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Growth and yield of *Moringa oleifera* as influenced by spacing and organic manures in South-Western Nigeria

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Abstract

The envisaged demand for *Moringa oleifera* plant parts to fulfill its multipurpose functions can only be met when production is based on improved agronomic recommendations. Seeds of *moringa* were sown on the Teaching and Research Farm, Ekiti State University, Ado-Ekiti at 30x40 and 60x80 cm spacing as main plots while cow dung and poultry droppings were compared to a control as subplots. The treatments were combined as a 2×3 factorial and replicated four times in a randomized complete block design. The manures were applied at 20.0 metric tons per ha in three splits at 0, 6 and 12 weeks after planting (WAP). Plant height, stem girth and fodder yield were measured at 16, 20 and 24 WAP. The plants were significantly taller and with smaller stem girth at 30×40 cm than 60×80 cm spacing. Manure application slightly increased plant height but the plants had significantly higher stem girth. The effect of manure was similar at the two spacings but showed the superiority of poultry dropping compared to cow dung. Biomass yield was higher at 30×40 cm spacing while the response to manure application was significant (P=0.05). Poultry dropping gave significantly higher biomass yield at 30x40 and 60x80 cm spacings. The significant fertilizer value showed that poultry droppings should be used for the cultivation of moringa, especially when the close spacing of 30x40 cm is adopted.

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Introduction

The awareness of moringa (*Moringa oleifera*) *as* a multi-purpose crop has increased considerably in Nigeria from its common uses as a living fence and salad in the northern states to consumption of the leaves and seeds and the claim for medicinal purposes in the southern states (Oluduro and Aderiye, 2007). Moringa has low toxicity in animals (Makkar and Becker, 1996; Furo and Ambali, 2011) which has increased interest in its utilization as a protein source for livestock (Asaolu *et al*., 2012; Adegun and Aye, 2013). The leaves have a high nutritional value which is needed for the growth and health of animals even as studies on the functions as a galactogogue in dairy production, parasite load reduction and in pharmaceuticals have yielded positive results (Alonzo-Diaz *et al*., 2010; Dela Cruz, 2012). These have influenced the adoption of moringa as a national crop whose cultivation and consumption are being actively encouraged through the Raw Materials Research and Development Council. Also, Moringa has been listed with artemisa, a critical ingredient in malaria treatment as important medicinal plants for cultivation as raw materials to be utilized by pharmaceutical companies by the Nigerian Medicinal Plant Development Council (Olokor, 2012).

The main form of cultivation of moringa is in agroforestry practices by smallholder farmers and whose promise for sustainable development lies in the ability to continue producing feed materials for animals and streams of income for farmers over a number of years. The envisaged demand for moringa plant parts can only be met when production is based on improved agronomic recommendations. One component of improved farming practices which affects crop output is plant population a*s* determined by spacing, plant geometry and stand density because it influences growth, yield and yield components (Lauer, 1994). There are few studies on the effects of population on moringa production. Adegun *et al.* (2013) obtained highest fodder yields of moringa from plants spaced at 30x40 cm compared to higher spacing in south-western Nigeria. Results of other authors recommended different planting populations based on intended usage of the biomass and the provenances of the plant (Goss, 2012; Gadzirayi *et al*., 2013; Edward *et al*., 2014).

Nutrient management has constituted an important aspect of improved farm practices developed to attain high yields and quality in all crops to meet the demand of an ever-increasing human population. Herein lays the importance of fertilizers needed to maintain soil fertility in all commercially-grown crops especially under continuous cultivation. Moringa has low demand for soil nutrients (Foidl *et al*., 2001) but increased fodder yield under continuous cultivation is possible through soil and fertilizer nutrient management in order to grow the value-chain both in terms of increased productivity of animals and income to the farmers (Animashaun *et al*., 2013). The benefits of fertilizers (organic and inorganic) do not only apply to increased nitrogen (N) uptake by plants but also to the improvement of fodder yield (Wang *et al*., 2011). Inorganic (mineral or chemical) fertilizers are water-soluble and produce immediate effects in terms of improved crop growth, yield and quality but the continuous application in large doses poses environmental pollution threats and would induce nutrient imbalance and deficiencies that culminate in poor soil quality and reduced crop yields. Besides, the rising costs of chemical fertilizers beyond the reach of resources-poor farmers appear to have favoured the preference for materials of plant and animal origin (organic fertilizers) as sources of nutrients whose use will ensure sustainability of crop production systems (Agyemin-Boateng *et al*., 2006).

