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EFFECT OF PIG MANURE ON GROWTH AND PRODUCTIVITY OF TWENTY ACCESSIONS OF *Moringa oleifera* IN NIGERIA

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ABSTRACT

An experiment to determine the effect of pig waste on the survival, growth and productivity of 20 accessions of Moringa oleifera from the various agroecologies in Nigeria was conducted from August 2011 to November 2012. The experiment was a factorial combination of 3 rates of pig waste – 0, 10 and 20 t/ha – and 20 accessions of Moringa oleifera. Analysis of variance results indicated a general decline in survival percentage of the accessions with time with the Kolo accession showing the highest survival percentage of 84.4% 15 months after transplanting, while Baruten recorded the lowest survival rate (37.8%). There were significant variations across accessions in all the morphological and pod and seed parameters evaluated. The accession from Kolo showed the tallest plants and the widest stem girth while Ugya produced more leaves at the last measurement. Kolo, Ugya, Idere and Awo - Garaji had comparatively higher dry weights than other accessions. There was a linear response to pig waste application although the 0 and 10 t/ha rates were statistically the same. Variation in the pattern of response of reproductive parameters to organic manure was noticed with Baruten and Zaria not producing viable pods at manure rate of 10 t/ha while Idere and Maiduguri failed to bear pods at rates of 20 t/ha. Accessional differences in survival and growth can be exploited for selection and breeding purposes while organic manure can be utilized to improve growth and yield of the species.

Key words: accessions, *Moringa oleifera*, pig waste, growth, productivity

INTRODUCTION

Moringa oleifera belongs to the family Moringaceae which has 14 species. Of these species, the most common and widely cultivated is *Moringa oleifera* (Makkar and Becker, 1997; Marcu, 2006). It is a drought tolerant plant whose tuberous tap root system is an in-built mechanism against water stress. *Moringa* is believed to be native to India but now found in semi-arid, tropical and sub-tropical climates (Moyo *et al*., 2011). *Moringa oleifera* is commonly called the drumstick tree for its pods that are used in drumming or the horse radish tree due to the flavour of its roots (Palada and Chang, 2003). It thrives in a wide variety of soils and climate, but prefers sandy-loam soil and areas with temperature of 25 to 40 ^{0}C, an annual rainfall of at least 500 mm, and elevation of 600–1000 m above sea level. (Rajakrishnamoorthy *et al*., 1994). The plant is considered one of the most useful species of the world, being invaluable as human food, browse plant, medicine and water purifier (Palada and Chang, 2003). In Nigeria, Moringa has a longstanding use as live fence, ornamental plant, yam stakes and snake repellent (Stevens, 2014).

Yield variation is dependent on such factors as accession, season, fertilization and irrigation regime. And although the plant is an efficient nutrient miner owing to its deep and extensive root system, growth and yields can be optimized by application of organic or inorganic fertilizers (Palada and Chang, 2003). Generally produce quantity and quality is enhanced with application of fertilizers (Ani and Baiyeri, 2008). Ramachandran *et al.* (1980) achieved higher yields with organic fertilizer than growing *Moringa* without fertilizer. A positive response was obtained when manures (poultry/cow dung), bio-fertilizers and NPK at different levels were used in the management of *Moringa* (Beulah, 2001). Adebayo e*t al.* (2011) in their study observed increased vegetative growth and dry matter yield of *M. oleifera* with organic amendment

For certain reasons, organic manure is preferred to inorganic fertilizers. Apart from adding nutrients

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to the soil (Ndukwe *et al.,* 2009), it also improves soil properties (Thompson and Troel, 1978) and acts as a liming material by reducing soil acidity (Olatunji *et al.,* 2012). The problem of non-availability of inorganic fertilizers in their right quantities has become acute since the federal government disengaged from fertilizer importation and distribution in 1997. Consequently, most farmers now use organic manure (Ojanuga, 2006). In the study area, Nsukka, in south-eastern Nigeria, pig waste is readily available and cheaper than poultry manure and other organic fertilizers. This is most likely the case in other parts of Nigeria where pig rearing is common. In okra, application of pig waste has been shown to increase the yield of the crop by more than 50% (Olatunji and Oboh, 2012). Since report of this manure in moringa culture in Nigeria is very scanty, we decided to test the response of the species to pig waste.

