Journal of Agriculture and Food Environment
Volume 9(1): 59-66, 2022

Faculty of Agriculture
Delta State University
Abraka, Nigeria

Original Research Article

Fertilizer Management Systems for Improved Establishment Fruiting and Yield Patterns of Bush Mango (*Irvingia gabonensis)* in Southeastern Nigeria

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Received 25th December 2021; Accepted 25th February, 2022; Corrected 21st March, 2022

Abstract

Low yield and irregular fruiting patterns which characterize most tropical fruits may be due to soil infertility. The application of organic and inorganic manures could improve yield of both arable and cash crops. The indigenous tropical fruits, despite their widely acknowledged socio-economic importance, are neglected in terms of research and nutritional improvement. This study on organo-fertilization aimed to address the fertility management system of the bush mango in southeastern Nigeria. The experiment studied the long term (15 years) effect of combination of three poultry manure rates (0, 2000 and 4000 g/tree) at establishment and then topped annually with four NPK 20-10-10 fertilizer rates (0, 200, 400 and 600 g/tree). The organo-fertilizer rates were applied to the trees in two split doses annually using the ring method (May and September) for 15 years in a row. The conventional fertilizer system for bush mango production was the control. Poultry manure significantly ($p \leq 0.05$) enhanced bush mango establishment and juvenile growth of the transplant. Poultry manure (4000 g), and 400-600 g NPK produced large canopies with prolonged maturity period and stable yields. The control and 0 manure/fertilizer applied to bush mango resulted in late maturity and poor fruit yield. Bush mango fertilized with 2000g of poultry manure and 200g NPK fertilizer matured early and maintained a regular fruit yield pattern.

Key words: Bush mango, fruiting pattern, organo-fertilization and soil infertility.

Introduction

Plantation agriculture demands removal of natural vegetation including endemic fruit and timber trees. The traditional farming system lacked the present plantation agriculture concept (Okigbo, 1977). However, an integrated tree/food crop and production system has since evolved a sustainable agroforestry farming system. In home gardens, tree crops are highly valued among farmers for a sustainable rural economy (Alagba *et al.,* 2012*).* Yields of tree crops are high and regular because of continuous organic matter supply and recycle strategy (Nweke *et al.,* 1988). In nearby and distant farms of Nigeria, cultural practices are focused primarily on arable crops (Uzo, 1980). Trees benefit indirectly from the system. Recently, mono-cultural plantation agriculture has evolved in southeastern Nigeria for cash crops such as oil palm, cocoa, cashew, mango, citrus, plantains and bananas (Opeke, 2005). These cash crops have advanced through in-depth research to sustainable yields and soil stabilization plantations on erodible hillsides and watersheds. Productivity of tree crops is low for a variety reasons including low use and or absence of fertilizer (Enwezor *et al.,* 1989), lack of agronomic packages, (Ibeawuchi *et al.,* 2005) and poor research information use (Adelaja and Olaniyan, 2000). The establishment, growth and productive life span of bush mango often exceeds 100 years in space, time, and location in diverse environmental fluctuations and heavy rainfall (Uzo, 1980). This scenario complicates fertilizer management in tropical infertile ultisol. Fruit tree crops are perennials with significant morphological and phenological variations as plants age (Alagba, 2010). Thus, fertilizer management demands proper long-term research for sustainable fruit yielding orchards. The strategies and techniques of fertilizer management also change as the trees physiologically develop from juvenile to reproductive growth phases (Alagba, 2010). Thus proper tree monitoring and balancing of physiological growth phases and timely nutrient(s) applications for sustainable plant growth is critical (Enwezor *et al.,* 1989). For example plantains malnourished at the prefloral (juvenile) growth phase (Ndubizu *et al.,* 1983) mature late and produce poor bunches at maturity (Swennen, 1990). The basis of fertilizer (inorganic, organic or both) recommendation for plantation crops demands in-depth knowledge of initial soil fertility status, attainable potential crop yield over cropping cycle(s) and expected nutrient losses (Enwezor *et al.,* 1989).

The current awareness of the roles of indigenous fruit trees in the socio-economic life of rural economy of Nigerians (Alagba *et al.,* 2012, Okafor, 1977, Ladipo *et al.,* 1996, Ejiofor and Okafor, 1987) has stimulated demand for improved research-driven production packages of these indigenous fruit trees including fertilizer management. Even the conventional fertilizer research manual on fertilizer use in Nigeria (Enwezor *et al.,* 1989) grossly lacked information on fertilizer management for indigenous fruit trees including bush mango. Traditionally, application of organic manure for fruit tree establishment is widely practised while inorganic fertilizer rates are known for most cash crops (Enwezor *et al,* 1989).

