NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 54 Number 2, December 2023 Pg. 110-116
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

Integration of NPK 15:15:15 Fertilizer and Poultry Manure on Production and Profitability of Orange Flesh Sweetpotato/Garden Egg Intercrop in Rain Forest Zone of Nigeria

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Abstract
The study was conducted at National Root Crops Research Institute (NRCRI), Umudike farm in two cropping seasons, to determine optimum organic and inorganic fertilizer rates for orange flesh sweetpotato (OFSP)/garden egg intercrop. The experiment was 2 x 3 x 2 factorial in a randomized complete block design (RCBD) with three replications. The treatments consisted of sweetpotato and garden egg applied sole and intercropped together, three rates of NPK 15:15:15 fertilizer (0kg/ha, 300kg/ha, 600kg/ha), two levels of poultry manure (5t and10t/ha). Data were collected on soil physico-chemical, growth and yield attributes and using. Results indicated that intercrop significantly ($P<0.05$) reduced garden egg growth but did not affect most sweetpotato attributes. Garden egg fruit yield and orange-fleshed sweetpotato root yield were reduced by intercropping. Application of fertilizer at 300kg/ha and poultry manure at 5t/ha increased garden egg fruit yield while application of 300kg/ha NPK fertilizer increased sweetpotato. The land Equivalent Ratio in all the crop mixtures was above unity (1) with the application of 300kg/ha of NPK 15:15:15 fertilizer + 5t/ha PM giving the best result. This treatment was the best, based on gross monetary returns.
Keywords: Integration, garden egg, orange flesh sweetpotato, intercrop, profitability

Introduction

Intercropping is an agricultural practice of growing two or more crops simultaneously on the same field during a growing season in definite patterns or arrangements (Fageria, 1992, Filho; 2000). It is a scientific application of mixed cropping in terms of crop spacing, time of planting and quantity and quality of fertilizer application (Muoneke, 2017). Intercropping enhances crop biodiversity and interactions among plants, arthropods, mammals, birds and microorganisms providing a more stable agro-ecosystem and a more efficient use of natural resources (such as space and growth resources). There is pressure on the availability of arable land for crop production due to infrastructure development (building of schools, hospitals, roads etc) which makes intercropping the option to ensure food security. The intercropping is a means of increasing productivity and biodiversity. It is also a means of weed and erosion control. Sweetpotato (*Ipomoea batatas* (L.) Lam) is one of the world's most widely grown sub-Saharan Africa. Nigeria is one of the largest producers in Africa. It is a crop used for poverty alleviation and food security due to its high productivity per unit area of land and time which makes it a crop for the survival of resource-poor farmers in Nigeria (NRCRI, 2005). Orange flesh sweetpotato (OFSP) Umuspo 1 is a variety of sweetpotato which is high in β-Carotene a provitamin A crop and can potentially reduce the effects of vitamin A deficiency. Garden egg (*Solanum gilo*) L.) is a small-size dessert fruit type, fruit vegetable that belongs to the Solanaceae family of flowering plants. It is also an important crop grown in Nigeria for its quality fruits which have cultural, social and economic importance. Both sweetpotato and garden egg feature prominently in the cropping systems in many agricultural zones of Nigeria. They may be grown as monocrops or intercrops but mixed cropping or intercropping is the predominant cropping system (Ekwere *et al*., 2009). Fertilizers (organic and inorganic) are needed for plant growth and development. Fertilizer needs for intercrops are generally increased from 10% to 30% higher than for crops in pure stands (Sullivan, 2003). In the intercrop of maize and soybean, yield and yield components of both crops increased as the NPK fertilizer rate increased from zero to 300kg/ha (Mbah *et al.,* 2007). Yield advantage was also obtained in maize and cowpea intercrop with the increase in N-fertilizer application (Okpara, 2000). Ogbonna (2001) reported that a consistent increase in yield was obtained in egusi melon/ maize intercrop as nitrogen application was increased from 0 to 50kg/ha but higher application reduced yield.

