planting (WAP). Weeding, staking of yam and other agronomic practices were done at the appropriate times. Yam tubers were harvested at 32 weeks after planting (WAP) and weighed immediately. Pigeon pea pods were harvested from the first to the last week of March of the following year. The seeds were dried to 14% moisture content and weighed. Farm gate prices of the harvested crops were obtained. Monetized aggregate yield was calculated as the productivity (Ikeorgu, 2002). Total calorie yield was calculated using the method of Onyenuga (1968). At the end of March, pigeon pea plants were cut and the above ground biomass weighed. Samples were milled and nutrient composition (N, P, K, and Ca) determined according to Udo and Ogunwale (1978). The amount of N, P, K, and Ca contained in the haulm per

hectare was thereafter calculated. The data obtained was subjected to analysis of variance (Gomez and Gomez, 1984) and treatment means compared at 5% probability level.

RESULTS

Yam tuber and Pigeon pea grain yields

Fertilizer application significantly improved yam tuber yield in sole cropped yam. The highest yam tuber yield of 7.38 t ha^{-1} under this cropping system was obtained

With 200 kg ha^{-1} NPK (20:10:10) in 2000/2001 (Table 1). In 2001/2002 cropping season, however, highest tuber yield of 5.62 t ha^{-1} was obtained with 400 kg ha^{-1} NPK (20:10:10), this was not significantly

Table 1. Effect of cropping system and fertilizer on yam tuber yield in sole yam minisett and yam minisett/pigeon pea intercrop.

Cropping system	Fertilizer rate (NPK 20:10:10) kg/ha	Yam tuber yield (t/ha) 2000/2001	2001/2002
Sole yam	0	5.15	3.77
	200	7.38	5.10
	400	7.10	5.62
	600	nd	5.41
	Mean	6.54	4.98
Yam/pigeon pea	0	5.28	4.13
	200	5.15	5.06
	400	5.13	4.33
	600	nd	4.76
	Mean	5.19	4.57
	LSD (5%)		
	Cropping system (CS)	0.81	NS
	Fertilizer rate (F)	0.98	1.16
	CS x F	NS	NS

NS = not determined at 5% probability level
nd = not determined in 2000/2001

Table 2. Effect of fertilizer rate on Pigeon pea grain yield in yam minisett/pigeon pea intercrop

Fertilizer rate (NPK 20:10:10) kg/ha	Grain yield (t/ha) 2000/2001	2001/2002
0	1.35	0.50
200	2.26	0.56
400	1.79	0.82
600	nd	0.51
Mean	1.80	0.60
LSD(5%)	0.03	NS

nd = not determined in 2000/2001

different from the yield of 5.10t/ha obtained with the fertilizer rate of 200 kg/ha (Table 1) Intercropping pigeon pea with yam significantly decreased yam tuber yield compared to sole cropped yam only in 2000/2001 (Table 1). Fertilizer application significantly resulted to higher pigeon pea grain yield over no application only in 2000/2001. The highest grain yield was obtained with 200 kg ha^{-1} NPK 20:10:10. Even though slight increase in pigeon pea grain yield was obtained with fertilizer in 2001/2002, the increase was not significant (Table 2). The calorie yields of the systems were not affected by cropping systems. On the other hand fertilizer at 200 kg ha^{-1} increased calorie yield of both cropping systems (Table 3).

Pigeon pea (Cajanus cajan) biomass (Dry matter)

Application of fertilizer significantly increased pigeon pea biomass production in the two cropping seasons studied. In 2000/2001 cropping season the highest pigeon pea dry matter was obtained with 200 kg ha^{-1} NPK 20:10:10 while in 2001/2002 cropping season the highest pigeon pea

Table 3. Effect of cropping system and fertilizer on calorie yield of sole yam minisett and yam minisett/pigeon pea intercrop