MATERIALS AND METHODS

Ripe pods of *Moringa oleifera* were collected from the following locations across Nigeria in 2011: Awo-Anekpa, Baruten, Mayo-Belwa, Dooshima, Maiduguri, Awo-Garaji, Giri, Idere, Iri, Ityomu, Kano, Kolo, Kontagora, Kuje, Nsukka, Rini, Ugya, Yola, Zaria and Zuru. Seeds were extracted from the pods and grown in the nursery. Seedlings were transplanted from the nursery after 1 month at an intra-row distance of 0.5 m and inter-row distance of 1.0 m on a single row plot of 5 plants. Organic manure (pig waste) was applied to the seedlings at one month after transplanting at the rates of 0, 10 and 20 t/ha. The experiment was 3 x 20 factorial in randomized complete block design and replicated three times. Treatments were pig waste (3 levels – 0, 10 20 t/ha) and 20 accessions of *Moringa leifera*.

The experiment was conducted between August 2011 and Nov 2012 at the Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. Data were collected on survival, plant height, plant girth and number of leaves per plant at 6, 9, 12 and 18 months after transplanting (MAT). Fully expanded leaves were counted and recorded as number of leaves per plant. Plant height was measured 2 cm from the ground with a meter rule while plant girth was taken with a 15 cm vernier calipers and a meter rule on individual plants in a plot. Fresh and dry weight yields were determined after pruning at 18 MAT using a digital weighing balance while the leaves and stems were dried in the oven at 60^0C to constant weights. Pod and seed characters were also determined.

Data collected were subjected to analysis of variance according to the procedure for a two factorial experiment in RCBD. Separation of treatment means for statistical significance was done using the least significant difference as outlined by Obi (2002).

RESULTS

Properties of soil of the experimental site and pig waste are presented in Table 1. Pig manure had higher values of pH, organic matter and nitrogen when compared to the soil values. The main effect of the factors on morphological growth parameters measured showed significant variation*s (*$p < 0.05$) across accessions (Table 2). There was a clear pattern of decreasing survival percentage for most of the accessions, from 6 to 15 MAT.

Thus, at 6 MAT, 75% of the accessions recorded up to 70% survival. This decreased progressively to only 30% of accessions recording up to 70% survival at the final stage of assessment (15 MAT), Zaria maintained a steady survival percentage of 84.40 for one year which dropped to 68.90% at 15 MAT. Baruten had the lowest survival percentage throughout the period of the experiment as shown while Kolo had the highest value (80%) over a period of 15 MAT. In contract to the decreasing survival percentage, plant height and other morphological attributes increased from 6 to 15 MAT (Table 2). Although Kano had the lowest plant height at the beginning (6 MAT) and at the end (15 MAT), Kolo which ended up the tallest was not the highest from the beginning. It also recorded larger girth than other accessions while Ugya had more leaves 15 MAT. Interestingly, Kolo recorded significantly higher number of leaves per plant than other accessions at 12 MAT when there was a general drop in leaf number. Effect of interaction of the factors on growth characters (Table 3) showed that the Yola accession grew taller than others when 0 or 10 t/ha application of manure was made. However, the highest dose of application (20 t/ha) favoured Ugya. This later accession also exceeded others in stem girth and number of leaves at this manure rate. When no manure was applied, Kolo and Ugya had larger girths. Control plots of Kolo and Nsukka accessions had more leaves than others. For all morphological parts examined, mean response to manure rate was in the order 20 t/ha > 10 t/ha > 0 t/ha. Similar pattern of response was observed for leaf and stem dry weights (Table 4). In summary, Kolo and Ugya had highest leaf dry weight. Kolo, followed by Idere and Awo - Garaji also recorded higher stem dry weights than other accessions.

The main effect of accession on pod and seed characters of the 20 *M. oleifera* accessions across Nigeria is presented in Table 5. The Giri, Idere and Kolo accessions produced more than four pods per plant. Kano accession on the other hand did not produce any pods. Pod circumference varied from a high of 5.80 cm (Idere) to a low of 0.48 cm (Zaria). Pods produced by Awo - Garaji and Idere were the longest, being longer than 20cm; while pods from Baruten accession were the shortest (3.19 cm).Pods produced by seeds sourced from Maiduguri were the heaviest while those of Kano were the lightest.