Organic fertilizers nourish soil organisms which, in turn, slowly make nutrients available to plants. The commonest materials of animal origin are wastes such as farmyard manure, poultry manure and cow dung which are cheap and contain nutrients that support better root development leading to higher crop yields (Abou El-Magd *et al*., 2005). Animals excrete 75, 80 and 90% of N, phosphorus (P) and potassium (K) in the ingested feed and these appear in the manures. Thus, manure composition depends on the quality of the feed offered to the animals; feeds high in protein would give high N manures and the more P and K are in the feed, the richer is the manure in these nutrients. Thus, soil application of these nutrient-rich materials will be a good and environment-friendly farm practice. However, there is generally low level of organic manure use in Nigeria despite the huge amounts of liquid and solid wastes generated daily from intensive management systems that involve housing and feeding livestock in pens, sheds and cages. Besides, most of the studies on manure had been on arable crops (cereals and legumes), especially in the savannah where large numbers of ruminant livestock exist (FMANR, 1990) while there is insufficient knowledge of their effects on perennial fodder crops to enhance their effective utilization (Ayeni, 2011).

Moringa is one of the perennial fodder plants whose cultivation is being promoted in southwestern Nigeria to ensure availability of good quality feed to improve the nutrition of ruminant livestock population. Information on improved agronomic practices must be available. This study was designed to provide information on moringa cultivation with respect to growth and fodder productivity as affected by population and application of organic manures.

Materials and methods

Location of the experiment

The experiment was carried out on the Teaching and Research Farm, Ekiti State University, Ado-Ekiti (latitude 07°31'15"N, longitude 05°13'17"E) between May and November 2012. Ado-Ekiti in the southwestern zone of Nigeria experiences a tropical climate with marked rainy and dry seasons between March-November and November-March respectively. The mean annual temperature range is 20-28°C while the rainfall of 1,367 mm is characterized by bimodal distribution with peaks in June and September.

Sample preparation

A fairly-level portion of land was ploughed, harrowed and marked into 3.0x3.0 m plots separated by 1.0 m paths; and topsoil (0-15 cm) samples were randomly taken from the plots. The composite soil sample, well-rotted poultry droppings and cow dung samples were air-dried and sieved (<2 mm). Soil particle size distribution was determined using the hydrometer method; the pH of soil and manures was determined in 1: 2.5 sample-distilled water mixtures and read off an electronic pH meter while organic matter, total N, available P and exchangeable cations were determined using the methods described in IITA (1979).

Experimental design, Data collection and analysis

Seeds (2-3) of moringa were sown at 30×40 and 60×80 cm spacing and seedlings thinned to one (1) per hill after emergence. 200 g each of poultry manure and cow dung were applied by banding at thinning and repeated at six and 12 weeks after planting (WAP). The control treatment did not receive any manure. The treatments were combined in a 2×3 factorial and arranged as a randomized complete block design with four replicates. The plots were weeded manually at 6 and 12 WAP. At 16 WAP, plant height and stem girth were measured with tape rule. Fresh fodder yield was taken as plant material (tender stem and leaves) pruned 20 cm from the tip within 2×2 m plot, bulked and weighed. The measurements were repeated at 20 and 24 WAP. The data collected were averaged and subjected to analysis of variance (ANOVA) of the SAS Package version 9.0 (2005). The means were separated for significant differences at P=0.05 using the Duncan's Multiple Range Test (DMRT).

Results

Table 1 shows the characteristics of the soil in the study site and organic manure samples. The soil was a moderately acid (pH=5.55) sandy loam with organic matter and total N contents of 1.65 and 0.09%, respectively. Soil available P was 4.31 mg.kg^{-1} while the exchangeable K, Ca and Mg were 0.19, 1.38 and 0.74 cmol.kg^{-1}, respectively. The cow dung was near neutral (pH=6.90) while poultry waste was slightly acid (pH=6.20). The organic matter, total N and exchangeable K were higher in poultry droppings whereas cow dung contained more available P and exchangeable Ca and Mg. The in C/N ratio was 5.94

and 7.05 in poultry droppings, respectively.

The effects of spacing and application of organic manures on some growth parameters of moringa are shown in Tables 2 and 3. Plant height and stem girth increased slightly as the moringa aged over the harvesting periods. The main effects of spacing showed that plants were significantly (P=0.05) taller at 30×40 cm spacing over the harvesting periods such that the overall means were 162.21 cm at 60×80 cm spacing and 168.88 cm at 30×40 cm spacing. Manure application slightly increased plant height at all harvests and the mean values of 163.92 cm for the control and 166.17 cm for the poultry droppings and cow dung were not significantly different. The spacing × manure interaction showed that application of poultry droppings and cow dung produced plants that were taller at 30×40 cm spacing than same treatments at 60×80 cm spacing at 16 and 20 WAP while plant height did not differ significantly at 24 WAP. The overall mean showed that plants were tallest at the combination of 30×40 cm spacing application of poultry droppings while application of cow dung gave tallest plants at 60×80 spacing. The plants were significantly thicker at 60×80 cm than 30×40 cm spacing at all harvest periods with the overall means of 16.74 and 15.60 cm, respectively. The effect of manure application was also significant as shown by values higher for poultry droppings than cow dung while the control was least at all times of harvesting. The overall mean values were in the order: poultry droppings>cow dung>control. The interaction effect was significant such that the best combinations were poultry droppings for plants at 30×40 cm and 60×80 cm spacing but in the latter, poultry droppings and cow dung were similar.

