Evaluation Of Soil Amendments For Sustainable Seed Yam Production And Tuber Storage In Southeastern Nigeria

[1]Obiefuna, J.C., [1]Okoli, N. A., [1]Emma-Okafor, L.C, [1]Alagba, R. A. and [1]Ibeawuchi, I.I.
[1]Department of Crop Science Technology
Federal University of Technology Owerri, Nigeria
Email: lilianokafor35@yahoo.com

***Abstract*—Yam, like other heavy feeder of the ecozone contributes to the low soil fertility of ultisols in Southeastern Nigeria. Sustainable crop production creates the need for soil fertility and acidity management through the application of assorted animal manures and limes as organic soil amendments. Two years (2014 and 2015) field trials investigated the effect of the application (10 t ha^{-1} each) of four animal manures (poultry manure, pig waste, cow dung and goat droppings) mixed respectively with four rates; 0.0, 2.0, 4.0 and 8.0 t ha^{-1} of palm bunch ash (PBA) from the University farm. The 4x4 treatments mixtures and NPK fertilizer control was ring applied to two yam varieties (Dioscorea rotundata and D. alata) in two equal splits at two and six weeks after vine sprout. The yam setts each 400± 5g were spaced 1.0 x 1.0 m in 4.0 x 4.0 m plots. The factorial experiments were laid in a randomized complete block design in three replicates. Routine agronomic practices were practiced. Growth and yield data were collected and analyzed using Genstat Release 4.24 DE 2008 window. The means were separated using Fishers Least Significance Difference (FLSD) at 5% probability. Soil amendment mixtures showed significance seed yam yields and storage variations which were superior to those of the control in the two yam varieties. Application of sole poultry manure produced superior seed yam yield (48.62 t ha^{-1}) followed by pig waste (42.64 t ha^{-1}), goat manure (40.56 t ha^{-1}) and cattle manure (38.06 t ha^{-1}) respectively. However, seed yam storage was poor (42-60%) when manure is applied solely with organic manure especially poultry manure for the two cropping seasons. Seed yam produced with organic soil amendment mixtures showed significantly ($P \leq 0.05$) heavy yields, prolonged shelf life minimized rot in both yam varieties for the two years over the control and sole applications of animal manures. Application of poultry manure 10 t ha^{-1} and 4.0 t ha^{-1} palm bunch ash mixtures produced the heaviest seed yam weight (65.86 t ha^{-1}) which stored satisfactorily (92-98) and sprouted early (five months after harvest). Pig waste (10 t ha^{-1}) and PBA (8.0 t ha^{-1}) mixture is the next alternative in yield and storage (86%). Soil residual nutrients status was low in the control resulting to over 50.0% yield reduction in the second year. Poultry manure and palm bunch ash mixture (10:4 t ha^{-1}) is recommended for quality commercial seed yam production in Southeastern Nigeria.**

Keywords—Soil amendment, animal manure, seed yam production

I. INTRODUCTION

The need for self sufficiency in food production in Nigeria is a prime concern of all Nigerians particularly women and children, governments, agriculturists and economic development agents [1]. Moreover, rapid population growth in Nigeria posses a great challenge to food production to satisfy food, feed and raw materials needs [2]. This scenario increases the overall demand for the food crops [3]. Yam (*Dioscorea spp)* is a major food crop widely grown and massively consumed as an important source of carbohydrate in the diet of most Nigerians. Also, yam contributes about twenty percent of the daily calorie intake of Nigerians [3]. There has been a general decline in yam production in Nigeria over the years. Recent studies showed that both the area under yam cultivation and total yam output declined at compound rates of 1.88% and 1.49% per annum respectively [4]. This was associated with many problems in yam production to include the laborious method of cultivation and harvesting, extreme sensitivity of the crop to intrusion by other crops and weeds, poor storage, difficult breeding, scarcity and high cost of sets, and poor soil [5]. The dominant soil type in yam producing areas of southeastern Nigeria is very low soil nutrient fertility ultisol [6]. In this ecozone, crop yield improvement has depended heavily on fertilizer inputs (organic and inorganic). Inorganic fertilizer use is problematic ranging from aggravated soil acidity to scarcity and high cost [7]. The advocated alternative is the use of organic manures and mixtures for the numerous benefits especially environmentally friendliness [8], [9]. Thus, for improved crop production in the ecozone, the appropriate use of soil amendments especially animal manure and organic limes is required [10].

