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EFFECTS OF NITROGEN LEVELS AND HARVEST FERQUENCY ON THE GROWTH AND LEAF QUALITY OF MORINGA (*Moringa oleifera* Lam) IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted under irrigation at teaching and research farm of Faculty of Agriculture, Bayero University Kano, during 2011/2012 dry season to investigate the effects of different nitrogen levels and harvest frequency on growth and leaf quality of Moringa (Moringa oleifera (Lam)). The treatments consisted of four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and three times of harvest frequency (2, 3, and 4 weeks). These were arranged in a split plot design with the nitrogen levels allocated to the main plots while the harvest frequency allocated to the sub plots and replicated four times. The data collected were subjected to analysis of variance (ANOVA) using GenStat and significant different means were separated using DMRT. The result shows that application of nitrogen significantly (P<0.05) increase plant height, number of leaflets plant^{-1}, plant stem diameter, number of branches plant $^{-1}$, fresh and dry weights plant^{-1}. Generally, the growth characters assessed gave maximum value with 150 kg N ha^{-1} treatment. At first harvest highest protein content of the leaf was also obtained with the higher Nitrogen level (150 kg N ha^{-1}), highest Magnesium was obtained with 100 kg N ha^{1} while highest quantity of phosphorus and potassium were obtained with 50 kg N ha^{1}. The increase in harvest frequency significantly (P<0.05) increased dry leaf quality of Moringa with the highest protein quality obtained from 4 weeks harvest frequency. Nitrogen and harvest frequency interaction was found to be significant (P<0.05) on dry leaf quality of Moringa.

Keywords: Moringa, nitrogen, harvest frequency and leaf quality

INTRODUCTION

Moringa oleifera is a small tree with sparse foliage often planted in compound and farmlands (Keay, 1989) and belongs to the family *Moringaceae*. The genus *Moringa* has about 13 species, and it is native to northern India. It spreads to the tropical and sub-tropical regions of Asia, Africa and Latin America gaining significant importance throughout the world, which is attributed to its nutritional, medicinal and industrial values (Muhammad, 2008). The tree is found growing in most parts of Nigeria and it is locally referred as *Zogale*, or *Bagaruwar Makka* in Hausa, in Fulfulde it is called *Kabije, Gawara* or *Konamarad*e. The Yorubas call it *Ewe ile* and the Igbo call it *Ikwe Oyibo*. Moringa was probably introduced into Nigeria by Arab traders and the plant has several Arabic names *Ruwag, Alim, Halim, Shagara Al ruwag* (Auwalu, 2009). In many parts of West Africa, Moringa leaves are considered as important leafy vegetables (Auwalu, 2009), which provides both high protein content and quality that meets the estimated amino acid requirement especially for children between the age of 2 - 5 (Kalb and Kuo, 2002).

Leaves of Moringa are the most nutritious part of the plant, and have been used to combat malnutrition especially among infant and nursing mothers. The leaf contains 22-35% protein together with all essential amino acids. It also contains carbohydrate at varying levels. The protein quality of Moringa leaves rivals that of milk and eggs. Ounce by ounce Moringa leaves contain four times vitamin A and beta-carotene than carrot, four times calcium and two times protein than milk, more iron than spinach, seven times vitamin C than oranges, and three times more potassium than bananas (Fahey, 2005) and more proteins than peas (Kalb and Kou, 2002). Moringa leaf is an excellent source of vitamins, minerals and protein perhaps more than any other tropical vegetable (Anonymous, 2008).

In Nigeria, Moringa is often grown as a live fence or a backyard tree, not much work has been done on the agronomy of the crop (Auwalu, 2009), there is need therefore, to explore the most favorable conditions for cultivating Moringa in order to meet the growing demands by farmers. Moringa growers have to increase their production by adopting appropriate strategies and techniques which will lead to sufficient and sustainable yields without depleting the natural resource base by establishing the best agronomic practices for cultivation and utilization of the crop. Thus, the aim of this research work was to determine the optimum level of Nitrogen required for growing Moringa as vegetable crop and the appropriate harvest frequency for optimum quality of the Moringa leaves.