The need to improve soil fertility and crop production to support the rapidly growing populations has led to a renewed interest in the use of organic manures and inorganic fertilizers for soil fertility maintenance (Ayeni *et al.,* 2009). Integration of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop production and productivity while minimizing environmental impact from nutrient use is the best (John *et al.,* 2004). The reasons for integration could be the cheapness and availability of organic manure, coupled with the high cost of inorganic fertilizers which may be out of the reach of resource-poor farmers (Rahman, 2000). The use of chemical fertilizers in crop production has not been sustainable due to their high cost and scarcity, soil acidity, increased soil bulk density, low water infiltration rate, nutrient imbalance and a combination of both recommended (Nottidge *et al.,* 2005). The use of organic and inorganic fertilizers enhanced soil productivity, increased soil organic carbon content, enhanced the activities of soil microorganisms and improved soil crumb structure and the nutrient status of the soil as well as crop yield. The objective of this was to evaluate the integration effect of fertilizer NPK 15:15:15 and poultry manure on the production and profitability of sweetpotato/ garden egg intercrop in the rainforest zone of Nigeria.

Materials and Methods

The field experiment was carried out at the National Root Crops Research Institute, (NRCRI), Umudike experimental fields during the 2020 and 2021 cropping seasons. Umudike is located at longitude 07˚ 33' E and latitude 05˚ 29'N and at an elevation of 122 m above sea level in the rainforest agro-ecological zone of Nigeria. The soil was predominantly sandy loam and the pH of the soil was slightly acid. The experiment was laid out in a factorial arrangement using a randomized complete block design (RCBD) and replicated three times. Each plot size was 6m x 4m 24m^2, replications and plots were separated by 1m and 0.5m, respectively. The experimental field was cleared, disc-ploughed, harrowed and ridged in April and May in the 2020 and 2021 cropping seasons, respectively. Planting was also done on 15/04/2020 and 30/05/2021. The treatments consisted of all possible combinations of two cropping systems (sole and intercrop), three rates of NPK 15:15:15 fertilizer (0kg/ha, 300kg/ha, 600kg/ha) and two levels of poultry manure (5t and 10t/ha). The farm was weeded at four weeks after planting (WAP) and fertilizer application was done immediately after weeding at 4 WAP. Data on plant height and the number of branches for garden egg; and vine length, number of branches and leaf area index (LAI) for sweetpotato were taken at 8 and 10 WAP. Sweetpotato root yield was harvested at 16 WAP and garden egg fruit yield was harvested in piecemeal and summed up. Data collected were subjected to analysis of variance using GENSTAT DISCOVERY edition 1 (Lawes Agricultural Trust, 2003) and means compared using Fisher's least significant difference (LSD) at a 5% level of probability.

Results and Discussion

Results

The results of physico chemical analysis of the soils of the experimental sites in the 2020 and 2021 cropping seasons are presented in Table 1 the soil texture was sandy loam. P^H in water was 5.3 and 5.6 and in salt was 4.0 and 4.5 respectively showing the soil was acidic. Monthly total rainfall (mm), sunshine (hr), Maximum and minimum temperature in Table 2. The results of the physico-chemical analysis of the experimental sites in the 2020 and 2021 cropping seasons are presented in Table 1 the soil texture was sandy loam while pH in water and salt was 4.0 and 4.5 in 2020 and 2021 respectively showing that the soil was acidic. The Annual rainfall ranged between 1800 and 2200 mm with a 65-year average of 2159.6 mm. The rainfall distribution pattern is bio-modal with peaks in July and September. In 2020 the highest amount of rainfall occurred in July with 482.7 mm and the lowest in December with 0.00 mm while in 2021 the highest rainfall occurred in August and the lowest in January with 0.0 mm. The temperature regime is typically equatorial without substantial variation throughout the year. Thus, the temperature is high throughout the year and the annual average temperature varies from 22 ˚C to 34 ˚C while the mean minimum temperatures were 23.25˚C and 21.75 ˚C, respectively (Table 2). The effect of organic and inorganic fertilizers on the growth and yield of garden eggs in 2020 and 2021 are in shown Table 3. Intercropping reduced ($P<0.05$) garden eggplant height, LAI and number of branches at 8 and 10 weeks in both years. The application of NPK 15:15:15 fertilizer at the rate of 300 and 600kg/ha increased significantly ($P<0.05$) the height of garden the egg at 8 WAP and 10 WAP in 2020 and 2021 while the application of poultry manure at the rates of 5 and 10 t/ha enhanced plant height, LAI and number of branches over the control (0kg/ha). The effect of interaction between cropping systems x fertilizer, and fertilizer x poultry manure on the growth attributes of garden eggs was not significant in both years. In 2020, garden egg fruit yield (t/ha) was not affected cropping system but in 2021 had higher fruit yield (t/ha) in sole crop than intercrop. Fruit yield (t/ha) increased with the application of 300 and 600kg/ha NPK 15:15:15 fertilizer in 2020 compared to the control (0kg/ha). The application of 600kg/ha did not enhance fruit yield significantly ($P<0.05$) compared with the application of 300kg/ha NPK 15:15:15 fertilizer. The application of 5 and 10t/ha poultry manure increased garden egg fruit yield in both years compared with the control (0kg/ha). There were however no significant differences ($P<0.05$) between the application of 5 and 10t/ha poultry manure on garden egg fruit yield and yield components in both years. The effect of interaction between cropping systems x fertilizer, and fertilizer x poultry manure on garden egg yield was not significant in both years.