Nigeria is the largest producer of yam in Africa [2]. Planting materials constitute about 33% of the total cost of yam production [2].Several authors have documented the importance of yam as a staple with high nutritive value in most areas of West and

Central Africa [11, 12].In spite of its importance in the economic life of Nigerians, peasant yam cultivation with crude implements and the ethnocentric attachment to yam is very strong in areas of its production [13]. In most parts of Nigeria, yams are a symbol of wealth and influence in the community. This attachment has ironically aggravated the food crises by making producers fail to consider total food availability systems in favor of production of other crops like cassava, where food return to input ratio under existing technology is more profitable than that of yams [1]. Traditionally, yam is propagated by means of the tuber. Whole seed tubers of 100-500g or larger tubers cut into approximately 200g pieces are planted [14];[15]. In practice, this implies that over 20% of the annual yam production is reserved for planting. However, the possibility of propagating yams by several seed types is available [16]; [17]. However, of all these types of yam propagation, only the use of tuber pieces (sets) readily results in reasonable tuber yield at harvest. For this reason nearly all the commercial yam production relies on the use of tubers or tuber pieces as planting material. Therefore, the commercial planting material for yams is also the edible tubers. Thus, severe competition exists between yam tubers as food and seed yam in yam production. The hunger pressure favors yam tubers demand for consumption [18]. Furthermore, yam setts rot more heavily in storage prior to planting [5]. This paper attempted to improve the seed yam and tuber storage through the application of appropriate animal manure/palm bunch as mixtures as a sustainable soil amendment and manure seed yam production package in southeastern Nigeria.

II. MATERIAL AND METHODS

The experiment was conducted at the Teaching and Research Farm, Federal University of Technology, Owerri, latitude 05^{O} 27" N, and longitude 07^{O} 02" The annual rainfall is heavy (>2000 mm), bimodal and distributed over 5 months rainy season (March to October) followed by four months dry season (November to February). The average temperature of 25-75^{O}C and relative humidity of 82-85% are prevalent. The soil is an ultisol characterized by high acidity and low nutrient soil fertility [6]. The three year fallow experimental site was cleared, ploughed, harrowed and ridged 1.0 x1.0 m apart. The experimental plots were marked out 4.0 x 4.0 m and provided with 2.0 alleys between plots and blocks. Random auger samples (0-30cm depth) were collected from the experimental site for pre-cropping soil physicochemical analysis. Soil samples were similarly taken on treatment basis after second year yam harvest and analyzed. The four animal manures (poultry, pig, goat and cattle) came from university livestock unit then organic oil palm bunch ash was sourced from Ada Oil Palm Limited, Imo State. Animal manures and palm bunch ash were analyzed for chemical properties [19]. The treatments consisted (10 t ha $^{-1}$ each) poultry manure, pig waste, goat droppings and cattle dung mixed with 0.0, 2.0, 4.0, and 8.0 t ha $^{-1}$ of palm bunch ash. The control yam varieties received 400kg NPK 15:15:15 per hectare. The 4 x 4 factorial experiment was laid in Randomized Complete Block Design replicated three times for two yam varieties *Dioscorea rotundata* and *D. alata* for the two consecutive years 2014 and 2015. The yam setts (400± 0.5g) were sourced from Department of Crop Genetic Resources Unit and spaced 1.0 x 1.0 m on the ridge in the field. The animal manure/organic lime mixtures were applied by the ¾ ridge band method two weeks after yam sprouting. Growth and yield analyses were statistically analyzed using Genstat Release 4.24DE 2008 window. The means were separated using Fisher's Least Significant Difference (FLSD) at 5% probability.

III. RESULT AND DISCUSSION

The preliminary chemical properties of the experimental soil and soil amendment materials (poultry, pig, goat and cattle manures) and the organic lime (palm bunch ash) revealed marked nutrient variations as in Table1. The soil acidity is moderate (5.82) while nitrogen, potassium, magnesium and calcium were low. The soil was thus low in nutrient contents and therefore low in fertility [6]. Most of animal manures are alkaline and high in mineral nutrients in which the soil was grossly deficient.

Table 1: Chemical properties of soil and soil amendment materials

Chemical properties of soil amendments/soil						
Amendments	pH	N (%)	P (ppm)	Cmolkg^{-1} K	Mg	Ca
Cattle manure	6.21	0.70	0.50	0.15	0.21	0.20
Pig manure	6.88	1.45	1.20	0.28	0.21	0.60
Goat manure	6.80	0.90	0.40	0.07	0.23	0.25
Poultry manure	7.58	1.60	1.50	0.23	0.19	0.75
Palm bunch ash	11.20	2.10	3.05	0.98	0.20	0.58
Soil	5.82	0.18	8.63	1.54	0.16	0.64

The sole application of animal manures significantly (P≤ 0.05) produced superior seed yam yields of *D. rotundata* to those*D. alata* for the two consecutive years (Table 2).