MATERIALS AND METHODS

The experiment was conducted during the 2011/2012 dry season at teaching and research farm of Faculty of Agriculture, Bayero University, Kano (latitude 11^0 58′ N and longitude 8^0 25′ E, 457m above sea level) in the Sudan Savannah ecological zone of Nigeria. The field had been intensively cropped resulting in degraded soil condition as reflected by the soil physio-chemical analysis (Table 1). The treatments combination consisted of four levels of Nitrogen (0, 50, 100 and 150 kg ha^{-1}) and three levels of harvest frequency (2, 3 and 4 weeks). The experiment was laid out in a complete randomized block design at initial stage (because at that stage only nitrogen factor was under consideration) but at 12 weeks after sowing (i.e. at harvesting stage) a split plot design was adopted with nitrogen levels at the main plots while harvest frequency ,mm was allocated to the sub plots and replicated four times. The main plot size measured 3m x 2m (6 m^2) and was demarcated into three sub plots of (1m x 2m) and each consisted of twenty rows of one meter length. The four inner rows were used as net plots and eight boarder rows were used for sampling purpose. An alley way of 1.5m, 1m and 0.5m were left between replicate, main plot and sub plots respectively. The land was cleared and harrowed, leveled and prepared into irrigation basins, with irrigation channels provided. Two seeds were sown per hole manually at the depth of 2cm which were later thinned to one seedling per stand at two weeks after sowing (2 WAS). Spacing of 20 cm inter row and 10 cm intra row was used. Nitrogen fertilizer (urea 46% N) was used as source of nitrogen and it was applied at 3 WAS, along the side of the Moringa plant (Palada and Chang, 2003). Weeding was carried out manually by hoe three times at three weeks interval before harvesting. The plants were first harvested at 12 weeks after sowing as suggested by Grubben and Denton (2004). The plants were cut manually with knife at 20cm from the ground level to encourage side branching so as to enhances yield of subsequent harvests, and it was after the first harvest that the harvest frequency of 2, 3 and 4 weeks treatments were introduced and lasted for three months. Data were obtained on plant height, stem diameter, number of branches $plant^{-1}$, leaflets number $plant^{-1}$, fresh and dry weight $plant^{-1}$, protein, Mg, Ca, Fe, P and K contents of the Moringa leaves and the data collected were subjected to analysis of variance (ANOVA) using the general linear model of GenStat. Significant treatment means were separated using DMRT (Duncan, 1955).

RESULTS AND DISCUSSION

Effects of Nitrogen levels on Vegetative Growth of Moringa during the First 12 Weeks.

The mean plant height, stem diameter and number of branches $plant^{-1}$ increases with time, showing significant (P<0.05) differences from the 4^{th} WAS. The highest nitrogen level (150 kg ha^{-1}) gave the highest increased in plant height, stem diameter and number of branches $plant^{-1}$ followed by 100 kg N ha^{-1} then 50 kg N ha,$^{-1}$ while the control (0 kg N ha^{-1}) gave the lowest increase in plant height, stem diameter and number of branches $plant^{-1}$ (Table 2). The leaflets number $plant^{-1}$ fresh and dry weight $plant^{-1}$ increases with time in all treatments and were significantly (P<0.05) different from the 4^{th} week onwards. Individual plants with higher level of nitrogen had a higher leaflets number, fresh and dry weight $plant^{-1}$ followed by the medium and lower nitrogen levels respectively, while the lowest number of leaflets, fresh and dry weight $plant^{-1}$ were obtained with the control (Table 3). At 4^{th} WAS only 150 kg N ha^{-1} recorded significantly (P<0.05) higher weight $plant^{-1}$ while 100, 50 kg N ha^{-1} and the control were found to be statistically at par, at same period 150 and 100 kg N ha^{-1} produced plant that were statistically the same in dry weight $plant^{-1}$, followed by 50 and 0 kg N ha^{-1}.