Table 1: Soil properties of the experimental site and pig waste

Sampled depth (0-30cm)	Before experiment	After experiment			Pig Waste
	2011	20 t/ha	10 t/ha	0 t/ha	
Mechanical properties					
Clay %	14	16	16	18	-
Fine sand %	22	18	16	19	-
Coarse sand %	55	57	61	58	-
Texture class	SL	SL	SL	SL	
Chemical properties					
pH in water	4.9	5.4	5.5	5.4	6.8
pH in KCl	4.2	4.5	4.5	4.5	-
Organic carbon (%)	0.85	1.63	1.31	1.26	18.55
Organic matter (%)	1.47	2.81	2.25	2.17	31.99
Total nitrogen (%)	0.028	0.098	0.084	0.07	1.68
Phosphorus (ppm)	32.64	35.44	28.91	20.52	0.45
Exchangeable bases in mg/100g soil					
Sodium (Na^+) (mg/100g)	0.28	0.47	0.55	0.51	0.004
Calcium (Ca^{2+}) (mg/100g)	1.2	2.80	2.0	1.2	0.64
Magnessuim (Mg^{2+}) (mg/100g)	1.6	1.6	1.6	1.6	1.08
CEC (%)	5.6	11.6	10.4	12	-
Base saturation (%)	56.25	44.91	43.17	30.92	-
Exchangeable acidity in me/100g soil					
Aluminum (Al^{3+}) unit 2,	-2	1.4	1	1.4	-
Hydrogen (H^+) unit 2,	2.4	1.2	1.4	1.4	-
Moisture content (%)	20.34	-	-		22.4

Idere, Giri and Yola accessions produced more than eight seeds per pod. In contrast, the Kano provenance only managed to produce one seed per pod.

The heaviest seeds came from Maiduguri, Awo - Garaji and Giri while the lighter ones were from Baruten and Zaria. It was remarkable that at 0 t/ha manure rate, Yola accession produced the highest number of pods; Awo - Anekpa, Maiduguri, Kontagora and Zuru did not produce any viable pods, that is pods with seeds. At 10t/ha, Baruten and Zaria did not produce viable pods but Irri and Awo - Garaji produced highest pod numbers. At the highest application of manure (20 t/ha), Idere and Maiduguri did not produce pods (Data not shown). All the accessions that did not produce viable pods at those manure rates indicated above did not produce seeds. Correlation coefficients between evaluated characters showed a number of significant positive relationships (Table 7). Thus, most of the growth traits had significant positive relationships with each other and with the other traits. The only notable exception was number of leaves which had positive correlations with all other traits but was significantly so only with stem girth. The latter's relationship with pod weight; seed number and plant height was positive but non-significant.

DISCUSSION

Laboratory analysis shows that compared to soil values, pig manure is particularly high in pH, organic matter and nitrogen. Although the textural class (sandy loam) fits the requirements for Moringa growth (Price 2007), the pH of 4.9 is a little out of range with the neutral to slightly acidic soil pH of 5.0-7.0 prescribed for the species (Palada and Changi, 2003). Nsukka soils are noted for their acidity (Baiyeri and Tenkouano, 2007), which imposes limitation on amount of nutrients available to the plant (Baiyeri and Mbah, 2006). In the context of this, application of organic manure becomes desirable. Poultry manure in particular, has been linked with reduction of soil acidity apart from soil nutrient enrichment (Olatunji and Oboh, 2012; Sunassee, 2001). The reduction in exchangeable acidity and improvement in the soil pH from 4.9 to 5.5 as well as increased nutrient status of the site (especially the plots that received 20 t/ha) in organic matter, total nitrogen, phosphorus, calcium and base saturation as indicated in 2013 soil analyses result may be attributed to the application of pig waste. This indicates a mode of action similar to that of poultry manure and highlights the importance of pig waste in soil improvement. Generally, organic materials are known to modify soil properties (Thompson and Troeh, 1978) and boost the soil nutrient content (Dauda *et al.* 2005; Ndukwe *et al.* 2009). The decreasing survival percentage with increasing number of months contradicts the age- long belief that *Moringa* is a 'never die' tree, thriving in areas of extreme climatic conditions and destitute soils. This suggests that the species is still susceptible to the vicissitudes of environmental factors as is common with other species. In an international provenance trial of the Neem tree (*Azadirachta indica*) involving 23 provenances, Lamichhane and Thapa (2011) observed a survival rate ranging from 33-92% in the 5th year of tree establishment. In this report, the highest survival rate after 15 months of transplanting was 80%. With few exceptions, evaluated traits (growth and yield parameters) showed linear response to manure rates. This confirms the well acknowledged role of fertilization in enhancing the performance of the species (Price, 2000; Ramachandra *et al.,* 1980).

