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Increasing Productivity of Yam (*Dioscorea rotundata*) Through Improved Cultural Management Practice in South – South Nigeria

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ABSTRACT
Yams (*Dioscorea*) are among the food sources in the country especially in times of food scarcity. *D rotundata* locally known as white yam is one of two species, which are economically important in South – South Nigeria. To date, no modern production technology has been developed for this crop as such as productivity is relatively between 26t/ha and 35t/ha in farmers fields. Assessment of yam farmer's current production practices shows the need to fine-tune some of its components. The most critical of them are fertilizer and seed management. Hence, field experiments were conducted to improve the existing cultural management practices for increased yam production. It was found that white yam can be successfully grown for three consecutive years without using fertilizer on virgin soils with yields comparable with those applied with organic and inorganic fertilizers. Nevertheless, a declining trend in soil fertility of the unfertilized plots, implying the depletion of the soil's natural fertility, which might cause the drastic decline in yield after three consecutive cropping. With this, the capacity of the soil to produce high yield is sustained, therefore, shifting cultivation, a common practice among yam growers, is minimized. In addition, the use of medium setts (40-89) was found to significantly produce more vigorous plants and higher crop stand resulting to an increase in yield by 138% as compared to the farmers practice of using small setts.
Keywords: Yam, sustained, yield, improve, cultural, management, practice

INTRODUCTION

Yam (*Dioscorea*) is an important food source especially in rural communities. Traditionally, yam is a minor root crop, a low priority commodity. These crops thrive well in marginal areas where the more important crops cannot be successfully grown. Yam is a very important crop for food security because of its excellent storage properties; it can be stored four to six months without refrigeration and provides an important food safety net between growing seasons. *Dioscorea esculenta*, and *rotundata* grown in the Indian sub continent, in Southern Vietnam, in the South Pacific islands, in the Philippines and West African respectively are most nutritious yam (htt://www.croptrust.org/main). Recent research studies have shown that yam can also be processed and cooked into various food products. The acceptability of processed yam as a functional ingredient in food products was evaluated and found to be an excellent substitute to modified starches and a functional ingredient for low pH processed food like sauce and salad dressing (Amani et al, 2004).

Traditionally, yam is grown with minimal or no intervention at all and thrives well in marginal areas. However, this growing condition explains the very low yield obtained in farmers' field, which is only around 2.6t ha^{-1} -3,3t ha^{-1} (BAS, 2002). Hence, one way to increase yam production is to improve its existing production management. In Papua New Guinea, Ernest and O,Sullivan (2003) studied the effect of improved fallow and live-staking of yam using *Gliricidia sepium*. Results from four trial sites showed no difference in yield attributable to staking system, while NPK fertilizer increased yield by 50% (from 18.6 to 27.9t/ha) in two Bogia District sites, but not in two Markham Valley sites (http://www.cropscience.org.au). Moreover, in Diby's study in Ivory Cost, the leaf area index (LAI), tuber diameter and final yield of two yam species were influenced by fertilizer application and soil characteristics. The values for these parameters were significantly increased in the most characteristics. The values for these parameters were more marked for D. *alata.* Fertilizer application enhanced the yield in the Savannah site, whereas slight or even negative fertilizer responses were recorded in the forest site (http://www.cropscience.org.au/ics2004). Elfick (2008) recommends that yams planted in soil, which has just been cleared from bush does not usually need any fertilizers. If the soil has had yams or other crops growing in it before, it is advisable to apply it with some fertilizer (http://www.uq.edu.au/School-Science-Lessons).

The production statistics of yam, especially white yam point to middle belt region as the top grower. In fact, half of the yam produced in the in the country comes from the middle belt. Majority of the farmers in middle belt consider yam as a cash crop, being one of the crops that can be successfully grown in this area. However, production is limited to only $26tha^{-1}$. Based on the feedback of farmers, the absence of a recommended technology for yam largely contributes to its yield status.

Assessment on the existing farmers' cultural management practices prompts the need to fine – tune some of its components, particularly on nutrient and seed management. In middle belt region, yam farmers do not apply fertilizer to their plants that is why they need to look for a new area to plant their crop after at least three years of continuous cropping in the same area due to the possible drastic decline in yield. This is the reason why farmers cannot do away with shifting cultivation. Another contributory factor to the low yield is the use of planting materials or setts averaging about 20-30g. As observed, farmers sell their quality produce while they set aside small and non-marketable ones for household consumption and some are set aside as planting materials. In selecting seed stock, it is a general rule that the premium produce should be chosen as planting materials to ensure quality. In line with that, several field experiments were initiated to develop or improve existing management practices that could be integrated as package of technology (POT) components for yam. Hence, the objective of this work is to develop an improve management practice for yam sustainable yield.