The effect of sweetpotato on cropping system, NPK fertilizer and poultry manure on the growth and yield of sweetpotato in 2020 and 2021 are presented in Table 2. The growth attributes of sweetpotato were similar under

both sole and intercrop systems in both years. The only exception was in the number of branches at 8 and 10 WAP in 2021, which was higher in sole than in intercropping. Application of NPK fertilizer at 300 or 600kg/ha on sweetpotato increased vine length and number of branches compared to the control at 8 and 10 WAP in 2020. The NPK fertilizer rates of 300 and 600kg/ha had similar effects on vine length at 8 WAP and 10 WAP and on the number of branches at 10 WAP in 2021. Fertilizer rates however did not differ in their effects. Application of 5 and 10t/ha poultry manure compared with the control (0 t/ha) generally enhanced sweetpotato vine length and LAI across sampling dates in both years. Application of 10t/ha poultry manure resulted also in higher LAI in both years than the application of 5 k/ha poultry manure. Cropping system x fertilizer, and fertilizer x poultry manure interaction effects were not significant in both 2020 and 2021 cropping seasons. In the 2020 cropping season, the cropping system had no significant effect on sweetpotato yield, but in 2021, intercropping reduced significantly ($P<0.05$) root yield t/ha. All cases of fertilizer application in 2020 increased significantly root yield (t/ha) compared to the control (0 t/ha). In 2021, however, root yield (t/ha) was not increased by the application of 300 and 600 kg/ha NPK 15:15:15 fertilizer rates. There were significant reductions in yield especially at the higher fertilizer rate of 600kg/ha NPK. Applications of poultry manure at the rate of 5 and 10 t/ha did not affect significantly sweetpotato root yield. The interaction effects between cropping system x fertilizer and fertilizer x poultry manure were not significant in both cropping seasons.

Productivity of the intercropping system

The total LERs in all the intercrops were greater than unity in the 2020 and 2021 cropping seasons (Tables 4 and 5). The application of 600 kg/ha of fertilizer + 10 t/ha of poultry manure on sweetpotato/ garden egg mixture gave the highest LER of 2.36 followed by the application of 300kg/ha + 5t/ha of poultry manure (2.21) while the least (1.00) came from the control (0kg/ha) on the mixture in 2020. The highest partial LER (1.17) for sweetpotato was obtained from 300 kg/ha fertilizer + 5 t/ha poultry manure applied to the crop mixture. This was followed by an LER of 1.09 obtained from the application of 600 kg/ha fertilizer + 10 t/ha poultry manure to the crop mixture. The reverse was the case with eggplant as the application of 600 kg/ha fertilizer + 10 t/ha poultry manure to the crop mixture gave the highest partial LER (1.27) followed by LER of 1.04obtained from the application of 300 kg/ha fertilizer + 5 t/ha poultry manure in 2020. In 2021, the application of 5/t of poultry alone gave the highest LER of 1.70 followed by the application of 300kg/ha of fertilizer + 5t/ha of poultry manure on crop mixture gave the highest LER of 1.45 while the least came from 0kg/ha with LER of 0.09 (Table 4). The highest GMRs of ₦18,256,400 in 2020 came from the application of 300kg/ha of fertilizer + 5t/ha of poultry manure on crop mixture and the least return of ₦6,484,500 from 0kg/ha on crop mixture (Table 3). In 2021, the highest GMR of ₦1, 10,376,000 was obtained from the application of 300kg/ha of fertilizer + 5t/ha of poultry manure on crop mixture and the least returns ₦5,448,000 from 0kg/ha on crop mixture (Table 4).