Table 2: Main effect of accession on survival and morphological growth parameters of *Moringa oleifera* at 6, 9, 12, and 15 months after transplanting (MAT)

	6 MAT				9 MAT				12 MAT				15 MAT			
Accession	SURV	PHT	NOL	PGT	SURV	PHT	NOL	PGT	SURV	PHT	NOL	PGT	SURV	PHT	NOL	PGT
Awo-Anekpa	80.00	75.50	3.48	11.47	80.00	123.20	16.25	20.99	80.00	139.80	1.59	23.56	73.30	148.80	1.40	25.29
Baruten	44.40	56.60	1.84	9.01	40.00	106.70	12.01	15.68	40.00	137.50	2.28	19.31	37.80	146.80	4.80	21.76
Mayo-Belwa	77.80	69.20	3.81	10.76	75.60	121.60	15.93	17.05	71.10	146.70	2.60	19.82	68.90	158.30	6.53	22.43
Dooshima	86.70	81.60	2.32	11.59	86.70	125.60	18.42	19.33	80.00	140.40	3.60	22.89	75.60	156.30	5.52	24.34
Maiduguri	64.40	67.90	1.29	10.50	62.20	109.00	16.92	17.52	62.20	123.00	1.86	20.54	53.30	147.10	7.77	23.00
Awo-Garaji	84.40	94.00	2.96	13.40	80.00	135.90	23.74	22.45	75.60	153.00	3.83	27.32	68.90	171.50	8.42	30.61
Giri	91.10	74.90	2.21	12.00	84.40	113.30	18.57	18.64	84.40	131.30	2.94	23.50	77.80	153.90	8.31	27.25
Idere	88.90	86.10	1.87	13.07	88.90	139.90	27.54	22.96	82.20	150.60	2.97	26.75	77.80	163.10	8.50	28.65
Iri	71.10	64.40	3.08	9.99	68.90	109.30	22.62	16.42	66.70	120.90	4.10	19.20	51.10	149.10	6.67	23.67
Ityomu	77.80	70.10	2.67	10.99	71.10	107.40	18.71	17.53	68.90	117.40	3.38	19.13	68.90	123.70	5.03	20.24
Kano	55.60	38.90	2.91	6.92	48.90	79.30	13.04	13.12	48.90	90.50	1.06	15.00	46.70	100.90	5.93	16.64
Kolo	86.70	88.10	4.32	13.42	80.00	141.80	27.42	24.90	80.00	167.00	7.30	30.71	80.00	187.20	14.99	33.76
Kontagora	88.90	63.80	2.88	9.47	86.70	96.80	15.78	15.05	82.20	109.70	2.49	17.19	66.70	119.20	7.14	19.11
Kuje	53.30	63.10	3.32	10.79	51.10	103.80	17.98	18.04	48.90	114.30	1.59	19.69	46.70	128.40	4.37	22.28
Nsukka	82.20	88.60	4.71	13.14	82.20	128.10	19.07	19.66	77.80	143.90	2.48	23.52	71.10	160.60	7.04	27.41
Rini	71.10	71.70	2.82	10.36	68.90	111.30	20.69	17.20	66.70	119.50	2.78	19.30	53.30	136.20	8.89	21.55
Ugya	73.30	71.20	3.86	11.71	71.10	108.10	21.06	20.44	68.90	127.00	4.53	26.17	62.20	160.20	23.62	30.28
Yola	64.40	92.50	3.65	12.37	62.20	137.90	21.49	20.40	60.00	162.60	4.50	23.86	57.80	180.70	8.39	26.79
Zaria	84.40	61.90	4.06	10.26	84.40	93.60	13.57	14.14	84.40	101.50	1.61	16.32	68.90	123.60	2.03	19.82
Zuru	77.80	67.30	2.99	10.25	71.10	114.20	15.61	16.18	64.40	131.60	2.37	19.38	60.00	144.00	5.49	21.50
$LSD_{(0.05)}$	21.10	20.97	1.60	2.60	21.46	29.83	7.74	4.91	22.04	34.51	3.31	6.20	22.52	40.23	9.48	6.85

