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Full Length Research Paper

Plant population and fertilizer application effects on biomass productivity of *Moringa oleifera* in North-Central Nigeria

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***Moringa oleifera* is a medium-sized soft wood tree species grown all over northern Nigeria as an ornamental and vegetative crop with great nutritional and medicinal value. It is cultivated for its biomass production. This paper suggests the best levels plant population and fertilizer for maximum biomass production of *Moringa oleifera* in North-Central Nigeria. The study showed that number of branches per plant was same (p>0.05) irrespective of variations in plant population and fertilizer application. Though the highest leaf production was obtained at the fertilizer rate of 400 kg/ha at a plant population of 20000 stands/ha but statistically they were not significant. However, application of urea significantly (p>0.05) increased the dry matter of *Moringa oleifera* per plant. This finding suggested that *Moringa* plant at 20000 stands/ha and fertilizer rate of 200 kg/ha will be the best for the cultivation of *Moringa* for its biomass production in the North-Central zone of Nigeria.**

Key words: Biomass, fertilizer, population, trees.

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INTRODUCTION

Moringa oleifera (LAM) known as drumstick is a medium-sized soft wood tree of about 10 m height belonging to the family *Moringaceae* (Adediran et al., 2003). Native to south Asia, it is considered to have its origin in Himalayan Mountains and grows naturally (Dogra et al., 1995). The tree has been found growing in an area receiving less than 400 mm mean annual rainfall (Odee, 1998). It is now cultivated in the whole tropics, including the Northern region of Nigeria.

The tree plant *Moringa* has been discovered to possess many valuable properties (Narayana and Parvathi, 2004). The tree is not a nitrogen-fixing plant but its fruits, flower and leaves contains 5 to 10% protein on average (Shahina et al., 2005). The leaves are readily eaten by human and provide excellent material for production of biogas. Several studies demonstrate that significant proportions of traditional fodder can be replaced with *Moringa* leaf (Aregheore, 2002). They are well suited for use in alley cropping (Booth, 1999). Meanwhile, the plant is commonly used as living support for fencing in the communities. The seed is often used to purify dirty or cloudy drinking water (Von Maydell, 1996). Its seed cake is used as protein- rich plant fertilizer. It has also been reported that juice extracted from the leaves can be used to make a foliar nutrient, capable of increasing crop yield up to 30% (Roa et al., 1994). *Moringa oleifera* is adapted to a wide range of soil types but does best in well drained loamy soil (Doerr and Cameron, 2005). When cultivated extensively and then ploughed into the soil, *Moringa oleifera* can act as a natural fertilizer for other crops (Dutt et al., 1997; Mathur, 2006). However, the cultivation of *Moringa oleifera* in large quantity due to increase in awareness and demand for its leaves is still at a very slow phase in the region. This is as a result of the scanty knowledge on the management of the species at juvenile stage as it affects biomass production and fertilizer application.

This paper aims to achieve the following objectives:

1. To assess the effect of nitrogen fertilizer (urea) on the growth and development of *Moringa oleifera* in the field.
2. To determine the appropriate level of fertilizer application that will improve biomass production of *Moringa* significantly.

Table 1. Treatment combinations.

Factor A	Factor B	Spacing	Fertilizer (kg/ha)
1	1	50x50 cm	0
1	2	50x50 cm	200
1	3	50x50 cm	400
2	1	1x1 m	0
2	2	1x1 m	200
2	3	1x1 m	400

3. To recommend the best plant population for maximum biomass production of *Moringa oleifera*.

MATERIALS AND METHODS

Location of the experiment

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture, University of Abuja, Gwagwalada, Abuja, Nigeria. Gwagwalada is located on latitude 6°45' and 7°39' East and longitude 8°25' and 9°20' North (Ishaya and Abaje, 2009). The average temperature of 33°C, 14% humidity during planting season (May, 2012) and an annual rainfall between 1,100 to 1,600 mm.

Soil analysis and seed source

Soil analysis report of the plot at the University of Abuja Crop Science Department Laboratory showed that the soil texture is sandy loam with sand, silt and clay having 10, 16 and 74% respectively with a pH of 5.80. The Total Nitrogen (N) and Available Phosphorus (P) in percentage are 0.175 and 12.25 respectively while potassium (K) exchangeable cations 0.23 cmol/kg. 4 weeks old potted seedlings of *Moringa* sowed from seeds (Bauchi Local) were transplanted to the experimental plot after ploughing and harrowing.

Experimental treatments

Factorial (2 x 3) randomized complete block designed (RCBD) with 3 replications was fitted into experiment. The treatment factors of which effects were assessed include the plant population (A) with two different planting spacing, 50x50 cm (A1) and 1x1 m (A2) and the Nitrogen Fertilizer (urea) (B) with 3 levels, 0 kg/ha (B1), 200 kg/ha (B2) and 400 kg/ha (B3). Each replicate (block) contained 6 plots of 3x3 m each separated within by 0.75 m. A pathway of 1 m was created between the blocks. Thus a total of 18 plots were used in the trial. The experimental plot size was 11x24 m. The treatment combinations are shown in Table 1.