Discussion

The soil of the study site was sandy loam, acidic with low organic matter. This is typical of the Umudike location and has also been reported by others (Ano, 1990, Okwuowulu, 2000). Intercropping also reduced ($P<0.05$) all the growth attributes and yield of garden eggs compared to sole cropping on average. This trend could as a result of intense interspecific competition from the Umuspo 1 (orange flesh sweetpotato) main crop which limited the growth resources available to garden eggs. In intercropping systems, nutrient uptake is intense compared to sole cropping (Muoneke, 2017). Application of poultry manure at the rates of 5 and 10 t/ha significantly enhanced most garden egg growth attributes such as plant height, number of branches and LAI compared to the control (0kg/ha) while NPK 15:15:15 fertilizer application enhanced most of these attributes. Poultry manure like most other organic manures had longer lasting effects due to slow mineralization and release of nutrients in addition to many other edaphic advantages over NPK fertilizers. These characteristics perhaps enabled it to influence garden egg growth attributes compared to inorganic NPK fertilizer. Both rates of 300 and 600kg/ha NPK 15:15:15 fertilizer did not differ from each other in their effect on garden egg growth attributes suggesting that the former rate was adequate for garden egg production. The application of NPK 15:15:15 fertilizer increased plant height and fruit yield of garden egg in 2020 but this yield improvement was not evident in 2021. This inconsistency may be due to edaphic differences in experimental sites and weather differences in both years. The highest total LER and GMR obtained from the intercrop compared to the sole crop in the 2020 and 2021 cropping seasons indicated that intercropping of the garden egg and Umuspo 1 orange flesh sweetpotato was more productive and profitable than sole cropping. This finding is consistent with those of many other authors (Mbah, 2005, Mbah *et al*., 2007 and Anyaegbu, 2017). In 2020 the highest LER and GMR were obtained when the garden egg was intercropped with Umuspo 1 OFSP and at the application of 300kg/ha fertilizer + 5t/ha poultry manure or 600kg/ha of fertilizer + 10t/ha of poultry manure on crop mixture while in 2021 it was from the application of 300kg/ha of fertilizer + 5t/ha of poultry manure. These combinations gave the best yield advantage obtained. This study showed that garden eggs and Umuspo 1 OFSP could be grown together for maximum productivity, land use as well as monetary returns to the farmers. For food security and income generation, intercropping of Umuspo 1 OFSP and garden egg as well as the application of 300kg/ha of fertilizer + 5t/ha of poultry manure, would benefit farmers.

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Table 1: The physico-chemical analysis of the soils of the experimental sites in the 2020 and 2021 cropping seasons

Soil properties	2020	2021
Sand (%)	78.80	65.80
Silt (%)	9.40	13.40
Clay (%)	10.80	20.80
Texture	Sandy loam	Sandy loam
Chemical characteristics		
pH (H^2o)	5.3	5.6
pH(KCl)	4.0	4.5
P mg/kg	33.8	36.1
N (%)	0.09	0.11
Organic carbon (%)	1.04	1.26
Organic matter (%)	2.17	1.79
Ca (Cmol Kg^{-1})	2.8	3.20
Mg (Cmol Kg^{-1})	1.60	2.00
K (Cmol Kg^{-1})	0.16	0.17
Na (Cmol Kg^{-1})	0.12	0.16
EA	1.46	1.04
ECEC (Cmol Kg^{-1})	6.14	6.58
BS (%)	76.25	84.18

***Source**: NRCRI Umudike Soil Laboratory Unit*

Table 2: Monthly Rainfall (mm) and Temperature (˚C) in 2020 and 2021

	Rainfall (mm)		Temperature (˚C)	
Month	2020	2021	2020	2021
January	0.0	0.0	33	33
February	0.0	0.0	34	34
March	126.1	58.1	33	33
April	116.6	70.9	32	33
May	270.9	41.3	32	33
June	340.6	247.2	31	30
July	482.7	297.1	30	27
August	92.4	482.6	30	29
September	433.7	348.7	30	29
October	185.4	331.2	31	31
November	200.3	99.0	32	33
December	0	24.9	33	30
Total	2248.7	2001	381	375
Mean	187.39	166.75	31.75	31.25