SURV - Survival count; PHT - Plant height; NOL - Number of leaves; PGT - Plant girth

Table 3: Effect of accession (A), manure rate (M) (t/ha) and interaction A x M on plant height (cm), stem girth (cm), and No of leaves) of *Moringa oleifera* at 15 months after transplanting (MAT)

	Plant height (cm)				**Stem girth (cm)**				**No of leaves**			
Accession	**0**	**10**	**20**	**Mean**	**0**	**10**	**20**	**Mean**	**0**	**10**	**20**	**Mean**
Awo-Anekpa	124.10	141.00	181.20	148.80	20.73	24.40	30.74	25.29	0.02	1.37	2.80	1.40
Baruten	129.00	118.90	192.50	146.80	21.09	15.57	28.63	21.76	2.47	2.00	9.93	4.80
Mayo-Belwa	95.40	159.00	220.50	158.30	15.51	21.62	30.15	22.43	2.17	8.10	9.33	6.53
Dooshima	128.60	177.50	162.90	156.30	18.87	28.32	25.84	24.34	2.23	5.43	8.90	5.52
Maiduguri	112.50	111.00	217.80	147.10	17.92	16.84	34.25	23.00	2.10	1.00	20.20	7.77
Awo-Garaji	104.10	228.80	181.60	171.50	20.45	36.93	34.46	30.61	1.00	13.20	11.07	8.42
Giri	118.00	159.20	184.50	153.90	20.31	28.06	33.37	27.25	3.50	10.43	11.00	8.31
Idere	97.00	174.50	217.80	163.10	17.21	30.78	37.96	28.65	1.10	9.53	14.87	8.50
Iri	129.30	137.50	180.50	149.10	19.07	24.01	27.94	23.67	2.74	5.47	11.80	6.67
Ityomu	81.70	110.80	178.50	123.70	14.35	18.00	28.38	20.24	1.17	2.17	11.77	5.03
Kano	49.70	117.30	135.70	100.90	10.29	17.89	21.75	16.64	0.58	5.27	11.93	5.93
Kolo	149.90	180.40	231.30	187.20	29.01	30.91	41.36	33.76	8.03	14.77	22.17	14.99
Kontagora	65.40	103.40	188.80	119.20	10.96	14.47	31.90	19.11	0.77	2.27	18.40	7.14
Kuje	85.90	149.00	150.40	128.40	14.79	26.05	26.01	22.28	0.27	7.83	5.00	4.37
Nsukka	154.90	161.00	165.70	160.60	21.21	27.71	33.29	27.41	6.10	4.27	10.77	7.04
Rini	78.00	136.40	194.30	136.20	11.55	20.89	32.23	21.55	0.00	4.60	22.07	8.89
Ugya	110.20	135.50	234.90	160.20	25.25	21.21	44.38	30.28	2.27	6.20	62.40	23.62
Yola	161.40	183.10	197.60	180.70	22.93	26.39	31.05	26.79	2.68	8.10	14.40	8.39
Zaria	82.60	122.80	165.30	123.60	14.60	19.84	25.01	19.82	0.00	2.17	3.93	2.03
Zuru	82.60	123.90	225.50	144.00	12.05	19.63	32.82	21.50	0.58	4.77	12.27	5.49
$LSD_{(0.05)}$	107.00	146.50	190.40		17.91	23.48	31.58		1.93	5.95	14.75	

Plant height
Lsd for Accession - 40.23
Lsd for Manure rate - 15.58
Lsd for accession x Manure rate - ns

Stem girth
Lsd for Accession - 6.85
Lsd for Manure rate - 2.65
Lsd for Accession x Manure rate - ns

No of leaves
Lsd for Accession - 9.48
Lsd for manure rate -3.67
Lsd for Accession x Manure rate - 16.43

Table 4: Effect of accession (A), manure rate (M) (t/ha) and interaction A x M on leaf and stem dry weight (g) of *Moringa oleifera* at 15 months after transplanting