METHODOLOGY

Experiments that fine-turn famers' cultural management practices were done from 2013 to 2016 in order to develop a technology that could increase the productivity of this crop. In three years, field experiments were conducted to improve the existing management practices, which could increase yam production via fertilizer application and seed management. Except for the specified treatments, management practice employed in conducting the field experiments were based on the Standardized Techniques for Root crops Evaluation developed by National Research Institute Umudike. The detailed methodology for each experiment is presented below.

Response of yam to *fertilizer application*: Traditionally, farmers hardly apply fertilizer to their yam crops. However, they claimed a drastic decline in yield after two to three consecutive years of planting in the same area. To draw a scientific basis of this observation, an experiment, which assumed that the drastic decline in yield is due to the depletion of the natural soil fertility after three consecutive years of cropping without using any fertilizer was done. The same area was used for each treatment in three cropping seasons. Soil samples before and after each cropping season were taken for analysis.

In the experiment, three fertilizer treatments were evaluated: T_1- Inorganic (30-30-30kg N_1 P_2O_5 K_2O/ha); T_2 organic (2 tons/ha); and T_3- No fertilizer application. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental unit was spaced 2m apart; hence, there were a total of 30 hills per plot. The fertilizer treatments were basically applied. Meanwhile, the setts were planted at 0.50m in between. Hilling – up was done two months after planting (MAP) and stakes were provided for each hill, which served as anchor for the vines. Weeding was done whenever necessary. The plants were harvested at 10 MAP.

Effect of the sett size on yam yield: This experiment assumed that one factor contributing to the low yield of farmers is the use of small setts. Hence, the experiment used different seed sizes as treatments: big (>90g), medium (40-89g), and small (>40g). The study was laid – out in RCBD with three replications. The experimental unit was a 15m^2 plot with three rows, each spaced at 1m apart, with a total of 30 hills per plot. Fertilizer was basically applied at a rate of 30-30-30kg N_1 P_2O_5 and K_2O ha^{-1}. Moreover, the setts were planted at 0.50m apart. Hilling – up was done at 2 MAP and stakes were provided for each hill serve as anchor for the vines. Weeding was done whenever necessary. Eventually, the plants were harvested at 10 MAP.

RESULTS AND DISCUSSION

Response of white yam to fertilizer Application

Generally, it was found that there were no significant differences among treatments across all parameters observers. Percentage of hills harvested was high all cropping seasons (Table 1). Notably, yield during the first year of the experiment was lowest on plots applied with inorganic fertilizer although differences were very little and were not significantly different among treatments. Highest yield (t ha^{-1}) was obtained in the second year with an average of 15-17t ha^{-1} wherein unfertilized plots produced the highest yield (17, 44ha^{-1}). In the third year however, the decline in yield was very apparent particularly on plots applied with organic fertilizer and those that were not applied with fertilizer (13.58 t /ha^{-1} and 13.63t/ ha^{-1}, respectively). The decrease in yield on plot applied with organic fertilizer, which was a little bit lower than the plots without fertilizer, was expected because the conversion period in organic farming is about 3-5 years. This means that the effect of the organic fertilizer which was applied could hardly be manifested in crops' performance in the first cropping years. That is entirely different from the boom and bust pattern observed when using inorganic fertilizer.

Further, the average number of tubers per hill was noted and findings indicate that more tubers were produced in the second year regardless of the treatments. It was likewise observed that plots applied with inorganic fertilizer produced the most number of tubers during the third year.

Data on average tuber weight show that bigger tubers were produced in the second year of trial. Interestingly, data gathered further show that plots without fertilizer application produced the biggest tubers in the first two years of the experiment. In the

Table 1. Percent hills harvested and computed yield (t ha^{-1}) of white as affected by yam organic and inorganic fertilizer application.

TREATMENT	HILLS HARVESTED (%)			COMPUTED YEILD (t ha^{-1})		
	Y1	Y2	Y3	Y1	Y2	Y3
	ns	ns	ns	ns	ns	ns
Inorganic	82.22	98.88	93.33	10.74	15.67	16.01
Organic	91.11	93.33	85.55	11.86	16.86	13.58
No fertilizer	94.44	93.33	93.33	11.80	17.44	13.63
	ns	ns	ns	ns	ns	ns

ns – not significant.