Source: NRCRI Meteorological Unit

Table 3: Effect of cropping system, NPK 15:15:15 fertilizer and poultry manure on the growth and yield of garden egg at different weeks after planting (WAP)

	Plant height/plant cm (WAP)				Leaf area index/plant (WAP)				No. of branches/plant (WAP)				Fruit yield (t/ha)	
	2020		2021		2020		2021		2020		2021		2020	2021
	8	10	8	10	8	10	8	10	8	10	8	10		
Cropping system														
Sole	59.50	64.70	61.20	64.20	0.11	0.13	1.11	0.12	7.99	8.58	8.73	9.29	7.02	6.15
Intercrop	50.60	55.70	51.50	53.50	0.06	0.07	0.07	0.07	5.15	5.86	5.37	6.14	6.18	3.66
LSD (0.05)	7.72	7.98	7.31	7.50	0.02	0.03	0.02	0.08	1.95	1.90	1.99	2.00	NS	1.13
Fertilizer NPK (kg/ha)														
0	48.90	53.60	50.60	52.80	0.07	0.08	0.07	1.08	5,60	6.56	4.20	6.79	5.26	4.90
300	59.90	64.90	60.60	64.20	0.09	0.12	0.09	0.11	7.58	8.06	6.58	8.42	7.28	5.11
600	59.40	65.50	60.60	62,50	0.09	0.11	0.09	0.10	7.02	7.38	6.72	8.40	7.93	4.64
LSD (0.05)	9.16	9.34	5.93	4.20	NS	NS	NS	NS	NS	NS	NS	NS	1.68	NS
Poultry manure (t/ha)														
0	46.30	51.00	47.70	50.30	0.05	0.06	0.06	0.06	3.83	5.20	4.25	4.74	4.72	3.88
5	61.00	66.30	63.30	65.00	0.09	0.10	0.09	0.11	8.60	6.50	9.06	8.88	7.70	5.53
10	62.20	67.90	63.30	65.50	0.11	0.12	0.11	0.13	8.65	6.80	9.23	10.02	8.31	5.89
LSD (0.05)	8.05	8.21	7.69	5.40	0.03	0.02	0.03	0.03	1.84	NS	1.98	2.10	1.41	0.74
Cropping system x fertilizer														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer x poultry														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of cropping system, NPK 15:15:15 fertilizer and poultry manure on growth and yield of sweetpotato at different weeks after planting (WAP)

	Vine length/plant cm (WAP)				Leaf area index/plant (WAP)				No. of branches/plant (WAP)				Root yield (t/ha)	
	2020		2021		2020		2021		2020		2021		2020	2021
	8	10	8	10	8	10	8	10	8	10	8	10		
Cropping system														
Sole	75.50	80.20	81.00	82.10	1.03	1.21	0.72	1.15	11.43	11.60	12.35	12.46	13.45	17.06
Intercrop	66.60	78.2	72.60	74.00	0.94	1.11	0.62	1.05	9.83	10.20	9.92	10.35	13.08	15.38
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.72	1.67	NS	0.06
Fertilizer NPK (kg/ha)														
0	62.00	64.2	67.50	68.60	0.82	1.01	0.60	0.97	8.35	9.42	7.30	9.39	11.12	17.03
300	73.80	80.40	80.80	81.70	0.98	1.16	0.70	1.11	11.62	12.50	8.70	12.48	15.41	16.36
600	81.80	85.40	86.80	88.50	1.18	1.37	0.82	1.29	13.06	13.40	9.20	13.35	14.47	14.92
LSD (0.05)	9.36	8.02	9.04	8.82	NS	NS	NS	NS	2.03	1.70	NS	1.70	0.64	0.64
Poultry manure (t/ha)														
0	61.70	64,24	67.80	69.30	0.07	0.81	0.50	0.78	9.94	10.58	10.28	10.58	12.32	16.25
5	74.30	82.40	80.80	80.90	1.03	1.21	0.73	1.15	9.54	10.98	10.83	10.98	14.27	17.63
10	81,80	87,40	86.50	88.20	1.37	1.62	0.96	1.53	13.21	13.06	12.71	13.06	14.42	14.79
LSD (0.05)	9.26	9.10	9.18	9.12	0.27	0.31	0.18	0.29	0.26	NS	NS	NS	NS	NS
Cropping system x fertilizer														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer x poultry														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Effect of poultry manure and NPK 15:15:15 fertilizer on garden egg/sweetpotato intercropping on land equivalent ratio (LER) and gross monetary returns (GMR) in 2020