Table 2: Yield summary of seed yam production (t ha^{-1}) for two cropping seasons of *D. rotundata* and *D. alata*

Organic manure (10 t ha^{-1})	**Lime t ha^{-1}**	***D. rotundata* yieldt ha^{-1}**			**D. alata yieldt ha^{-1}**		
		2014	**2015**	**Mean**	**2014**	**2015**	**Mean**
Poultry manure	0.0	48.62	48.84	48.73	58.66	59.88	59.20
	2.0	60.64	62.42	61.53	56.24	52.52	54.30
	4.0	65.86	66.54	66.20	58.94	60.58	59.70
	8.0	62.54	62.58	62.50	58.64	60.45	59.50
	$\bar{x}$	59.42	60.10	59.74	51.12	58.36	58.18
Pig waste	0.0	48.64	32.36	40.50	50.12	54.02	52.00
	2.0	50.62	61.62	56.10	58.62	56.46	57.50
	4.0	50.56	64.08	56.30	64.24	62.50	63.30
	8.0	58.05	62.86	56.70	60.56	50.54	55.00
	$\bar{x}$	51.96	55.23	52.40	58.39	55.88	56.95
Goat droppings	0.0	46.65	42.65	44.60	50.28	50.64	50.40
	2.0	54.46	54.08	54.20	52.02	54.42	53,20
	4.0	54.02	56.42	55.20	54.52	56.52	55.50
	8.0	54.02	56.28	55.10	54.48	56.42	55.60
	$\bar{x}$	52.29	52.36	52.28	52.83	55.00	53.68
Cattle dung	0.0	38.06	44.58	41.30	45.56	51.08	48.30
	2.0	40.26	46.64	43.40	46.28	56.28	51.20
	4.0	46.52	50.42	48.40	48.46	52.48	56.40
	8.0	42.64	48.60	45.60	48.42	54.50	51.40
	$\bar{x}$	41.86	47.58	44.68	47.18	53.59	51.30
Control (NPK		44.56	46.42	45.49	46.52	39.84	43.18
LSD $_{0.05}$ for manure		2.62	2.56	1.06	4.02	2.46	1.24
LSD $_{0.05}$ for lime		2.08	1.84	2.00	2.12	2.08	1.42
LSD $_{0.05}$ for organic manure x lime		2.04	2.04	1.08	1.06	1.42	0.86

However, application of increasing levels of organic limes to each of the animal manures produced equally heavy seed yam yield which were heavier than those of the control. The combination of poultry manure (10 t ha^{-1}) with 2.0, 4.0 and 8.0 t ha $^{-1}$ palm bunch ash respectively produced heaviest seed yams followed by pig, goat, and cattle manures in similar lime mixtures respectively. The control produced the least. Most seed yam yields of *D. rotundata* under the various soil amendment mixtures were superior to those of *D. alata* for the two cropping seasons. The seed yams of *D. rotundata* and *D. alata* responded differently in shelf life, earliness to sprouting and percentage seed yam tuber rot in storage (Table 3).

Table 3: The effect of animal manure and palm bunch ash mixtures on cumulative seed yam shelf life (months) and seed yam storage (months) of two yam varieties for 2014 and 2015 cropping seasons.

Organic manure (10 t ha^{-1})	Ash (t ha^{-1})	*D. rotundata*			*D. alata*		
		Shelf life (months)	Months for 50% sprouting in storage	Seed yam rot %	Shelf life (months)	Months for 50% sprouting in storage	Seed Yam rot %
Poultry manure	0.0	4.49	5.48	28.54	4.02	5.86	34.26
	2.0	8.13	5.68	17.60	6.02	5.88	22.08
	4.0	8.84	5.14	18.54	6.42	5.46	21.54
	8.0	9.08	5.16	18.06	6.38	5.44	21.42
	$\bar{x}$	7.64	5.37	20.69	5.71	5.66	24.83
Pig waste	0.0	4.06	6.48	24.54	7.54	5.62	35.58
	2.0	8.53	6.44	12.62	7.82	5.60	12.64
	4.0	8.02	6.02	8.72	7.82	5.14	10.44
	8.0	8.68	6.04	8.66	7.92	5.24	10.52
	$\bar{x}$	7.32	6.25	13.64	7.78	5.40	17.30
Goat droppings	0.0	4.64	6.62	28.54	6.44	6.82	26.04
	2.0	7.62	6.58	16.42	5.26	7.64	14.28
	4.0	8.40	6.56	12.48	5.42	7.08	12.40
	8.0	8.44	6.44	12.52	5.08	7.42	12.40
	$\bar{x}$	7.28	6.54	17.49	5.55	7.24	16.28
Cattle dung	0.0	4.04	5.44	29.62	6.82	6.28	25.08
	2.0	8.44	5.42	18.48	6.80	7.62	14.42
	4.0	8.56	5.06	14.47	6.82	7.84	12.28
	8.0	8.54	5.08	14.24	6.84	7.86	12.26
	$\bar{x}$	7.34	5.25	19.21	6.82	7.40	16.01
Control (NPK)		4.56	4.24	48.68	6.48	4.52	58.64
$LSD_{0.05}$ for manure rates		1.26	1.04	2.04	2.40	1.04	2.04
$LSD_{0.05}$ for lime rates		0.02	1.02	2.21	1.08	1.56	2.22
$LSD_{0.05}$ for manure x lime		0.48	1.84	1.26	1.16	1.48	1.62