Table 1. Characteristics of topsoil (0-15 cm) in the study site and organic manures.

Characteristics	Soil	Poultry droppings	Cow dung
PH(water)	5.55	6.20	6.90
Sand,g.kg^{-1}	55.32	-	-
Silt,g.kg^{-1}	30.80	-	-
Clay,g.kg^{-1}	13.88	-	-
Textural class	*SL	-	-
Organic matter,g.kg^{-1}	1.65	16.60	14.84
Total N,g.kg^{-1}	0.09	1.62	1.22
C/N ratio	10.63	5.94	7.05
Available P,mg.kg^{-1}	4.31	1.20	1.42
Exchangeable cations,cmol.kg^{-1}			
K	0.19	2.80	2.60
Ca	1.38	1.26	3.20
Mg	0.74	0.68	0.62
Na	0.09	0.15	0.12

*SL=Sandy loam.

Fresh fodder yields of moringa as influenced by spacing and application of organic manures are shown in Table 4. The main effects of spacing and manure were significant (P=0.05) at all harvests with 30×40 cm giving higher fodder yield than 60×80 cm spacing while the order of performance of the manures was control<cow dung<poultry droppings and these were reflected in the overall means. The spacing x manure interaction effect showed that 30×40 cm spacing was better and yields were significantly increased by application of poultry droppings. Also application of poultry droppings increased the fodder yield more than application of cow dung at 60x80 cm spacing.

Discussion

The moderate acidity and low contents of organic matter, total N, available P and exchangeable K of the soil in the experimental site are typical of highly-weathered soils of the tropics which have inherent nutrient status and would therefore benefit from fertilizer application in order to maximize crop yields

(Manan and Mason, 2013). The soil was deficient in organic matter, total N and available P based on critical levels of organic matter, total N, available P and exchangeable K for soils in south-western Nigeria at 2.0 g.kg^{-1}, 0.15 g.kg^{-1}, 8-12 mg.kg^{-1} and 0.15-0.20 cmol.kg^{-1} (FDALR, 2004). Poultry manure contains more N than cow dung because of the higher nutrient status of the feeds while the lower C/N ratio means that the N would be more readily available even as the nutrients are fairly consistent. N in poultry manure comes from uric acid, ammonium salts and faecal matter; the uric acid transforms readily to ammonia which mineralizes to nitrate which make poultry manure a cheap and effective N source for sustainable crop production (Dikinya and Mufwanzala, 2010).

Table 2. Effect of spacing and application of organic manures on plant height in *Moringa oleifera*.

			Weeks after planting			
			16	20	24	Mean
Spacing						
	30×40 cm		166.93	169.50	169.92	168.88
	60×80 cm		156.75	163.42	166.00	162.21
		LSD(P=0.05)	2.35	4.22	4.39	3.29
Manure application						
		Control	159.63	164.88	167.25	163.92
		Poultry droppings	163.50	166.50	168.50	166.17
		Cow dung	162.38	168.00	168.13	166.17
		LSD(P=0.05)	6.13	5.17	5.67	4.02
Spacing		Manure Application				
	30×40cm	Control	165.50	167.50	168.50	167.18
		Poultry droppings	169.00	170.00	172.00	170.34
		Cow dung	166.25	171.00	169.25	168.83
	60×80cm	Control	153.75	162.25	166.00	161.00
		Poultry droppings	158.00	163.00	165.00	161.98
		Cow dung	158.50	165.00	167.00	163.65
		LSD(P=0.05)	7.33	7.31	7.28	5.69