First year, the said treatment produced tubers with an average weight of 74.31g as compared with those applied with fertilizer, which had an average weight of less than 60g. In the second year, plots without fertilizer produced tubers with an average weight of 77.7g while those applied with inorganic and organic fertilizer had an average weight of 70.39g and 66.34g respectively. In the thirds year however, plants without fertilizer produced tubers with an average weight of (77.7g) while those applied with inorganic and organic fertilizer had an average weight of 70.39g and 66.34g respectively. In the third year however, plants without fertilizer produced the smallest tubers (50.18g) as compared with those applied with inorganic (57.21g) and organic fertilizers (56.73g).

The highest percentage of marketable tubers in terms of number and weight was the direct result of the bigger tubers produced in the second year of trial (Table 3). That result follows the general trend that unfertilized plants, which registered the highest percent marketable tubers in the last two years, eventually had the lowest in the third years.

Congruent to farmers claim, result imply that yam can successfully grown in newly cultivated areas without applying fertilizers as evidenced by their higher through comparable yield with the fertilized ones. Moreover, unfertilized plants were able to produced high yield, which was comparable with the fertilizer plants (either) (organic or inorganic) for three consecutive years.

Table 2: Average number of tubers per hill and average tuber weight (g) of white yam as affect by organic and inorganic fertilizer application

TREATMENT	AVE. NUMBER OF TUBER/HILL			AVE. TUBER WIEGHT (g)		
	Y1	Y2	Y3	Y1	Y2	Y3
Inorganic	8.94	10.27	16.53	59.89	70.39	57.21
Organic	10.51	11.60	15.87	56.41	66.34	56.73
No fertilizer	8.39	11.53	15.13	74.31	77.70	50.18
	ns	ns	ns	ns	ns	ns

ns – not significant

Table 3: Percent marketable tubers (by number and weight of *White yam* as affect by organic and inorganic fertilizer application.

TREATMENT	PERCENT MARKETABLE (NO)			PERCENT MARKETABLE (WT)		
	Y1	Y2	Y3	Y1	Y2	Y3
	ns	ns	ns	ns	ns	ns
Inorganic	26.07	39.74	26.94	48.56	66.57	51.78
Organic	27.49	35.94	26.08	51.51	66.55	49.03
No fertilizer	34.13	45.23	22.98	52.35	70.92	48.91

ns – not significant

This is attributed to the natural soil fertility, which provided enough nutrients for the plants within the experimental period. This result concurs with Elfick's observation, which prompted him to recommend that yams planted in soil, which has just been cleared do not usually need any fertilizers. However, if the soil has been used to grow yams or other crops earlier, fertilizer application is recommended (http://ww.uq.edu.au/School-Science -Lesson.

After the third year of the experiment natural soil fertility was depleted (Table 4). Generally, highest reduction in soil nutrient content was observed on plots applied with inorganic fertilizer and those not applied with fertilizers. In terms of organic matter reduction, the highest was recorded in unfertilized plots. However, the difference in percent reduction with treatments applied with inorganic fertilizer was very nil. Similar trend was observed in terms of nitrogen reduction. Nevertheless, phosphorus content of plots applied with organic fertilizer increased while that of the plots under the other two treatments decreased by 35%. Meanwhile, highest percent reduction on potassium was observed in unfertilized plots. Although plots applied with inorganic and those not applied with fertilizers had almost the same fertility status after three years, a relatively high yield was still obtained by the former. This means that the plant were able to convert the applied supplemented fertilizer into economic returns.

Further, soil analysis results show that plots applied with organic fertilizer had the highest soil fertility after three years. This implies the capacity of the soil to sustain yield, which was comparable with those applied with inorganic fertilizer for the succeeding years. Although the yield obtained in unfertilized plots were comparable with their fertility declined. Such trend may cause a drastic reduction in yield during the succeeding years, most especially if supplemental fertilizer is not applied.

Table 4: Soil analysis before and after the conduct of the fertilizer experiment.

TREATMENT	OM		N		P		K	
	(%)	% reduction	(%)	% reduction	(ppm)	(%) reduction	(ppm)	% reduction
Before the experiment	1.89		0.0945		31.95		1054.13	
After 3 years								
Inorganic	1.216	35.66	0.0608	35.66	20.77	34.99	390.11	53.19
Organic	1.516	19.78	0.058	19.78	38.37	-20.09	493.35	53.19
No fertilizer	1.203	36.34	0.0601	36.40	20.58	35.58	408.30	61.26

Additionally, soil analysis results show that plots applied with organic fertilizer had the highest resident soil fertility results after three years. This implies the capacity of the soil to sustain yield, which was comparable with those applied with inorganic fertilizer for the succeeding years. Although the yields obtained in unfertilized plots were comparable with their fertility declined. Such trend may cause a drastic decline in yield during the succeeding years, most especially if supplemental fertilizer is not applied.