Seed yam produced with sole application of animal manures stored poorly (four (4) months) after harvest and had the highest percentage of seed yam rot. The poor storability and rot is aggravated by heavy animal manure which stimulated excess cell growth and enlargement expression [9]. The shelf life of the seed yams improved when manured with animal manures fortified with increasing levels of palm bunch ash. The same mixture also enhanced sprouting and reduced percentage seed yam rot in yam both seed yams produced with NPK fertilizer (control) were inferior in quality to those produced with animal manures/palm bunch ash mixtures. The control was inferior to all animal manures/palm bunch ash mixture. The application of sole animal manures or in mixture with palm bunch ash for the production of yam setts of *D. rotundata* and *D. alata* significantly ($P \leq 0.05$) improved the post harvest soil properties (Table 4).

Table 4: Post-harvest seed analysis for animal manure/lime mixtures used for the seed yam production of two yam varieties in southeastern Nigeria

Animal manure (10 t ha^{-1})	Lime (t ha^{-1})	*D. rotundata*				*D. alata*			
		pH	N (%)	P (ppm)	K Cmolkg^{-1}	pH	N (%)	P (ppm)	K Cmol kg^{-1}
Poultry manure	0.0	7.56	0.82	16.02	1.72	7.62	1.12	17.06	1,52
	2.0	8.04	1.42	16.12	1.62	7.88	1.52	16.52	1.58
	4.0	8.22	1.48	18.56	2.06	8.42	1.48	17.48	2.10
	8.0	8.54	1.62	20.28	2.18	8.58	1.50	17.64	2.48
	$\bar{x}$	8.09	1.34	17.75	1.87	8.15	1.43	17.18	1.90
Pig waste	0.0	7.54	0.36	15.64	1.54	8.16	0.64	13.84	1.08
	2.0	7.62	1.26	16.18	1.62	8.24	1.18	14.60	1.52
	4.0	7.85	1.42	16.20	1.64	8.56	1.54	18.66	1.64
	8.0	7.42	1.48	16.28	1.68	8.62	1.48	18.50	1.66
	$\bar{x}$	7.61	1.13	16.08	1.62	8.40	1.21	16.40	1.48
Goat droppings	0.0	7.08	0.68	15.46	0.88	7.14	0.72	15.18	0.86
	2.0	8.42	1.12	14.18	1.04	8.24	1.12	15.62	1.24
	4.0	8.56	1.11	14.26	1.18	8.40	1.28	15.60	1.42
	8.0	8.62	1.26	15.18	1.26	8.82	1.42	16.08	1.62
	$\bar{x}$	8.16	1.04	14.77	1.09	8.15	1.14	15.62	1.29
Cattle	0.0	6.28	0.66	13.50	0.86	7.04	0.72	13.62	0.76
	2.0	8.62	1.02	14.62	1.06	8.18	1.28	14.08	1.08
	4.0	8.64	1.22	14.68	1.25	8.24	1.46	14.28	1.28
	8.0	8.68	1.46	15.44	1.56	8.40	1.82	15.06	1.46
	$\bar{x}$	8.06	1.09	14.56	1.18	7.97	1.31	14.26	1.15
Control NPK		4.68	0.16	10.06	0.78	5.84	0.26	17.64	0.81

Although, the soil was acidic at planting, as in the control, the soil in all other treatments were alkaline including sole application of animal manures. Animal manure in sole or mixture with palm bunch ash significantly improved the nutrient contents after two years cropping for seed yam production. The practice is sustainable and recommendable [8]. The choice then depends on animal manure/palm bunch ash mixture, amendment availability, culture and scale of economy.

IV. CONCLUSION

Seed yam production in the tropical ultisol using soil amendment is significantly sustainable. However, application of sole animal manure 10 t ha $^{-1}$is apparently excessive and needs further fine turning for balanced seed yam yield and quality production.. Further work should exploit other organic limes including kitchen ash and activated charcoal.

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