Data collection and analysis

Data on number of branches/plant, number of leaves/plant, the height/plant, biomass index/plant were collected. All data collected were subjected to two-way Analysis of Variance (ANOVA)

RESULT AND DISCUSSION

Number of branches per plant of *Moringa oleifera* as influenced by plant population and fertilizer application

Statistical analysis on the branching system of *Moringa oleifera* as influenced by plant population and leaves of urea application is shown in Table 2 and Appendix 1. The number of branches per plant remained fairly the same ($p>0.05$) irrespective of variations in plant population and fertilizer application. In contrary, Osman and Abo Hassan (2010) reported that NPK fertilizer influenced the branching of *Avicennia marina* and Nawar et al. (2010) also reported that the NPK fertilizer had effect on the branching of the stems of Faba bean when it was applied. This may be as a result of the short duration of 11 weeks of which the branching effect will not be well established due to elongation of the apical bud for more photosynthetic reaction of the tree plant.

Number of leaves per plant of *Moringa oleifera* as influenced by plant population and fertilizer application

Statistical analysis on the leaves production of *Moringa oleifera* did not respond significantly ($p>0.05$) to fertilizer application (Table 2 and Appendix 2). Though the highest leaf production was obtained at the fertilizer rate of 400 kg/ha at 11 WAP and at a plant population of 20,000 stand/ha but statistically they are not significant. Ramachandran et al. (1999) affirmed the fact that *Moringa* trees generally will grow well without the application of fertilizer. Though Foidl et al. (2001) in their *Moringa* productivity trial recommended 7.5 kg farm yard manure and 0.37 kg ammonium sulphate per tree for

Table 2. Effect of treatments on *Moringa oleifera* as influenced by plant population and fertilizer application in North Central, Nigeria in 2012.

Treatments		Dry matter/plant (kg)	Plant height/plant (m)	Number of branches/plant	Number of leaves/plant
N levels (kg N/ha)	Plant population (plants/ha)				
0	10000	17.13	80.64	9.33	288.67
	20000	31.37	82.36	9.25	276.00
200	10000	28.72	93.02	9.17	288.60
	20000	34.31	75.59	9.42	314.42
400	10000	20.85	82.74	8.50	380.83
	20000	24.26	83.71	8.92	347.92
SEm (±)		4.229	41.970	0.2489	40.856
$LSD_{(0.05)}$		7.6640	76.05	0.5163	74.036
CV (%)		47.11	14.52	9.10	11.72

increased vegetable growth which was confirmed in the findings of Gupta et al. (1989) that manure and inorganic fertilizer had positive effect on the growth of Moringa leaves.

Plant height per plant of *Moringa oleifera* as influenced by plant population and fertilizer application

Plant height of *Moringa oleifera* as influenced by plant population and nitrogen application is shown on Table 2 and Appendix 3. The reading showed that the highest height per plant was obtained at 200 kg/ha at 11 WAP followed by 400 kg/ha at 11 WAP. However, application of urea did not significantly (P>0.05) increase the plant height of *Moringa oleifera.*

The plant height remained the same irrespective of variation in the plant population and fertilizer application. The result of this study on the above parameters correspond with both Gupta et al. (1989) and Palada (1996) reports on the effect of various levels of nitrogen fertilizer on the growth of maize plants, that there was no significant increases in plant height with increase in nitrogen.

Dry matter of weight per plant of *Moringa oleifera* as influenced by plant population and fertilizer application

Dry matter of *Moringa oleifera* as influenced by plant population and urea application is shown on Table 2. The result showed that irrespective of fertilizer application, highest dry matter per plant was obtained at 200 kg per hectare with a planting population of 20,000 stands at 11 weeks after planting. However, application of urea significantly (p>0.05) increased the dry matter of *Moringa oleifera* per plant. This finding corresponds with Gupta et al. (1989) that recorded increase in biomass when organic and inorganic fertilizers were applied on *Moringa* seedlings at different levels.

The highest dry matter weight per plant was recorded at stands with fertilizer rate of 200 kg per hectare with a planting population of 20000 stands per hectare. This implied that 200 kg/ha Nitrogen fertilizer (Urea) was optimum fertilizer rate for the growth of the plant in the central zone of Nigeria. While 20,000 stands per hectare was the best planting spacing for the leaves production in *Moringa* plant.

Conclusion and Recommendation

The result showed that *Moringa* grown at 20,000 stands per hectare with 200 kg/ha of urea recorded the highest branching than those grown at 10,000 stands per hectare while the highest number of leaves was recorded at 20,000 stands per hectare at a fertilizer rate of 400 kg per hectare. The result also showed that the highest height per plant was recorded at 10,000 stands per hectare at a fertilizer rate of 200 kg per hectare but the highest dry matter weight was obtained from stands grown at 20,000 stands per hectare and fertilizer rate of 200 kg per hectare.

Based on the above findings and to minimise cost of fertiliser and waste of land, a recommendation of plant at 20,000 stands per hectare and fertilizer rate of 200 kg per hectare will be the best for the cultivation of *Moringa* for biomass production in the North-Central zone of Nigeria.