Plant population, stand density and planting arrangements are used to optimize plant growth, development and yield per unit area of land such that plants should be established at the spacing that will produce maximum economic yields of crops. The effects of spacing on crops are reactions to the supply of physical factors around it and the modifications caused when the supply of one factor falls below the combined demands of the associated crops. This competition is obvious among crowded plants which would grow taller in reaction to competition for space and sunlight. Closer spacing would cause comparatively less availability of space around each plant for lateral development and thereby enforce vertical growth (Patel *et al.*, 1980). Moringa was taller at 30×40 cm spacing compared to 60×80 cm in the first harvest (16 WAP) and this reflected also in the heights of the re-growths pruned at 20 and 24 WAP. The stem girth increased at the wider plant spacing of 60×80 cm such that thinner plants at 30×40 cm are a reflection of interplant competition. The wider spacing would also produce more branches per plant but which was not recorded and whose semblance would be the number of pruned stem portions at each harvest. The harvest involved cutting 20 cm portions at the tip of each stem within 2×2 m plot and bulking for biomass yield. This breaking of apical dominance should induce profuse branching but the biomass yield decreased in the two spacings after each pruning which implies the smaller sizes of the large number of branches. The higher fodder yield at closer spacing has been attributed to higher leaf production from the increase in moringa population in north-central Nigeria (Abdullahi *et al.*, 2012). Also, the dense population of 83,330 plants.ha^{-1} attained with 30×40 cm spacing produced highest moringa fodder yield compared to wider spacings in south-western Nigeria due to higher yield per unit area of land (Adegun *et al.*, 2013).

Table 3. Effect of spacing and application of organic manures on stem girth of *Moringa oleifera*.

			Weeks after planting			
			16	20	24	Mean
Spacing	30×40cm		15.16	15.59	16.09	15.60
	60×80cm		16.12	16.79	17.31	16.74
		LSD(P=0.05)	0.81	0.75	0.72	0.75
Manure application						
		Control	14.17	15.02	15.52	14.90
		Poultry droppings	16.98	17.37	17.88	17.35
		Cow dung	15.78	16.18	16.72	16.23
		LSD(P=0.05)	1.00	0.92	0.89	0.92
Spacing		Manual application				
	30×40cm	Control	13.93	14.43	14.85	14.40
		Poultry droppings	16.50	16.90	17.48	16.93
		Cow dung	15.05	15.43	15.95	15.48
	60×80cm	Control	14.40	15.60	16.18	15.39
		Poultry droppings	17.45	17.83	18.28	17.85
		Cow dung	16.50	16.93	17.48	16.98
		LSD(P=0.05)	1.41	1.31	1.25	1.31

One of the factors which determine optimum density in plants is soil quality, especially the fertility level as influenced by nutrient management practices. This reflected in the significant spacing × manure interactions in the growth parameters and biomass yield. The control treatment gave the least values at each harvest compared to the manures. This is in line with the observation that application of organic manures (poultry manure and cow dung) were comparable in enhancing vegetative growth of moringa seedlings in the nursery (Imoro and Abubakar, 2012) even as their liming effects would raise soil pH to the level suitable for higher fodder production in moringa. Asante *et al.* (2012) observed lower stem girth of moringa without application of organic amendments at 8 and 12 weeks after germination. The better performance of moringa treated with poultry droppings than cow dung has been attributed to the higher nutrient content, especially N, of the former. Poultry birds consume feeds that are richer in proteins such that the manures generated would contain more N which helps in promoting vegetative growth of the plant (Imoro and Abubakar, 2012).

Table 4. Effect of spacing and application of organic manures on fresh fodder yield of *Moringa oleifera*.

			Weeks after planting			
			16	20	24	Mean
Spacing						
	30×40cm		11.52	11.03	11.21	11.26
	60×80cm		7.84	6.13	5.83	6.56
		LSD(P=0.05)	3.34	1.57	0.63	0.48
Manure application						
		Control	7.37	6.90	7.17	7.15
		Poultry droppings	11.84	10.10	10.13	10.69
		Cow dung	9.83	8.74	8.29	8.95
		LSD(P=0.05)	1.18	0.55	0.78	0.59
Spacing		Manual application				
	30×40cm	Control	9.05	9.35	9.65	9.35
		Poultry droppings	13.90	12.70	13.15	13.25
		Cow dung	11.60	11.05	10.88	11.18
	60×80cm	Control	5.68	4.45	4.68	4.94
		Poultry droppings	9.78	7.50	7.10	8.13
		Cow dung	8.05	6.43	5.70	6.73
		LSD(P=0.05)	1.67	0.78	1.10	0.84

Conclusion

This study indicated that moringa established from seed and thinned to one seedling per hill performed better at a closer spacing of 30×40 cm than 60×80 cm in terms of height and biomass yield in the plant harvested at 16 weeks and the subsequent pruning at 20 and 24 weeks. Poultry droppings and cow dung are valuable sources of nutrients whose application promoted the vegetative growth of moringa. However, poultry manure was better than cow dung in terms of plant height, stem girth and fresh fodder yield. The best combination to recommend for field establishment of moringa as a fodder plant is 30×40 cm spacing and application of poultry droppings. Studies to determine the appropriate rate and timing of poultry droppings application and to evaluate the response to integrated application of poultry manure and inorganic fertilizers will improve the recommendations for the establishment of moringa fields.

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