Accession	**Leaf dry weight**				**Stem girth**			
	0	10	20	Mean	0	10	20	Mean
Awo-Anekpa	0.54	1.05	4.39	1.63	22.80	26.70	57.80	35.80
Baruten	4.19	0.42	9.77	4.79	25.60	12.10	68.40	35.40
Mayo-Belwa	0.06	2.57	10.30	4.31	6.90	27.30	61.60	32.00
Dooshima	0.59	4.06	7.56	4.07	21.50	39.70	79.70	47.00
Maiduguri	1.43	1.14	16.20	6.26	37.60	8.40	114.90	53.60
Awo-Garaji	0.02	10.45	11.30	7.26	15.60	132.00	76.50	74.70
Giri	1.22	9.23	14.29	8.24	16.30	39.10	100.70	52.00
Idere	0.21	4.35	16.79	7.11	11.70	70.40	168.90	83.70
Iri	1.19	1.88	8.57	3.88	24.80	31.40	55.60	37.30
Ityomu	0.30	0.90	5.82	2.34	6.20	15.50	63.10	28.30
Kano	0.54	1.96	3.16	1.89	2.30	13.60	16.50	10.80
Kolo	3.37	10.32	19.44	11.04	51.90	74.10	167.00	97.60
Kontagora	0.10	0.37	4.91	1.79	4.00	3.90	63.30	23.70
Kuje	0.14	5.13	1.25	2.18	4.00	41.40	33.50	26.30
Nsukka	1.13	1.98	7.14	3.42	25.90	31.30	70.60	42.60
Rini	0.12	0.94	15.18	5.41	4.20	16.20	88.30	36.20
Ugya	0.40	3.05	32.17	11.87	17.90	20.20	191.40	76.50
Yola	1.31	5.67	12.62	6.54	25.20	50.20	178.50	84.60
Zaria	0.00	0.35	1.47	0.61	4.50	16.70	24.80	15.30
Zuru	0.40	3.73	9.57	4.30	2.90	25.80	101.50	43.40
$LSD_{(0.05)}$	0.77	3.48	10.59		16.60	34.80	89.10	

Leaf dry weight (LEAF - DW)
Lsd for Accession - 5.74
Lsd for Manure rate - 2.22
Lsd for accession x Manure rate - ns

Stem dry weight (STEM - DW)
Lsd for Accession - ns
Lsd for Manure rate - 20.97
Lsd for Accession x Manure rate – ns

Table 5: Main effect of accession on the pod and seed parameters of *Moringa oleifera*

Accession	Pods/plant	Pod circumference (cm)	Pod length (cm)	Pod weight (g)	Seed No/pod	Seed weight (cm)
Awo-Anekpa	2.44	0.76	6.39	0.90	2.56	0.42
Baruten	2.44	0.26	3.19	0.27	1.28	0.18
Mayo-Belwa	2.33	1.51	8.62	1.62	3.06	0.79
Dooshima	3.33	2.95	16.80	2.51	3.72	1.20
Maiduguri	2.78	3.59	20.45	4.22	7.50	1.96
Awo-Garaji	3.78	3.74	22.88	3.73	7.69	1.83
Giri	4.44	3.43	18.37	3.13	8.61	1.81
Idere	4.22	3.80	21.36	3.73	9.06	1.94
Iri	3.89	3.57	19.61	2.74	6.74	1.55
Ityomu	3.00	1.82	10.15	1.32	2.89	0.74
Kano	-	-	-	-	-	-
Kolo	4.11	3.56	18.55	3.31	5.25	1.37
Kontagora	2.33	1.71	8.50	2.02	3.33	1.01
Kuje	2.76	2.56	12.93	1.67	3.96	1.21
Nsukka	2.22	0.84	5.48	0.54	2.11	0.43
Rini	2.67	2.90	11.94	2.68	6.22	1.52
Ugya	3.11	2.11	9.00	1.16	1.67	0.73
Yola	3.11	3.72	17.16	3.67	8.22	1.70
Zaria	1.89	0.48	2.50	0.34	1.00	0.22
Zuru	2.56	1.52	7.17	1.27	2.83	0.71
$LSD_{(0.05)}$	1.25	2.07	11.46	2.07	4.75	0.37

Table 6: Effect of pig waste on pod and seed characters of twenty accessions of *M. oleifera* at Nsukka, Nigeria