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Appendix 1. Number of branches of *Moringa oleifera* as influenced by plant population and fertilizer application.

ANOVA	Sources	Df	ss	ms	Fcal	ftab (<0.05)
5 WAP	Trial	17	9.85			
	A	1	0.03	0.03	0.06Ns	4.96
	B	2	2.96	1.35	2.7Ns	4.10
	AB	2	1.09	0.55	1.1Ns	4.10
	Block	2	1.00	0.50	1Ns	4.10
	Error	10	5.04	0.50		
7 WAP	Trial	17	12.99			
	A	1	0.50	0.50	1.47Ns	4.96
	B	2	0.93	0.47	1.38Ns	4.10
	AB	2	0.64	0.32	0.94Ns	4.10
	Block	2	7.56	3.78	11.12*	4.10
	Error	10	3.36	0.34		
9 WAP	Trial	17	17.45			
	A	1	0.50	0.50	0.65Ns	4.96
	B	2	0.69	0.35	0.45Ns	4.10
	AB	2	0.58	0.29	0.38Ns	4.10
	Block	2	6.45	3.23	4.19*	4.10
	Error	10	7.7	0.77		
11 WAP	Trial	17	19.37			
	A	1	1.12	1.12	1.62Ns	4.96
	B	2	0.80	0.4	0.58Ns	4.10
	AB	2	0.41	0.21	0.30Ns	4.10
	Block	2	10.14	5.07	7.35*	4.10
	Error	10	6.9	0.69		

Source: Field Data Analysis, 2012.

Appendix 2. Number of leaves of *Moringa oleifera* as influenced by plant population and fertilizer application.

ANOVA	Sources	Df	ss	ms	Fcal	ftab (<0.05)
5 WAP	Trial	17	14032.6			
	A	1	1245.853	1245.83	3.30Ns	4.96
	B	2	5225.71	2612.86	6.93*	4.10
	AB	2	1447.31	723.66	1.92Ns	4.10
	Block	2	2344.05	1172.03	3.11Ns	4.10
	Error	10	3769.7	376.97		
7 WAP	Trial	17	21201.78			
	A	1	318.531	8.5	0.05Ns	4.96
	B	2	21803.87	10901.94	1.72Ns	4.10
	AB	2	2861.28	1430.64	0.23Ns	4.10
	Block	2	123799.46	61899.73	9.79*	
	Error	10	63232.67	6323.27		
9 WAP	Trial	17	847753.12			
	A	1	31166.73	31166.73	1.35Ns	4.96
	B	2	23263.26	11631.63	0.05Ns	4.10

Appendix 2 Contd.

	AB	2	622.92	311.46	0.01Ns	4.10
	Block	2	561976.7	286988.35	12.18*	4.10
	Error	10	230723.51			
	Trial	17	1255470.35			
	A	1	10500.42	10500.42	0.74Ns	4.96
	B	2	58725.42	29362.71	2.07Ns	4.10
11 WAP	AB	2	24023.13	12011.57	0.85Ns	4.10
	Block	2	1020332.59	510166.25	35.96*	4.10
	Error	10	141888.79	14188.88		

Source: Field Data Analysis, 2012.

Appendix 3. Plant height of *Moringa Oleifera* as influenced by plant population and fertilizer.

ANOVA	Sources	Df	ss	ms	Fcal	ftab (<0.05)
	Trial	17	74.67			
	A	1	0.01	0.01	0.003Ns	4.96
	B	2	8.73	4.39	10.265Ns	4.10
5 WAP	AB	2	8.73	4.27	1.231Ns	4.10
	Block	2	22.67.	11.34	3.268Ns	4.10
	Error	10	34.67	3.47		
	Trial	17	724.4			
	A	1	50.97	50.97	3.72Ns	4.96
	B	2	44.12	22.06	1.62Ns	4.10
7 WAP	AB	2	14.9	17.46	0.54Ns	4.10
	Block	2	473.37	236.69	17.28*	
	Error	10	137.03	13.70		
	Trial	17	4105.89			
	A	1	23.97	23.97	1.64Ns	4.96
	B	2	3.28	1.67	0.11Ns	4.10
9 WAP	AB	2	126.14	63.07	4.32Ns	4.10
	Block	2	3806.50	1903.25	130.36*	4.10
	Error	10	146			
	Trial	17	169334.93			
	A	1	306.37	306.37	0.02Ns	4.96
	B	2	65.37	32.69	0.002Ns	4.10
11 WAP	AB	2	222.05	111.025	0.01Ns	4.10
	Block	2	19013.07	9505.54	0.63Ns	4.10
	Error	10	149738.82	14973.88		

Source: Field Data Analysis, 2012.

Appendix 4. Dry matter of Moringa leaves as influenced by plant population and fertilizer application.

Sources	Df	ss	ms	Fcal	ftab (<0.05)
Trial	17	4076.64			
A	1	779.51	779.51	5.13*	4.96
B	2	1263.15	631.58	5.05*	4.10
AB	2	1293.34	646.67	4.25*	4.10
Block	2	10420.08.	960.04	6.31*	4.10
Error	10	1520.56	152.06		