Bush mango (*Irvingia gabonensis*) is a wild relative of commercial mango. Thus, the fertilizer recommendation for mango production (Enwezor *et al,* 1989) guided this preliminary organo-fertilizer trial for bush mango production. Although both organic and inorganic fertilizers have their respective challenges in tropical crop production, the long term synergy derivable from organo-fertilizer trials in tropical crop yield and soil fertility improvement is highly commendable (Ibeawuchi *et al.,* 2015) and advocated (Spore, 1993, 1994, Obi and Ebo, 1995).

The objective of the study was to develop organo-fertilizer regimes for sustainable bush mango establishment and fruit yields in Southeastern Nigeria.

Materials and Methods

The research was conducted at the Plantation Crops Research Farm, Federal University of Technology, Owerri, on latitude 05^0 27^1, and longitude 07^0 02^1 East and on an altitude of 55.6m in the rainforest zone of southeastern Nigeria. The mean annual temperature (30-32^{0}C) is high. The heavy annual rainfall (2500mm/annum) spans from early March to October, and exhibits a bimodal pattern (Onweremadu *et al.*, 2007).

The secondary vegetation of the experimental site was slashed manually. Volunteer trees were uprooted and gathered in windrows. Random top (0-15cm) and subsoil (15-30cm) samples were collected with soil augur, bulked, and analyzed for physico-chemical properties. Bush mango seedlings were transplanted to the field in April 2000 at a spacing of 10.00 x 8.00m in single row system. Three bush mango trees constituted the sample size. The treatments consisted of three cured poultry manure rates (0, 2000.00 and 4000.00g tree^{-1} which were soil incorporated in 60.0 x 60.0 x 80.0cm planting holes once and later (May) topped with four NPK 20:20:10 fertilizer rates 0, 200, 400 and 600g tree^{-1} annually as appropriate. The poultry manure was secured from the livestock (poultry) unit of the University Farm. Every year, fertilizers were each applied by the ring method at two equal splits, in May and September (Enwezor *et al.*, 1989). The conventional fertilizer regime: zero manure at planting (Y_1 0), Y_2 200, Y_3 300, Y_4 400, Y_5 500 and above 600g NPK for mango (*Magnifera indica)* a cash relative of bush mango was the check. The experiment was laid in a randomized complete block design of three replications. The orchard was slashed three times annually in May, August and November.

Growth and yield data on establishment, phenology and fruiting patterns of bush mango orchard for 15years were collected and statistically analyzed (Obi, 2002) using Genstat, Release 4.24 DE 2005, and reported.

Results

The application of poultry manure and NPK fertilizer rates individually or mixed had crucial effects on the establishment, maturity and yield of bush mango (Table 1). The application of increasing poultry manure rates 2000-4000g per tree at planting significantly improved the field establishment of bush mango over zero poultry manure application and the control. Although the bush mango attained similar heights (3-4m) at maturity, poultry manure, NPK and poultry manure/NPK mixtures resulted in significant ($P \geq 0.05$) variations in maturity earliness. Trees which received 2000g of poultry at planting and topped annually with 200g NPK fertilizer fruited early (5years). Trees without poultry manure or NPK fertilizer matured very late (8years). Plants manured annually with 200-400g NPK fertilizer tree^{-1} matured in 7 years.

The application of 2000-6000g poultry manure alone at planting or in combination with 200.0-400.0g NPK fertilizer further accelerated early maturity (6years) and expanded tree canopy spread (Table 2) in bush mango.

The fertilizer regimes had significant effects of the first fruiting in bush mango. Pre-mature fruit abortion was high on the unmanured bush mango trees, and resulted in very poor first fruit yield. Increasing sole NPK fertilizer or in combination with poultry manure minimized pre-mature fruit

Table 1: The effect of poultry manure and NPK inorganic fertilizer rates on the growth and yield characteristics of bush mango at first cropping