Manure rate (t/ha)	Pod weight (g)	Pod length (cm)	Pod circum-ference (cm)	Seeds /pod	Seed weight (g)
0	1.4	10.6	1.6	4.0	0.8
10	1.7	11.6	2.1	4.0	0.9
20	3.1	14.0	3.0	5.1	1.6
$LSD_{(0.05)}$	0.80	NS	0.80	NS	0.40

Adebayo *et al.* (2011) found that organic amendment increased both the vegetative and dry matter yield of *M. oleifera*. Similarly, higher leaf production in *Moringa* was attained with higher fertilizer rate (Abdullahi *et al.,* 2013). Increased pod/seed production with increase in manure rate confirm the report of Olatunji and Oboh (2012) in okra (*Abelmoscus esculentum*) where pod yield was increased by 52% as a result of the application of pig waste. This clearly shows that although *Moringa* may thrive in destitute soils, it does better with the application of organic manure.The accession from Kolo which maintained high leaf number throughout the year is a possible candidate for fodder. Current research efforts are geared towards identifying plants that can provide fodder all year round (Nouman *et al.,* 2013). As stated earlier, *M. oleifera* is known to do reasonably well even in marginal soils. Results obtained in this study point to accessional differences in this regard. For instance, with no manure application, Yola produced very heavy pods while accessions like Awo - Anekpa, Maiduguri, Kontagora and Zuru did not produce either viable pods or seeds at this rate. Still some did not produce viable pods or seeds at 10 or 20 t/ha. It is possible that at 0 t/ha of pig waste, soil fertility status was too low to support pod/seed production of some accessions. Failure of some accessions to produce pods/seeds at higher manure rates could indicate their lack of tolerance to such high levels of fertility for reproductive performance. It would have been reasonable to suggest that at higher soil nutrient levels, poor reproductive performance was compensated for by increased vegetative growth. However, this cannot be categorically stated as correlation analysis has failed to support this opinion. The relationship between vegetative and reproductive parameters was positive and in most cases, significantly so. This pattern of response to manure application may need further investigation for more definitive conclusions to be reached.

However, the inability of the Kano accession (Sudan savannah agro-ecological zone) to produce any pod at all may be attributed to genetic defect or poor adaptation to Nsukka environment. What is immediately evident is that such accessional variations may present opportunities for selection for breeding towards particular requirements. Alternatively, seeds from such accessions may be selected for planting based on soil nutrient status or the grower's management capacity. The high level of significant positive relationships among examined traits is heartwarming. The implication is that agronomic interventions seeking to increase vegetative yield would generally improve pod and seed production. Conversely, those interventions seeking to improve reproductive performance will also most likely enhance vegetative yield. Thus there will be no separate interventions for improving either vegetative growth or reproductive performance.

Table 7: Correlation coefficients between vegetative, dry weight and reproductive characters of *M. oleifera* at Nsukka, Nigeria

	Stem dry weight	Leaf dry weight	No of leaves	Stem girth	Plant height	Seed weight	Seed No./pod	Pod weight	Pod length	Pod circum-ference
Pods/plant	0.671**	0.643**	0.387	0.657**	0.541*	0.730**	0.703**	0.700**	0.833**	0.806**
Pod circumference (cm)	0.647**	0.557*	0.361	0.488*	0.478*	0.964**	0.899**	0.948**	0.968**	-
Pod length (cm)	0.627**	0.502*	0.253	0.515*	0.501*	0.946**	0.896**	0.943**	-	
Pod weight (g)	0.627**	0.496*	0.248	0.422	0.474*	0.971**	0.929**	-		
Seed No./pod	0.548*	0.417	0.122	0.366	0.428	0.958**	-			
Seed weight (g)	0.545*	0.463*	0.237	0.374	0.375	-				
Plant height (cm)	0.879**	0.721**	0.447	0.891**	-					
Stem girth (cm)	0.898**	0.804**	0.611**	-						
No of leaves	0.647**	0.861**	-							
Leaf dry weight (g)	0.861**	-								
Stem dry weight (g)	-									

*, ** - Correlation is significant at the 0.05 and 0.01 levels of probability, respectively.

CONCLUSION

In conclusion, this study has established existence of accessional differences in survival, growth and yield of *Moringa oleifera* in Nigeria as well as its response to manure application. It is evident that enough variability exists to warrant selection of accessions for genetic improvement or direct planting based on soil nutrient status or the farmer's competence.

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