The result of this study showed a significant impact of nitrogen application on the growth characters of Moringa measured at the experimental site. Nitrogen is known to be an essential nutrient necessary for stimulation of rapid vegetative growth because of its importance in photosynthesis and formation of chlorophyll, nucleic acid and amino acid (Samuel, 1980). Therefore, considering the low nutrient status of the soil of the experimental site it is to be expected that application of nitrogen will increase the growth performance of the crop.

Growth characters such as plant height, stem girth, number of leaves $plant^{-1}$ and number of branches $plant^{-1}$ were all found to be significantly (P<0.05) affected by level of nitrogen application this is in line with findings of Oliver (2009) who recorded similar result in which best performing result was obtained with NPK fertilizer (27-7-20) at 32 – 43 Kg $week^{-1}$ ha^{-1} in Moringa production. Dash and Gupta (2009) were also reported to have obtained significant increase in growth characters of Moringa treated with NPK/Urea (5 g pot^{-1}) and SSP respectively. The result was also similar to that of Matallawa (2012) who reported significant increase in plant height; stem girth, fresh and dry weight $plant^{-1}$ in Moringa treated with NPK 150 Kg ha^{-1} and 15t ha^{-1} poultry manure.

Effects of nitrogen levels and harvest frequency on nutritional composition of Moringa leaf

The result showed that 150 Kg N ha^{-1} produced leaf with highest protein content that was significantly (P<0.05) higher than 0, 50 and 100 kg N ha^{-1} during first harvest (Table 4), while at last harvest, the different nitrogen levels produced leaf with statistically similar protein content comparable to the control. Harvest frequency of 3 and 4 weeks were statistically at par and produced significantly (P<0.05) higher protein contents than 2 weeks at same period of first and last harvests (Table 4). The magnesium content of the Moringa leaf during first and last harvests showed that there was significant (P<0.05) difference among the nitrogen levels with 100 kg N ha^{-1} given the highest magnesium content, followed by 50 and 150 Kg N ha^{-1} which were statistically at par but significantly higher than 0 kg N ha^{-1} but there was no significant effect of harvest frequency on magnesium content (table 4).

The result presented on table 4 also indicated that 50 Kg N ha^{-1} produced leaf with higher phosphorus and potassium content that was significantly (P<0.05) higher than 150, 100 and 0 Kg N ha^{-1} which were statistically similar during first and last harvests, while during first harvest 4 weeks harvest frequency produced leaf with significantly (P<0.05) higher phosphorus content than 3 and 2 weeks harvest frequencies statistically at par. But during last harvest 4 and 3 weeks harvest frequencies statistically at par produced leaf with significantly (P<0.05) higher phosphorus content than 2 weeks harvest frequency. At same period of first and last harvests, 2 weeks harvest frequency produced leaf that was significantly (P<0.05) higher in potassium content than 3 and 4 weeks which were statistically similar. There were no significant effects of both nitrogen levels and harvest frequency on the calcium and iron composition of Moringa leaf during first and last harvests.

The study revealed that nitrogen and harvest frequency significantly (P<0.05) affected the quality of Moringa leaf, with increase in the rate of nitrogen application and weeks of harvest frequency high quality leaf was obtained especially with 150 kg N ha^{-1} and 4 weeks harvest frequency similar to what was obtained by Amaglo *et al.* (2009) . The highest protein content obtained agreed with findings of Brady and Weil (1999) who reported that plant responds quickly to increased availability of nitrogen. They also reported that healthy plant foliage generally contains 2.5 to 4.0 % nitrogen, depending on the age of the leaves and weather the plant is legume. Delvin and Witham (2002) reported that, the most recognize role of nitrogen in plant life is its presence in the protein molecule. While the minimum leaf quality was obtained from the control and two weeks harvest frequency. This indicated that there is still need for raising nitrogen level for maximum Moringa leaf production and high quality nutrition's leaf as suggested by Ajouku *et al.* (2008) and Davis (2000), who suggested 250 kg ha^{-1} of compound fertilizer and 280 kg N and 350 kg P ha^{-1} respectively also National Research Council (NRC), (2006), reported that mulching and fertilization improve yield and quality of the Moringa leaf.