Poultry manure rate g/tree	Annual NPK rate g/ tree	Establishment (%)	Years at 50% harvest	Height at harvest (m)	Canopy volume at first harvest (m^2)	Number at first cropping ($tree^{-1}$) Aborted fruits	Mature fruits
0.00	0	80.06	8.58	2.88	4.42	48.08	34.54
	200	78.28	7.48	3.52	5.68	38.44	84.06
	400	80.18	6.64	3.54	8.56	32.68	86.40
	600	82.04	6.68	3.42	8.58	35.41	85.66
	$\bar{x}$	80.14	7.345	3.34	6.81	38.65	72.67
2000.00	0	92.40	7.02	3.24	6.48	15.68	35.00
	200	94.16	5.50	3.40	8.56	14.08	104.30
	400	90.84	6.04	3.52	8.68	28.03	188.00
	600	94.62	6.42	3.42	8.84	32.66	186.00
	$\bar{x}$	93.01	6.245	3.395	8.14	22.61	128.33
4000.00	0	96.66	7.48	3.03	8.56	14.33	34.00
	200	98.54	6.04	3.50	6.06	18.52	160.66
	400	96.42	6.28	3.52	12.26	28.46	184.00
	600	92.44	6.54	3.56	16.54	30.60	186.60
	$\bar{x}$	96.02	6.59	3.41	10.86	22.98	141.32
Control		80.54	7.28	3.52	8.54	18.64	156.08
$LSD_{0.05}$ for poultry manure		2.64	1.06	NS	2.42	9.52	12.18
$LSD_{0.05}$ for fertilizer		1.02	0.84	NS	2.06	6.48	9.40
$LSD_{0.05}$ for poultry manure x NPK		0.96	0.56	NS	0.84	2.50	5.06

Table 2: The effect of poultry manure and NPK fertilizer rates on fruit yield components of bush mango at first cropping

Poultry manure (g/tree)	Fertilizer rates (g/tree)	Fruit weight (g/fruit)	Shelf life (days)	Total soluble solids at Harvest	5days storage	Pulp weight (g $fruit^{-1}$)	Kernel weight (g/fruit)	Pulp:kernel ratio (approx.)
0.00	0	321.69	5.14	8.64	26.18	287.07	14.62	21:1
	200	330.45	4.06	0.28	20.44	315.43	15.02	21:1
	400	342.52	4.46	2.56	22.48	327.00	15.57	21:1
	600	346.42	4.54	8.62	21.56	330.67	15.75	21:1
	$\bar{x}$	330.27	4.55	5.03	22.67	295.04	15.24	21:1
2000.00	0	320.62	6.18	2.54	28.54	306.05	14.57	21:1
	200	350.04	8.58	4.06	21.28	334.12	15.91	21:1
	400	352.51	8.68	5.48	22.04	336.49	16.02	21:1
	600	354.68	7.14	8.04	20.52	338.56	16.12	21:1
	$\bar{x}$	344.46	7.65	5.03	23.10	328.81	15.66	21:1
4000.00	0	321.20	6.24	2.00	24.06	306.41	14.59	21:1
	200	330.48	8.64	4.62	22.00	315.46	15.02	21:1
	400	334.52	6.58	8.52	20.08	319.32	15.21	21:1
	600	358.04	6.82	8.64	24.54	325.50	16.28	21:1
	$\bar{x}$	336.09	7.07	5.95	22.67	316.67	15.275	21:1
Control		302.44	5.60	6.04	8.08	304.50	14.02	21.1
$LSD_{0.05}$ for poultry manure		NS	1.08	2.04	2.40	11.64	1.42	NS
$LSD_{0.05}$ for fertilizer		NS	0.82	1.16	1.08	5.06	1.06	NS
$LSD_{0.05}$ for poultry manure x NPK		NS	0.56	0.60	1.22	2.42	1.22	NS

abortion and increased the number of mature fruits. Least fruits were produced in the unmanured bush mango and those manured with sole poultry manure, NPK and the control. Fruit yields from bush mango manured with high (2000-4000g/200-400g) organo-fertilizer were similar.

The fruit weight was fairly uniform even when bush mango was not manured or as NPK fertilizer rates 200-600g were applied sole or in combination with poultry manure 2000-4000g tree^{-1}. The keeping quality of bush mango fruit improved from control (5days) to 6days for fruits produced from trees manured with poultry manure/NPK fertilizer mixtures. The fruits from unmanured trees or those manured with soles 200-600g fertilizers had poor shelf life. The pulp and kernel weights were similar with a pulp to kernel ratio of 21:1 in all fruits including the control and the unmanured bush mango trees.

The annual fruit yield in bush mango varied significantly between years and among organo/fertilizer rates (Table 3). The fruit yield increased as the trees aged and stabilized about the fifth year of production. Annually, fruit yields increased with increasing poultry manure/NPK mixture. Thus, application of 2000-4000g poultry manure to bush mango at planting and later topped with 200-600g NPK fertilizer sustained high fruit yields. The fruit yield varied significantly between years till the fifth year, especially when poultry manure was applied at establishment of bush mango. Regular rhythm of heavy cropping followed by low or zero cropping or vice versa was common. Thus, the poorly manured bush mango trees exhibited a very low to zero fruiting pattern at first cropping, and later improved to alternate heavy and low cropping pattern. Adequately manured bush mango trees, such as those which received 2000 poultry manure and 200-400g NPK, exhibited alternative heavy and medium cropping rhythm and after five years annually produced a regular and fairly constant fruit yield pattern.