Effects of Setts on Yam Yield

Yam farmers practice using smaller tubers or setts caused their low production. Result of the experiment shows comparable treatment effect in most of the observed parameters. As recorded at 2 MAP, the highest percent emergence was obtained on medium-sized setts (88.89%). However, this was comparable with the big setts having an average of 84.44% (Table 5). Meanwhile, small setts significantly had the lowest emergence with an average of 61.11%.

In addition, percent hills harvest was comparable in all treatments. In fact, a decline in plant survival was evident in all treatments, which could be attributed to the heavy sustained rainfall during the growth stages of the crop. In terms of vigor, big, and medium setts significantly produced more vigorous plants while small setts produced food to sustain the growing seedlings while their roots are not yet fully developed. Hence, seedlings produced from bigger tubers have an advantage over those from smaller ones at the early growth stages.

As shown in Table 6, treatment effect on yield components were not significant in terms of the average number of tubers per hills average weight of tubers and average per hill.

Table 5: Percent emergence, percent effects on yield and plant hills harvest and plant vigor of yam as affected by setts size.

TREATMENT	EMERGENCE	HILLS HARVESTED (%)	PLANT VIGOR
BIG	84.44^a	81.11	8.30^a
MEDIUM	88.89^a	77.77	7.70^a
SMALL	61.11^b	52.21	5.70^b
CV (%)	10.96	22.60	9.25

Means followed by the same letter are not significantly different at 1% level by DMRT
Significant at 5% level
Vigor: 9-very vigorous to 1-very poor vigor
ns- not significant average per hill.

Nevertheless, numerical values show that bigger setts produced plants, which were more superior to those coming from the smaller ones. The average number of tubers per hill ranged from 6.67-8.51, with medium setts having the highest. On the other hand, average weight of tubers ranged from 47.60g to 62.20g while average yield per hill was 321.30g to 502.30g. The bigger setts produced heavier tuber and the highest yield per hill. This trend was followed by the medium ones.
In spite of the comparable effects on yield components, significant difference was observed on computed yield per hectare (Table 7). Big and medium setts significantly produced the highest yield with an average of 8.00t/ha and 7.69 t/ha respectively. Lowest yields were obtained on small setts with only 3.23 t/ha which was comparable with yields obtained by farmers. No significant difference was observed on percent marketable tubers although small setts numerically produced the least marketable tubers.

Table 6: Average number of tuber per hiss, average weight of tubers, and average yield per hiss of white yam as affected by sett size

TREATMENT	AVE. NO. OF TUBER PER HILL	AVE. WEIGHT OF TUBERS (g)	AVE. YEILD PER HILL (g)
BIG	8.04	62.20	502.30
MEDIUM	8.51	59.62	497.30
SMALL	6.87	47.60	321.30
CV (%)	24.56	15.09	21.96
	ns	**ns**	**ns**

ns- not significant
Means followed by the same letter are not significantly different at 1% level by DMRT

Table 7: Computed yield and percent marketable tubers (by number and weight) of white yam as affected by the size of sett.

TREATMENT	COMPUTED YEILD ($t\ ha^{-1}$)	PERCENT MARKETABLE BY NUMBER	TUBER BY WEIGHT
MEDIUM	7.69^{a}	37.36	63.53
SMALL	3.23^{b}	24.78	50.75
CV (%)	26.36	19.51	14.08
	*****	**ns**	**Ns**

*-significant at 5% level
Means followed by the same letter are not significantly different at 1% level by DMRT.

CONCLUSIONS AND RECOMMENDATION

Yam can be grown without the use of inorganic input, hence, its hazardous effects to human and animal life and the environment are limited. Although applying inorganic fertilizers sustains high yield, it is not significantly different from those applied with organic fertilizer and those without fertilizer. On the other hand, soil fertility analysis shows that applying organic fertilizer sustains soil fertility, which prompts farmers to plant the crop in the same area without any fear of drastic yield decline. With this, shifting cultivation is avoided and its negative effect to ecological balance is abated. In addition, the use of medium setts produced plants with better growth and significantly increased yield by 138%, which is equivalent to an ROI of 1.69. Therefore the use of medium setts for production of white yam together with organic fertilizer application is recommended from this study.

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