Interaction between nitrogen levels and harvest frequency on nutritional composition of Moringa leaf

Table 5 and 6 shows the interaction between nitrogen levels and harvest frequency on protein and phosphorus content during first and last harvests of the Moringa leaf, the result indicated positive interaction between nitrogen levels and harvest frequency on protein, phosphorus and iron content. The best combination that produced leaf with highest protein content was 150 kg N ha^{-1} and 4 weeks harvest frequency during first harvest, while at last harvest 100 kg N ha-^{1} and 4 weeks harvest frequency was the best combination. The interaction between nitrogen level of 50 kg ha^{-1} and 4 weeks harvest frequency was the combination with highest phosphorus content during the two harvests regime. The highest iron content of the Moringa leaf (Table 7) produced during last harvest was recorded with 0 kg N ha^{-1} and 3 weeks harvest frequency combination, but statistically at par with 50 kg N and 3 weeks harvest frequency.

Conclusion

From the results of the study, it can be concluded that Moringa responded positively to both nitrogen and harvest frequency for better growth and quality of the leaves. All the growth characters and most of nutrient composition of leaves were all found to be affected with an increase in both Nitrogen and harvest frequency. Based on the study, it can be suggested that farmers in the area of study should apply 150 Kg N ha^{-1} and harvest frequency of 4 weeks after the initial harvest at 12 WAS for better growth and good quality of Moringa leaf.

Table 1; Pre-planting soil characteristics of the experimental site

Soil Properties	0 – 15cm	15 – 30cm
Clay	12	8
Sand	73	69
Silt	15	23
Textural Class	Sandy loam	Sandy loam
Chemical Properties		
pH in water	7.10	7.05
pH in 0.01m $CaCl_2$	6.60	6.30
Organic Carbon (g kg^{-1})	6.38	5.19
Total Nitrogen(g kg^{-1})	0.50	0.40
Available P(mg kg^{-1})	26	22
Exchangeable Bases (mol^{+} kg^{-1})		
Ca	4.36	4.0
Mg	2.10	1.73
K	0.27	0.29
Na	0.09	0.08
CEC	7.29	6.48

Table 2: Effects of Nitrogen levels on plant height (cm), stem diameter plant^{-1}(cm) and number of branches plant^{-1} of moringa during 2011/2012 dry season at BUK.

	Plant height (cm)			Stem diameter (cm)			Number of branches		
Treatment	4 WAS	8 WAS	12 WAS	4 WAS	8 WAS	12 WAS	4 WAS	8 WAS	12 WAS
Nitrogen(kg ha^{-1})									
0	8.89b	16.36d	42.00d	1.65c	3.50d	5.90d	7.75b	10.50d	14.17d
50	9.01b	37.80c	65.50c	1.75bc	4.67c	7.24c	7.75b	13.08c	16.67c
100	9.08b	44.85b	86.26b	1.93a	5.86b	10.86b	8.67a	14.50b	18.42b
150	9.89a	53.03a	105.54a	1.89ab	6.98a	12.15a	8.50a	15.25a	21.33a
SE+	0.300	1.611	3.200	0.093	0.180	0.810	0.401	0.510	0.564

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT.

Table 3: Effects of Nitrogen levels on leaflets number plant^{-1}, fresh and dry weights plant^{-1} of moringa during 2011/2012 dry season at BUK

	Leaflets number			Fresh weight plant^{-1}			Dry weight plant^{-1}		
Treatment	4 WAS	8 WAS	12 WAS	4 WAS	8 WAS	12 WAS	4 WAS	8 WAS	12 WAS
Nitrogen(kg ha^{-1})									
0	48.3c	102.3d	550.3d	1.12b	8.83d	21.45d	0.33b	3.97d	6.47d
50	51.7bc	446.8c	845.4c	1.18b	26.08c	41.95c	0.36b	7.71c	13.32c
100	54.0b	586.7b	1114.3b	1.12b	30.05b	62.34b	0.44a	9.19b	23.11b
150	58.3a	687.2a	1159.2a	1.50a	40.98a	109.28a	0.51a	10.51a	31.30a
SE+	3.19	38.28	91.65	0.150	1.340	6.940	0.062	0.693	5.370