Cropping system	Fertilizer rate (NPK 20:10:10) kg/ha	Calorie yield (KCal/ha) 2000/2001	2001/2002
Sole yam	0	19.63	14.37
	200	28.11	19.45
	400	27.06	21.40
	600	Nd	20.61
	Mean	24.94	18.95
Yam/pigeon pea	0	24.98	15.52
	200	27.71	21.42
	400	25.99	19.45
	600	nd	20.00
	Mean	26.23	19.10
	LSD (5%)		
	Cropping system (CS)	NS	NS
	Fertilizer rate (F)	3.49	3.44
	CS x F	NS	NS

NS = not determined at 5% probability level
nd = not determined in 2000/2001

Table 4. Effect of fertilizer rate on the Pigeon pea biomass (Dry matter) in yam minisett/pigeon pea intercrop

Fertilizer rate (NPK 20:10:10) kg/ha	Biomass (t/ha) 2000/2001	2001/2002
0	5.28	4.56
200	10.07	6.29
400	7.41	8.23
600	nd	4.56
LSD(5%)	3.50	2.85

nd = not determined in 2000/2001

biomass of 8.23 t ha^{-1} was obtained with 400 kg ha^{-1} NPK 20:10:10, this was however not significantly higher than 6.29 t ha^{-1} obtained with 200 kg ha^{-1} NPK 20:10:10. (Table 4).

Nutrient content of the Pigeon pea Dry Matter

Fertilizer application improved the nutrient content (N, P, K, Ca) of pigeon pea biomass (Table 5). In 2000/2001 cropping season the highest values of nitrogen (197.37 kg ha^{-1}), phosphorus (33 kg ha^{-1}), potassium (85 kg ha^{-1}) and calcium (20.2 kg ha^{-1}) in the biomass were obtained with 200 kg ha^{-1} NPK (20:10:10) while in 2001/2002 cropping season, highest amounts of these nutrient elements were obtained with 400 kg ha^{-1} NPK (20:10:10), even though the values were not significantly higher than those obtained with 200 kg/ha NPK(20:10:10).

Productivity of the cropping systems

Productivity of the systems expressed as the revenue that could accrue to a farmer from the proceeds of the crops was significantly higher in both cropping seasons under yam/pigeon pea than sole yam cropping system. Fertilizer application at 200 kg ha^{-1} resulted to significantly higher productivity over zero application in the sole cropping system in 2000/2001 cropping season. Intercropping yam minisett with pigeon pea resulted to mean productivity of N 193.6 x 10^3 and N 121.63 x 10^3 respectively for 2000/2001 and 2001/2002 cropping seasons which were significantly higher than N 130.8 x 10^3 and N 99500 obtained for sole yam minisett in the two respective cropping seasons (Table 6)

DISCUSSION

Fertilizer application increased yam tuber yield in sole yam cropping system. This is as expected because the soil of the experimental site is strongly weathered (Ano, 1990) and of low nutrient status. Intercropping yam with pigeon pea depressed yam tuber yield by 21% and 8% compared to sole yam in 2000/2001 and 2001/2002 cropping seasons respectively. There is distinct difference in the maturity

Table 5. Effect of fertilizer rate on the nutrient composition of pigeon pea biomass in yam minisett/pigeon pea intercrop.

Fertilizer rate NPK(20:10:10) kg/ha	Nutrient (kg/ha)	Cropping season 2000/2001	2001/2002
	Nitrogen		
0		103.49	89.34
200		197.37	123.28
400		145.24	161.31
600		nd	89.38
Mean		148.70	115.83
LSD(5%)		68.59	55.87
	Phosphorus		
0		17.42	15.05
200		33.23	20.76
400		22.23	27.16
600		nd	15.05
Mean		24.29	19.51
LSD(5%)		11.55	10.36
	Potassium		
0		44.88	38.76
200		85.60	53.47
400		62.99	69.96
600		nd	38.76
Mean		64.49	50.24
LSD(5%)		29.76	24.23
	Calcium		
0		106.13	91.66
200		202.41	126.43
400		148.94	165.42
600		nd	91.66
Mean		152.49	118.79
LSD(5%)		70.32	57.30

nd = not determined in 2000/2001

Table 6. Effect of cropping system and fertilizer on the productivity (Naira/hectare) of yam minisett/pigeon pea intercrop.