Table 3: Annual marketable number of fruits and fruiting patterns in bush mango as influenced by organo-fertilizers for seven consecutive years at Owerri

Poultry manure (g/tree)	NPK Fertilizer (g/tree)	Number of fruits per tree /year						
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
0.00	0	34.54	0.00	58.74	38.64	88.54	82.84	98.40
	200	84.06	36.82	112.44	128.46	224.56	228.06	330.84
	400	86.40	46.86	124.06	146.52	260.08	258.80	360.47
	600	85.66	42.52	128.64	142.62	266.42	282.06	368.52
	$\bar{x}$	72.67	31.55	105.97	114.06	209.9	237.94	314.56
2000.00	0	45.00	12.54	76.52	86.28	128.52	138.42	118.06
	200	104.30	48.62	168.44	184.52	286.04	348.00	320.64
	400	168.00	54.06	140.82	186.08	288.32	352.84	340.16
	600	180.00	48.08	188.86	188.52	292.06	368.54	304.56
	$\bar{x}$	124.33	40.83	143.66	161.35	248.74	301.92	295.86
4000.00	0	34.86	9.08	38.56	68.40	78.06	184.62	246.58
	200	160.86	42.50	150.08	312.52	406.42	410.50	326.58
	400	186.00	54.08	148.68	360.08	420.06	460.06	384.40
	600	186.60	58.44	156.24	388.64	450.28	468.40	420.56
	$\bar{x}$	142.08	41.03	493.56	282.41	338.71	355.90	440.63
Control		104.52	48.86	160.42	266.50	300.62	298.06	310.52
$LSD_{0.05}$ for poultry manure		12.18	8.66	10.08	9.60	8.58	15.06	10.04
$LSD_{0.05}$ for fertilizer		9.40	6.54	8.42	8.04	8.00	9.52	7.58
$LSD_{0.05}$ for poultry manure x NPK		5.06	6.02	6.54	5.18	6.04	7.08	6.82

Discussion

Yield maximization in arable and plantation agriculture depends on stand establishment, vigorous juvenile growth and productivity usually influenced by the soil environmental and cultural practices including manurial practice (Ibeawuchi *et al.,* 2005). The soils of southeastern Nigeria are inherently infertile, and low in macro elements necessary for normal crop growth (Onweremadu *et al.,* 2007). Application of soil amendment is therefore crucial for early crop growth and development (Enwezor *et al.,* 1989). Thus, bush mango establishment was poor without poultry manure at planting (Alagba, 2010). The resultant poor juvenile bush mango were not remedied by late (after one year) application or by increasing NPK rates (Onyekwelu *et al.,* 2007). This simulates the traditional manurial neglect of volunteer bush mango (Uzo, 1980). The delayed NPK fertilizer application one year after planting for tree crops (Enwezor *et al.,* 1989) is defective. Pre-planting application of at least 2000g of organic manures (poultry manure) and topped same year with NPK fertilizer is a pre-requisite of advocated improved bush mango establishment and sustainable orchard yields.

The annual application of NPK 400-600g manure with 2000-4000g poultry manure improved vegetative growth, fruiting sites, slightly delayed maturit but enhanced sustainable fruiting (Table 3). Although bush mango which received sole 200-600g NPK matured early, yield stability was delayed due to alternate fruiting patterns (Okigbo, 1977). The control and poorly manured bush mango trees exhibited a regular rhythm of alternate fruiting pattern variations reported in citrus (Goldschmidt, 2015). Fruiting and yield variations in the unmanured and control bush mango ranged from low to zero cropping for the first 3-4years of fruiting. In other treatments, the fruit yields ranked from high to medium/low yields within 5years. Alternate fruiting has been variously reported in some indigenous tropical fruits such as in *Dacryodes edulis* and citrus (Alagba *et al.,* 2012). The cause of alternate fruiting is elusive, although heavy carbohydrate depletion during the heavy cropping year is a suspect. While fertilization was ineffective in the organo-fertilization system, it was effective in bush mango (Goldschmidt, 2015) probably due to varietal traits (Okafor, 1975). Alternate fruiting phenomenon in tropical fruit trees is a critical physiological research challenge for sustainable productivity of bush mango and other indigenous tropical fruits**.**

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