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT

Table 4: Effects of Nitrogen Levels and Harvest Frequency on Nutritional Composition of Moringa Leaf at BUK 2011/2012 dry season during First and Last Harvest

	First Harvest						Last Harvest					
	Mg $100g^{-1}$	%					Mg $100g^{-1}$	%				
Treatments	Protein	Mg	P	K	Ca	Fe	Protein	Mg	P	K	Ca	Fe
Nitrogen ($kgha^{-1}$)												
0	23.79b	0.297b	0.214b	1.483ab	2.023	0.033	23.13b	0.297b	0.216b	1.491ab	1.981	0.037
50	25.10ab	0.329ab	0.264a	1.605a	2.102	0.032	24.53a	0.328ab	0.267a	1.613a	2.011	0.035
100	25.52ab	0.364a	0.216b	1.382b	2.113	0.032	24.79a	0.371a	0.219b	1.391b	2.035	0.035
150	26.35a	0.347ab	0.216b	1.395b	2.132	0.029	25.53a	0.350ab	0.219b	1.403b	2.066	0.032
S.E±	0.747	0.1820	0.0100	0.2904	0.5111	0.0220	0.612	0.0197	0.0101	0.0880	0.5274	0.0220
Harvest Frequency (weeks)												
2	24.26b	0.323	0.218b	1.560a	2.167	0.030	23.53b	0.330	0.220b	1.567a	2.092	0.032
3	25.62a	0.336	0.226ab	.1.471ab	2.118	0.033	24.90a	0.358	0.229ab	1.480ab	2.053	0.036
4	25.73a	0.319	0.239a	1.368b	1.993	0.032	25.09a	0.321	0.241a	1.377b	1.925	0.035
S.E±	0.403	0.0160	0.0050	0.0470	0.0670	0.0020	0.386	0.0160	0.0060	0.0470	0.3880	0.0020
Interaction												
N x HF	**	NS	**	NS	NS	NS	*	NS	**	NS	NS	*

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT. **Significant at 1%, *Significant at 5%, NS Not significant

Table 5: Nitrogen Levels and Harvest Frequency Interaction on Protein and Phosphorus Content of Moringa leaf at BUK during First Harvest

	Protein			Phosphorus		
Harvest Frequency (Weeks)	2	3	4	2	3	4
Nitrogen(kg ha^{-1})						
0	23.83b-d	21.62d	25.93ab	0.248bc	0.205de	0.188e
50	25.52a-c	24.44bc	26.01ab	0.204de	0.258b	0.331a
100	26.39ab	26.40ab	27.83a	0.210de	0.215de	0.224cd
150	25.10bc	24.57bc	23.15cd	0.209de	0.227b-d	0.213de
SE±		0.850			0.012	

Means followed by the same letter(s) are not significantly different at5% level of significance using DMRT.

Table 6: Nitrogen Levels and Harvest Frequency Interaction on Protein and Phosphorus Content of Moringa Leaf at BUK during Last Harvest

	Protein			Phosphorus		
Harvest Frequency (Weeks)	2	3	4	2	3	4
Nitrogen(kg ha^{-1})						
0	23.50cd	20.79e	25.08b	0.252b	0.208c	0.187b
50	25.23b	24.09c	25.05b	0.208c	0.259b	0.333a
100	24.16c	25.54b	26.88a	0.210c	0.219c	0.227bc
150	26.70a	23.70cd	23.32d	0.210c	0.231bc	0.217c
SE±		0.768			0.011	

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT.

Table 7: Nitrogen Levels and Harvest Frequency Interaction on Iron Content of Moringa Leaf at BUK during Last Harvest

HF (Weeks)	2	3	4
Nitrogen(kg ha^{-1})			
0	0.036ab	0.042a	0.033ab
50	0.034ab	0.029b	0.041a
100	0.032ab	0.037ab	0.038ab
150	0.028b	0.038ab	0.028b
SE±		0.003	

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT.

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