Cropping system	Fertilizer rate (NPK 20:10:10) kg/ha	Productivity of the system ('000 Naira/hectare)	
		2000/2001	2001/2002
Sole yam			
	0	103.0	75.4
	200	147.5	102.1
	400	142.0	122.3
	600	nd	108.2
	Mean	130.8	99.5
Yam/pigeon pea			
	0	173.0	107.6
	200	215.9	103.6
	400	191.9	127.5
	600	nd	120.8
	Mean	193.6	121.63
	LSD (5%)		
	Cropping system (CS)	25.55	20.01
	Fertilizer rate (F)	20.86	NS
	CS x F	NS	NS

t of yam = =N= 20,000
t of Pigeon pea grain = =N=50,000
N= 120.00 = $ 1.00
d = not determined in 2000/2001

Table 7. Rainfall data of the experimental site for 2000 and 2001*

Month	Year			
	2000		2001	
	Rainfall (mm)	No of rain days	Rainfall (mm)	No of rain days
Jan	14.8	2	0	0
Feb	0.9	1	7.8	1
Mar	13.6	4	175.9	8
Apr	164.5	13	224.1	13
May	153.6	14	194.3	17
Jun	265.5	20	552.5	16
Jul	265.2	21	273.5	17
Aug	216.9	16	179	24
Sep	277.5	23	317.2	23
Oct	228.4	19	277.1	16
Nov	75.9	3	18.6	2
Dec	3.8	2	0	0
Total	1680.9		2220.0	

*Source: National Root Crops Research Institute Meteorology Station, Umudike

Periods yam and pigeon pea which would allow for better use of resources over time. However, yam seems to suffer appreciable degree of competition with pigeon pea which may have been responsible for the significant decrease in yam tuber yield in the yam minisett/pigeon pea in the intercrop system in 2000/2001. There was no response to applied fertilizer by yam in the yam/pigeon pea intercropping system. Even though the soil of the experimental site was poor, pigeon pea is capable of making use of atmospheric nitrogen through nitrogen fixation. Yam may benefit from the fixed nitrogen when the leaves of pigeon pea fall and mineralize. Mineralization of pigeon pea leaves is known to be fast especially under high rainfall and temperature as was the case in the experimental site (Table 7). Nutrients contained in the leaves are returned to the soil. Pigeon pea produces a lot of fallen leaves during the growth period of yam. The nutrients from mineralization of these fallen leaves may have contributed to the Nutrient requirement of yam in the yam minisett/pigeon pea system. Fallen pigeon pea leaves have been reported to contain 1.96% N, 0.85 % K, 0.33 % P, 0.85 % Mg and 2.01 % Ca (Ano, 2000 unpublished). Fertilizer application at 200 kg NPK 20:10:10 significantly increased pigeon pea grain yield over zero application in 2000/2001. In 2001/2002, pigeon pea grain yield was low and was not affected by fertilizer application. The poor performance of pigeon pea in 2001/2002 cropping season is attributed to the very high rainfall experienced in 2001. Excessive rainfall causes poor performance of pigeon pea (Ramakrishna et al 1992). In 2000 and 2001 the total amount of rainfall were 1680.9 mm and 2220 mm respectively (Table 7). Higher productivity was obtained with yam/pigeon pea intercropping system over sole yam cropping system. Ano *et al* (2003) and Mba *et al* (2003) attributed higher productivity obtained with root crop/legume intercrop over root crop alone to the enhanced revenue from the legume. Pigeon pea grains cost 2.5 times the cost of yam tubers on per kilogram basis. Increased pigeon pea biomass and nutrient composition of the biomass obtained with fertilizer over no application was as expected because the soil of the experimental site was of low nutrient status. Application of fertilizer improved the level of nutrients available to the pigeon pea crop leading to higher biomass and nutrients in the plant's tissue.

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