Treatments	LER			GMR		
	Partial		Total	Partial		Total (₦)
	Sweetpotato	Garden egg		Sweetpotato	Garden egg	
0kg F (/ha)				3,112,200	3,600,000	6,712,200
300kg F (ha)				6,220,000	7,200,000	13,420,000
600kg F (/ha)				6,008,000	8,124,000	14,132,000
5 PM (t/ha)				4,976,000	8,724,000	13,700,000
10 PM (t/ha)				6,220,000	10,140,000	16,360,000
300kg F +5 (t/ha) PM				5,952,000	10,800,000	16,752,000
600kg F +10 (t/ha) PM				5,600,000	10,356,000	15,956,000
0kg F (ha) on Crop mixture	0.58	0.42	1.00	3,520,000	2,964,500	6,484,500
300kg F(ha) on Crop mixture	0.89	0.78	1.67	5,508,000	5,640,000	11,148,000
600 kg F (ha) on Crop mixture	0.96	0.80	1.76	5,760,000	6,480,000	12,240,000
5t PM(/ha) on Crop mixture	0.86	0.71	1.57	5,760,000	6,480,000	12,240,000
10t PM (/ha) on Crop mixture	0.78	0.62	1.40	4,308,000	6,156,000	10,464,000
30(kg F + 5t PM (ha) on Crop mixture	1.17	1.04	2.21	6,976,400	11,280,000	18,256,400
600kg F + 10t PM (/ha) on Crop mixture	1.09	1.27	2.36	6,088,000	13,188,000	19,276,000

F = NPK 15:15:15, PM = Poultry manure. NRCRI Market price in 2020 sweetpotato 1kg @ ₦400 and garden egg 1kg @ ₦1,200

Table 6: Effect of poultry manure and NPK 15:15:15 fertilizer on garden egg/sweetpotato intercropping on land equivalent ratio (LER) and gross monetary returns (GMR) in 2021

Treatments	LER			GMR		
	Partial		Total	Partial		Total (₦)
	Sweetpotato	Garden egg		Sweetpotato	Garden egg	
0 F kg F (/ha)				3,556,000	4,740,000	8,296,000
300kg F (/ha)				7,468,000	6,396,000	7,142,800
600kg g/ha)				6,244,000	6,636,000	12,880,000
5t PM (/ha)				4,992,000	6,840,000	11,832,000
10t pm (/ha)				6,144,000	9,396,000	15,540,000
300kg F +5t PM (/ha)				6,000,000	9,276,000	15,276,000
600kg F +10t PM (t/ha)				5,696,000	8,364,000	14,060,000
0kg F (/ha) on Crop mixture	0.60	0.38	0.98	2,304,000	3,144,000	5,448,000
300kg F(/ha) on Crop mixture	0.47	0.63	1.10	3,512,000	4,056,000	7,568,000
600kg/ F on Crop mixture	0.71	0.39	1.10	4,456,000	2,592,000	7,048,000
5 t PM (/ha) on Crop mixture	0.87	0.83	1.70	4,356,000	5,664,000	10,020,000
10t PM (/ha) on Crop mixture	0.64	0.62	1.26	3,912,000	5,796,000	9,708,000
300kg F + 5t PM (/ha) on Crop mixture	0.93	0.52	1.45	5,600,000	4,776,000	10,376,000
600kg+ 10t PM (/ha) on Crop mixture	0.85	0.56	1.41	4,844,000	4,704,000	9,548,000

F = NPK 15:15:15, PM = Poultry manure. NRCRI Market price in 2021 sweetpotato 1kg @ ₦400 and garden plant 1kg @ ₦1,200